ECTI & DAMT NCON

The 4th International Conference on Digital Arts, Media and Technology and
2nd ECTI Northern Section Conference on Electrical, Electronics, Computer and Telecommunications Engineering

2019

JANUARY 30 - 2 FEBRUARY 2, 2019 NAN, THAILAND

www.icdamt.org

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Message from President of ECTI Association

Welcome to ECTI-NCON 2019 & ICDAMT 2019.

The ECTI-NCON and ICDAMT have been commenced in 2016 in the same time with establishment of North section of ECTI Association. The North section of ECTI association consists of several universities in the upper Northern Thailand such as Mae Fah Luang University, Chiangmai University, University of Phayoa, Maejo University, and Chiangrai University. The North section has successfully organized the ECTI-NCON and ICDAMT already three times in Chiang Rai, and Chiangmai, and now the inter conferences become more and more well known among international researchers in the related fields around the world. They do expect and plan to visit beautiful lands and friendly people in the Northern Thailand every year. I personally was impressed to learn strong unity of people working in universities in the North section. In 2019e steering committee and the organizing committee decided to host the inter conferences in Nan province, where participants would enjoy visit of old city of Nan and many famous temples in the town during the best season in the year. This is a good opportunity not only for oversea people but also Thais to learn ethnical history and culture of the locals in Nan.

On behalf of ECTI association, I would like to sincerely appreciate great contributions and success of the North section, and express my faithful thanks to all authors, reviewers, organizing team, and many people who work hard behind the scene.

I wish ECTI-NCON 2019 & ICDAMT 2019 would get great success, and look forward to welcoming all participants to the conferences.

Kosin Chamnongthai (King Mongkut's University of Technology Thonburiailand)
President of ECTI Association

Message from General Chair

Distinguish guests, Ladies and gentlemen;

This is our great pleasure to give to you all the welcome message to all of our honor and beloved ECTI DAMT & NCON participants.

The ECTI DAMT & NCON 2019 (2019 Joint International Conference on Digital Arts, Media and Technology with ECTI Northern Section Conference on Electrical, Electronics, Computer and Telecommunications Engineering) is launched in Nan during January 30 – February 2, 2019 as the international conference initiated by ECTI association by the northern section and other main northern Thai universities, including: Maejo University, Chiang Mai University, University of Phayao, Mae Fah Luang University, Naresuan University and Chiang Rai Rajabhat University. The founding organizers strongly intend to create an opportunity for researchers, developers, designers, engineers and technologists to exchange ideas and discuss development in electrical engineering and related areas for strengthening the growth of smart industries.

We received great honors as keynote speakers from well-known persons that help exciting the technical program. Hopefully participants may enjoy not only study of research trend from the keynote speakers, but also discussion in advanced research results from presenters in oral, exhibition, and special sessions. The organizing team also provides a lovely welcome party at the venue on the first day for participants to get to know each other before starting the sessions, and a wonderful banquet as formal ceremony on the second evening.

On behalf of organizing committee, we would like to express our sincere thanks to all authors, reviewers, organizing team, and many people who work hard behind the scene for their great contributions for ECTI DAMT & NCON 2019. We do hope that the ECTI DAMT & NCON 2019 participants will benefit fruitful new knowledge, and may be able to make many new international friends from the conference.

We look forward to seeing and discussing with you all at the venue of ECTI DAMT & NCON 2020.

General Chairs
Kosin Chamnongthai, KMUTT, Thailand
Pradorn Sureephong, CMU, Thailand
Somchat Hanvongsa, RMUTL, Thailand

Message from Technical Program Chair

On behalf of the ECTI DAMT and NCON 2019 Technical Program Committee, we are pleased to welcome you to the 4th International Conference on Digital Arts, Media and Technology and 2nd ECTI Northern Section Conference on Electrical, Electronics, Computer and Telecommunications Engineering in Nanailand.

The Technical Program of ECTI DAMT and NCON 2019 consists of 7 technical programs from the International Conference on Digital Arts, Media and Technology, 8 technical programs from the ECTI Northern Section Conference on Electrical, Electronics, Computer and Telecommunications Engineering and 4 Special Sessions. This ECTI DAMT and NCON 2019 received a total of 105 submissions that came from several countries, out of which 86 papers have been accepted for presentation and publication in the conference proceedings, yielding an acceptance rate of 81.9%. Every paper went through a rigorous review process, in which each paper received at least three expert reviews.

Our warmest thanks go to our staff and Organization Committee colleagues, including the Technical Program Committee memberse paper reviewers for their invaluable work in shaping the Technical Program, and all the authors who kindly submitted their papers to ECTI DAMT and NCON 2019.

We sincerely hope you will enjoy ECTI DAMT and NCON 2019 and your stay in Nanailand.

Krittika Kantawong, Ph.D.
Technical Program Chair

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Keynote Speaker I

Assoc. Prof. Yodchanan Wongsawat
Director of Brain-Computer Interface Lab, Department of Biomedical Engineering
Vice Dean for Research and International Relations, Faculty of Engineering, Mahidol University

"Trends on Biomedical Engineering and Example on Brain-Computer Interfacing (BCI) Technologies"

One of the best ways to add the value to the existing products or to produce the high value products is to make them healthcare related. These require a group of people who could understand the physiology/anatomy and at the same time need to understand engineering. This is Biomedical Engineer. In this talk, the current trends on biomedical engineering innovation will be clarified. What is the mindset of the great biomedical engineer who can win Nobel Prize? In addition, the example on one of the emerging technologies, brain computer interface, will be demonstrated. Currently, researches on offline analysis of brain-computer interface (BCI) become widely applicable to both the preventive, assistive technologies and machine control. However, investigation on real-time processing of BCI for many applications is still in progress. Electroencephalogram (EEG) signal has been used in medical field for analyzing the brain conditions and activities. It can also be used to diagnose several brain diseases. In this talk, the recent researches in BCI/Neural interfacing and their applications for preventive,

treatment, rehabilitation and assistive technologies will be illustrated together with the analysis of the secret behind each method.

Bibliography: Dr. Yodchanan Wongsawat received the B.Eng. degree from Sirindhorn International Institute of Technology (SIIT), Thammasat University, Thailand, in 2001, the M.S. and Ph.D. degrees from the University of Texas at Arlington, USA, in 2003 and 2007. In May 2008, he joined the Department of Biomedical Engineering, Faculty of Engineering, Mahidol University, Thailand, where he is currently a vice dean for research and international relations, and the director of Brain- Computer Interface Laboratory. With his contribution in brain-computer interface technology, he has received the 2013 Mahidol University distinguished academic career award. In 2014, he has received the Mahidol University Award on Innovation. In 2016, he has received the Inventor Award from the National Research Council of Thailand and has been selected as the 2016 TEDxBangkok speaker. His current research interests include brain-computer interface (BCI), intra-operative monitoring, transcranial magnetic stimulation, and medical instrumentations.

Keynote Speaker II

Professor Yahoui Hamed
Université Claude Bernard Lyon 1, France

"Age of the digitalisation, an opportunity for the energy and the manufacturing sectors: Research and Education considerations"

Research: Development of DC loads in domestic such as LED lighting, computers, phones, and electric vehicles leads to adapt the AC grid by several DC converters. Secondly communication progress allows us to rethink the strategy of energy distribution to fit the needs and the growth of demand. Functionalities like monitoring, energy management and real time processing start to be a reality. An example of a micro DC grid solution funded by the French National research program will be presented.

Education: Nowadays in Europe, with the help of the digitalisation progress, automation is reshaping the manufacturing tools to decrease the product cost within environmental objective guidelines, customized production and valuable improvement of work conditions. it has involved a transformation of education curricula to adapt the learning contents in electrical degree's to fit the industrial needs.

Keynote Speaker III

Asst. Prof. Punnarumol Temdee
Mae Fah Luang University, Thailand

"Personalized Learning: Pedagogical Approach for Smart Learning Environment"

The learning system has always been influencing by the advanced technology. Smart Learning environment is designed and developed to promote flexible learning for the 21st century. It employs modern and advanced technologies to deliver interactive, personalized, and lifelong learning for the learners. More specifically, the Smart Learning Environment is designed and developed to promote different learners appropriately. Personalized learning is thus indeed required for Smart Learning Environment. Generally, this pedagogical approach recognizes student's individual information, such as learning style, interest, inspiration, learning goal, learning challenges, etc., and promote the proper content or response to the right learners. Understanding the demands of different types of learners is challenging, although it is important for appropriate feedback. This talk will be introducing the impact of personalized learning in a smart learning environment together with all basic elements for the implementation of this environment to promote successful learning for the learners.

Bibliography: Asst. Prof. Dr. Punnarumol Temdee received B.Eng. in Electronic and Telecommunication Engineering, M. Eng in Electrical Engineering, and Ph.D. in Electrical and Computer Engineering from King Mongkut's University of Technology Thonburi. She is currently a lecturer at School of Information Technology, Mae Fah Luang University, Chiang Rai, Thailand. Her research interests are social network analysis, artificial intelligence, software agent, context-aware computing, and ubiquitous computing.

Keynote Speaker IV

Professor Thanaruk Theeramunkong
Sirindhorn International Institute of Technology, Thammasat University; Artificial Intelligence Association of Thailand

"Information extraction and text mining applications in Thai language"

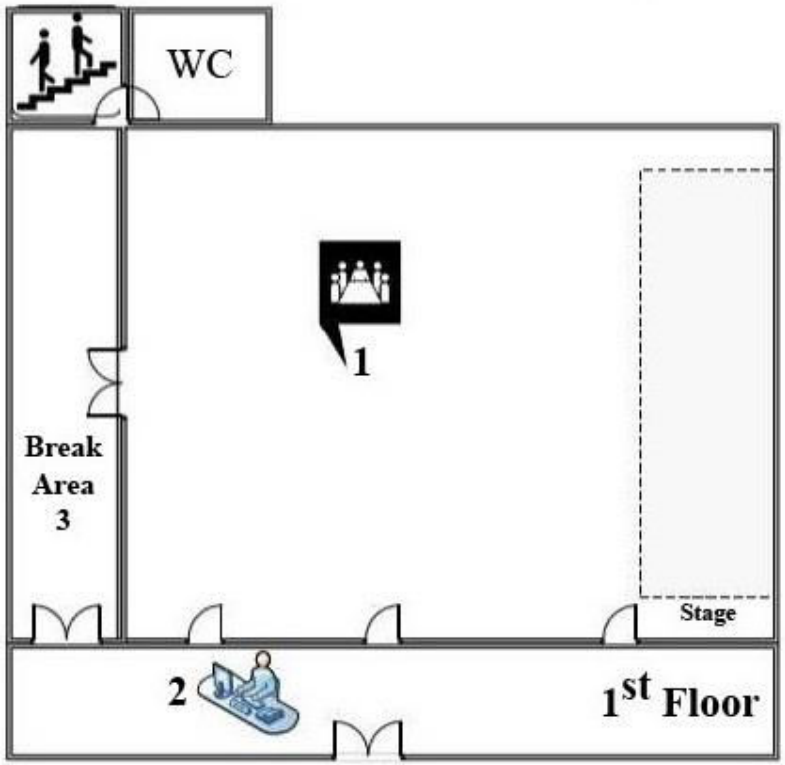
An introduction to characteristics of Thai language in computational point of view and a historical remark on Thai language processing research are provided. Thai language is one of the languages that are difficult to be analyzed since it has optional vowel expression, no word boundary, no sentence boundary, flexible word composition and flexible grammar structure. So far advances in Thai language processing are still limited due to lack of language resources and standardization in language structure by natural. Successful processing Thai tends to strongly depend on semantic - level processing, the hardest part in both theoretical and practical points of view. Among Thai language processing tools , information extraction and text mining are two important processes towards understanding Thai texts. In the talk, I report the progress of our research works in basic and application point s of view, including their potential use in the future.

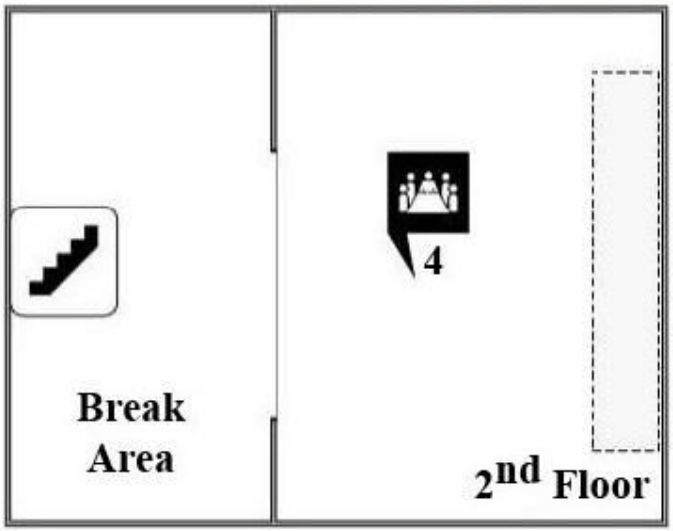
Keywords: Information extraction, text mining, text summarization, Thai language processing.

Bibliography: Thanaruk Theeramunkong is currently a professor at School of Information, Computer and Communication Technology at Sirindhorn International Institute of Technology (SIIT) at Thammasat University, Bangkok, Thailand. He is the Program Director of Information and Communication Technology for Embedded Systems (ICTES) at TAIST Tokyo Tech, National Science and Technology Development Agency (NSTDA). He is also an Associate Fellow, Academy of Science, the Royal Society of Thailand. As a professional society, He is the president of Artificial Intelligence Association of Thailand. He serves as an academic committee to the Industrial Section, National Research Council of Thailand (NRCT). He received his bachelor degree in Electric and Electronics Engineering, master and doctoral degrees in Computer Science from Tokyo Institute of Technology. He was a research associate at Japan Advanced Institute of Science and Technology in Japan and a MIS manager at C.P. Seven Eleven Public Co., Ltd. in Thailand. He got several awards, including the Very Good Research Award in engineering field from Thammasat University in 2008, 2009 and 2010. Recently, in 2014, he has received the National Outstanding Researcher Award in the field of Information Technology and Communication Arts. He also got several best paper a wards from conferences and societies, including the Japanese Society for Artificial Intelligence, PAKDD workshops, and KICSS. In 2015, he also got a Gold Medal with the Congratulations of the Jury from the 43rd International Exhibition of Inventions of Geneva for the inventions of automatic semantic - based multi - document summarization and application to public hearing. His research interests are natural language processing, data mining, text mining, machine learning and applications to service science. He was an associate editor of the Institute of Electronics, Information and Communication Engineers (IEICE). He is a member of the Steering Committee of the Pacific-Asia Conferences on Knowledge Discovery and Data Mining (PAKDD) and a member of the Steering Committee of the Pacific Rim International Conferences on Artificial Intelligence (PRICAI). He is the author of more than 48 papers in a number of journals with impact factors and more than 140 conference papers.

Conference Venue

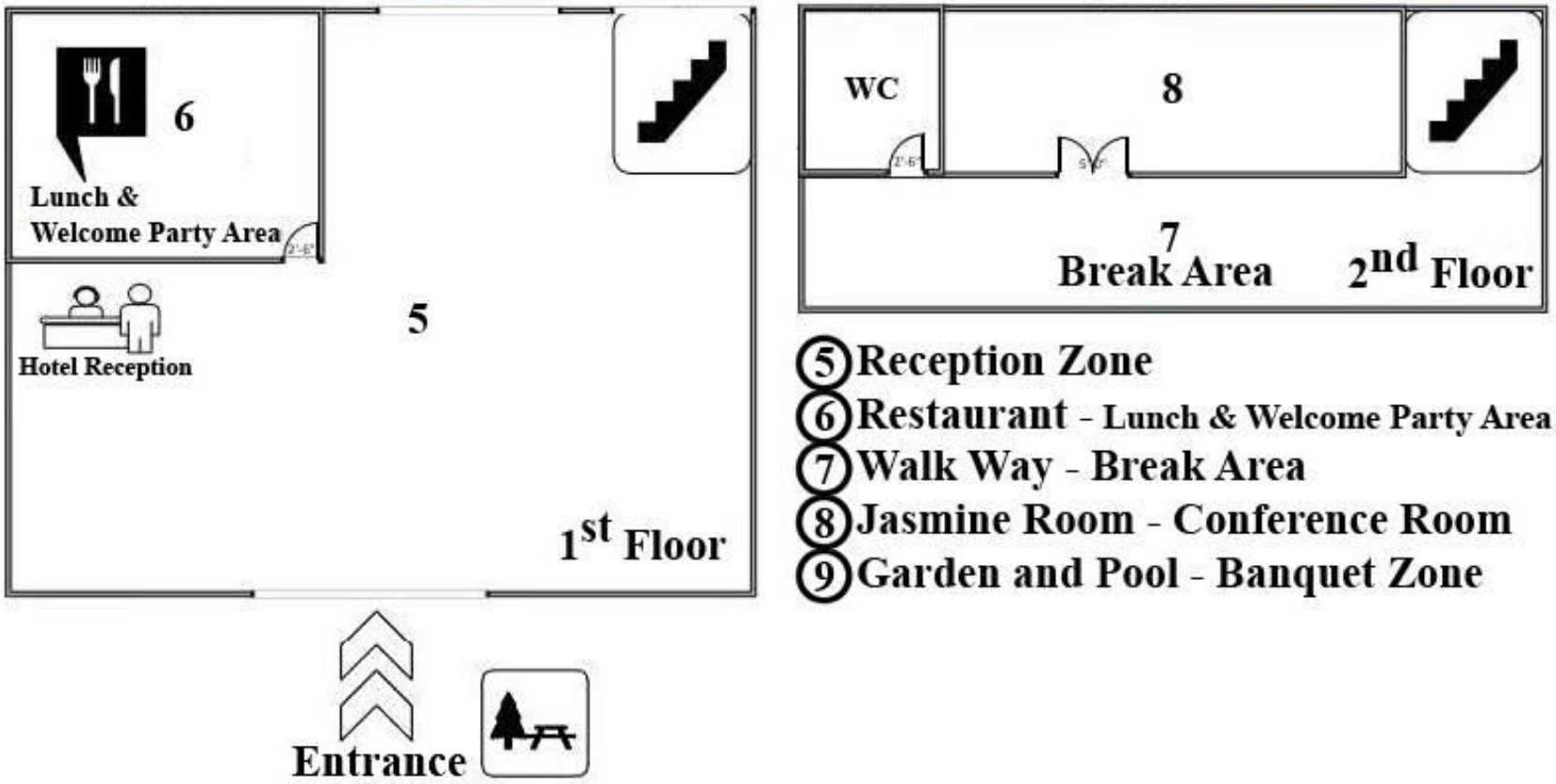
The Impress Nan Convention Hall





① Main Hall - Conference Room 1
② Registration Zone
③ Walk Way - Break Zone for Conference 1
④ Orchid Room - Conference Room 2

The Impress Nan Main Building



⑤ Reception Zone
⑥ Restaurant - Lunch & Welcome Party Area
⑦ Walk Way - Break Area
⑧ Jasmine Room - Conference Room
⑨ Garden and Pool - Banquet Zone

Program at a Glance

Wednesday 30th January 2019	
13:00 – 16:00	**Registration**
16:00 – 18:00	**Campus Tour (Free)**
18:30 – 20:30	***Welcome Party***

Thursday 31st January 2019			
9:00 – 10:30	**NCON: Information Technology 01 (Room 1)** Chair: Dr.Chayapol Kamyod (MFU)	**NCON: Power Systems (Room 2)** Chair: Asst.Prof.Dr Charnyut Karnjanapiboon (RMUTL)	**DAMT: Digital Arts and Media (Room 3)** Chair: Dr.Nop Kongdee (CMU)
	13	49	22
	15	50	32
	20	51	56
	21	52	63
	25	53	73
10:30 – 10:45	**Break**		

Thursday 31st January 2019			
10:45 – 12:15	**NCON: Control Systems 01 (Room 1)** Chair: Asst.Prof.Dr.Roungsan Chaisricharoen (MFU)	**NCON: Applications of AI 01 (Room 2)** Chair: Asst.Prof.Dr. Sakorn Mekruksavanich (UP)	**DAMT: Media and Medium Engineering (Room 3)** Chair: Katawut Kaewbanjong
	77	30	19
	78	68	85
	79	46	86
	80	64	87
	98	65	95
12:15 – 13:30	**Lunch**		
13:30 – 14:00	**Opening Ceremony**		
14:00 – 14:45	**Keynote Speaker 01** Assoc. Prof. Yodchanan Wongsawat		
14:45 – 15:30	**Keynote Speaker 02** Professor Yahoui Hamed		
15:30 – 15:45	**Break**		

Thursday 31st January 2019			
15:45 – 17:15	**NCON: Applications of AI 02 (Room 1)** Chair: Dr.Narit Hnoohom (MU)	**DAMT: AniAge (Room 2)** Chair: Yootthapong Tongpaeng (CMU)	**DAMT: Knowledge Management 01 (Room 3)** Chair: Dr.Santichai Wicha (MFU)
	16	27	11
	60	88	24
	41	90	34
	21	91	35
	25	94	36
	10		

Friday 1st February 2019			
9:00 – 10:30	**NCON: Data Science for IOT (Room 1)** Chair: Asst. Prof. Dr. Kreangsak Tamee (NU)	**NCON: Applications of AI 03 (Room 2)** Chair: Asst.Prof.Dr. Sakorn Mekruksavanich (UP)	**DAMT: Knowledge Management 02 (Room 3)** Chair: Dr. Surachart Buachum (NU)
	1	70	54
	8	75	55
	17	76	57
	45	43	58
	47	66	59

Friday 1st February 2019			
10:30 – 10:45	**Break**		
10.45 – 11.30	**Keynote Speaker 03** Asst. Prof. Punnarumol Temdee		
11.30 – 12.15	**Keynote Speaker 04** Professor Thanaruk Theeramunkong		
12:15 – 13:30	**Lunch**		
13:30 – 15:00	**NCON: Control Systems 02** **(Room 1)** Chair: Dr.Parot Ratnapinda (MJU)	**DAMT: Media Systems and Implementations** **(Room 2)** Dr. Kittisak Osathanunkul (MJU)	**DAMT: Multi-signal Processing and Applications** **(Room 3)** Chair: Dr. Paween Khoenkaw (MJU)Chair:
	77	30	19
	78	68	85
	79	46	86
	80	64	87
	98	65	95
15:30 – 15:45	**Break**		

Friday 1st February 2019			
15:45 – 17:15	**NCON: Information Technology 02 (Room 1)** Chair: Asst.Prof.Dr. Sakkayaphop Pravetjit (UP)	**DAMT: Knowledge Management 03 (Room 2)** Chair: Dr.Pradorn Sureephong (CMU)	
	16	27	
	60	88	
	41	90	
	21	91	
	25	94	

Saturday 2nd February 2019	
9:00 – 12:00	**Technical and Cultural Visit (additional fee)**

Technical Program

NCON: Information Technology 01 **1**

NCON: Power Systems **21**

DAMT: Digital Arts and Media **45**

NCON: Control Systems 01 **69**

NCON: Applications of AI 01 **89**

DAMT: Media and Medium Engineering **109**

NCON: Applications of AI 02 **132**

DAMT: AniAge **159**

DAMT: Knowledge Management 01 **184**

NCON: Data Science for IOT **206**

NCON: Applications of AI 03 **230**

DAMT: Knowledge Management 02 **255**

NCON: Control Systems 02 **282**

DAMT: Media Systems and Implementations **300**

DAMT: Multi-signal Processing and Applications **322**

NCON: Information Technology 02 **343**

DAMT: Knowledge Management 03 **364**

The 4th International Conference on Digital Arts, Media and Technology
and 2nd ECTI Northern Section Conference on Electrical, Electronics, Computer and Telecommunications Engineering

Identifying the Effectiveness of Arabica Drip Coffee on Individual Human Brainwave

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***Abstract*—Caffeine is one of the core substances in coffee. It can directly influence human brain nerve status. Arabica drip coffee is a widely known beverage; drinker often drinks it to keep the brain awake, sensitive, and focus on mental activity. Previous studies have shown that the level of attention in the human brain is controlled by Beta frequency and caffeine can affect the level of Beta frequency. Therefore, this study focuses on the Influence of attention level of local Arabica coffee to the individual brainwave, thus proving the value of the local Arabica coffee. The research applied twenty participants: ten males and ten females which age between 19 to 22. This research performed human brainwave detection via EEG and interpreted the data through the k-means algorithm. The t-Test study verified that the individual Beta frequency increases significantly after drinking the coffee. Additionally, the classification of k-mean showed that the individual effectiveness could be classified into three groups including low, medium, and high-efficiency level for both before and after drinking the coffee.**

Keywords—human brainwave, Electroencephalography (EEG), coffee, Arabica, caffeine, k-means algorithm

I. INTRODUCTION

Coffee drinker usually drinks coffee to enhance their performance or just enjoying the taste every day. Generally, people aware that caffeine can improve brain concentration and increase the level of work quality. There are many benefits of drinking coffee. However, people sometimes drink too much coffee, and it makes them exhausted and hard to sleep. In the long term, this effect can influence people's health, including psychology and physical to a lousy level [1-2].

There are five types of brainwaves that represent different brain frequency activities: Gamma, Beta, Alpha, Theta, Delta waves, respectively. Each of them has a particular type of task to the psychological status. For coffee effectiveness, the age, gender, and health status can influence the effects of caffeine on brain activity.For attention and memory, two main types of coffee, Robusta, and Arabica. It has two different effects on the individual [3]. This study argues that Arabica is better on raising the Attention and efficiency of the voluntary system. Caffeine can affect the brain activity of younger kids (10–16 years old) same as adults [4]. Besides, poor sleep results in health problem and also reduce the working quality [5]. Previous studies have shown that coffee can merely restore partly poor sleep, but for the long run, it affects the health negatively.

At the same time, drinking too much coffee can increase the risk of getting disease [6]. At least 50 mg per day (low amount) and 300 mg per day (high amount) can increase the risk in the same way. It is indicated that even a low dose of caffeine still can influence sleep brainwave [7]. It can naturally increase the hypertension risk, and can also affect another type of blood pressure disease. Caffeine is customarily considered to be used for restoring mental status from the low level [8]. Additionally, the previous study proved caffeine can protect the nerve cells. [9].

Caffeine is a universal central nervous system (CNS) stimulant in the medical profession. Nevertheless, some cases are presented that lower caffeine can decrease the efficacy of some medicines [10]. Nowadays people can quickly get caffeine in daily life, not only from the medicines but also from coffee. Some patient who drinks too much coffee while on medication is a signal of worsening their condition [11].

Besides, the usual way to detect the electrical activity of the brain is by using EEG. In the brainwave research, EEG Mindwave type (headset), especially Neurosky Mindwave is widely used to detect the raw data of brain signal [12]. It is used to observe the attention by collecting whole frequencies [13]. It was used to detect brainwave activity on 40 volunteers for building a machine learning model [14]. The experiment was shown that it could improve human brainwave control based on the IoT devices for a better level. The study intended to help developers learn how to improve their website design and creativity tool (ads, movies, texts). Also, this study processed and classified human brainwave for calculating the participant's brainwaves activity, i.e., attention, and meditation status. It performed EEG for especially to investigate Theta and Beta frequency, which can be affected by the caffeine. Previously, 200 mg caffeine is used to prove the effectiveness with forty female participants. These brainwaves are the marker of the executive control [15]. Some previous studies proved Attention could be released by the 75 mg of caffeine in coffee[16].

As mentioned before, the caffeine has proof that it has the effectiveness to brain activity. However, few studies have demonstrated how caffeine has affected each, which is the primary objective of this paper. This paper thus performs the k-means algorithm to cluster the data for classifying coffee effectiveness level of the personal brainwave. Furthermore, the primary parameter that needs to be adjusted is only the cluster number *k*. In this study, it is used to identify the different level of caffeine's effect on people into a specific group.

Additionally, this study is promising to reveal the beta wave (concentration) effectiveness of the caffeine in coffee on human brainwave via EEG implementation. The finding of this paper can also assist people in knowing more about the coffee which people drink every day.

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II. LITERATURE REVIEW

Due to coffee is one of the typical mental drink in the world, and one of the main elements in coffee is caffeine. Therefore, there are many works study the effects of brainwave by the caffeine. In a previous study, the proof of EEG demonstrates that caffeine can affect the Beta brainwave [17]. Neurosky provides a non-intrusive way to record EEG, where Beta waves associated with processing information, thinking and concentrating. [18]. Caffeine is the key to increase Beta brainwave, and the Beta brainwave can control the level of the attention and working memory [19]. As one of the most popular central stimulants, caffeine can improve mood and performance, and increase the frequency of arousal [20]. Caffeine can reduce sleep efficiency [21]. The increase of Beta brainwave can be detected by EEG after drink the caffeine after 30 to 60 minutes [22]. The study results in the caffeine further support the arousal effect [23]. Beta brain waves are in charge of making decisions and for solving problems and are connected with attention. Neurosky EEG biosensors are equipment which can detect brainwave of human from the scalp of the head. [24]. Therefore, through these previous EEG human brainwave studies about the coffee, we have learned that coffee has a significant influence on the human brainwave. Caffeine in Arabica drip coffee has different levels of influence on people of different ages and genders. K-means algorithm is good at clustering performance [25-27]; it is widely used in data mining for cluster analysis. The interpretability of the algorithm is relatively stable. It works vitally well even in scenarios were some assumptions are being broken with high speed, sophisticated and efficient during the computational process. This is deeming advantageous due to a large number of brain signals that will be used as a variable in this study. With a large number of the variables in the k-means algorithm is expected to produce distinctive clusters, over hierarchical clustering. Its real-time volatility is essential because an instance can change a variable from one cluster to another giving it a real-time computational result.

Following the existing works, this study also gathers Beta brainwave by EEG equipment from the human head. The main objectives of this paper are to confirm to which extent the Beta frequency is affected after drink Arabica Drip Coffee and to determine the classification method for classifying levels of effectiveness of the individual.

III. METHODOLOGY

A. Arabica coffee Preparation

Every 237 (ml) of coffee can have 95-165 caffeine (mg) after brewed [28]. Most of the drip brewers only reach approximately 190 degrees where the length of brewing time which is recommended the steep time of 4 minutes [29]. After around forty minutes, caffeine attains the top concentration in the human body [30]. Therefore, it is at least need 237 (ml) of Arabica drip coffee for the temporary object. It will brew to about 190 degrees and the steep time of 4 minutes before drinking. There are at least 40 minutes needed after drinking the coffee to get the effect. Then it will perform brainwave detection via EEG equipment.

B. Beta Brain-wave Frequency Record via EEG

Beta Brain-wave Activity Frequency Record via EEG, shown in Fig. 1.

Fig. 1. NeuroSky mindwave mobile equipment.

The MindWave Mobile safely measures and outputs the EEG power spectrums (beta waves), NeuroSky eSense meters (attention) and eye blinks. The device consists of a headset, an ear clip, and a sensor arm. The headset's reference and ground electrodes are on the ear clip and the EEG electrode is on the sensor arm, resting on the forehead above the eye. The brain waves data are received twice, the first time is conducted before their intake of coffee, and the second time is performed after 40 minutes of their coffee intake. The experiment focuses on Beta brain waves. Beta brainwave 12.5 - 30 Hz can be detected. The brain wave is collected by EEG equipment; this experiment focuses on collecting the beta wave for five minutes. After drank coffee, the beta wave will be affected. Table 1 shows the raw Beta brainwave collected by the EEG equipment from 20 young participants, age between 19 to 22 years old.

Then, the human beta brain wave will be converted into a voltage by using the TGAT hardware standard equation (1) [31]for an analysis.

$$Vv = \frac{(Rv * \frac{1.8}{4096})}{2000} \qquad (1)$$

Where 1.8 is the constant biased voltage; 4096 is the Value range; R_v *is the* average of raw value; V_v represents the voltage value.

C. Data Clustering

The process starts with the use of a clustering algorithm to obtain k clusters. Clustering from 20 samples (before drinking, after drinking, gender, age), k-means quantifies the usefulness of each feature.

IV. RESULTS AND DISCUSSION

From the methodology, the collected raw beta-brainwave data need to be converted into voltage by using equation (1). The raw and converted signals can be represented by Table I and Table II respectively.

TABLE I. RAW-BETA-BRAINWAVES

Student No	Gender	Age	Beta Waves	
			Before drinking	*After drinking*
1	M	20	15838.74	19303.30
2	M	19	8723.730	13616.06
3	F	20	14337.15	20356.82
4	F	21	16201.64	16457.66
5	M	21	15701.26	16147.58

Student No	Gender	Age	Beta Waves	
			Before drinking	*After drinking*
6	M	20	8091.506	13189.93
7	F	21	13964.99	18276.39
8	F	20	5804.075	7586.152
9	M	19	9975.706	10749.42
10	M	20	18059.88	25449.55
11	F	20	11599.38	14937.36
12	F	22	12828.51	15945.04
13	M	20	9492.692	25718.82
14	M	20	24493.86	29590.50
15	F	20	11917.22	16218.31
16	F	21	7081.071	8428.619
17	M	20	6655.272	7343.968
18	M	20	14712.02	17142.67
19	F	21	10934.34	14894.29
20	F	20	26326.40	26578.72

TABLE II. BETA – BRAINWAVES DATA BEFORE AND AFTER DRINK COFFEE

Student No	Gender	Age	Beta Waves	
			Before drinking	*After drinking*
1	M	20	0.0035	0.0042
2	M	19	0.0019	0.0030
3	F	20	0.0032	0.0045
4	F	21	0.0036	0.0036
5	M	21	0.0034	0.0035
6	M	20	0.0018	0.0029
7	F	21	0.0031	0.0040
8	F	20	0.0013	0.0017
9	M	19	0.0022	0.0024
10	M	20	0.0040	0.0056
11	F	20	0.0025	0.0033
12	F	22	0.0028	0.0035
13	M	20	0.0021	0.0057
14	M	20	0.0054	0.0065
15	F	20	0.0026	0.0036
16	F	21	0.0016	0.0019
17	M	20	0.0015	0.0016
18	M	20	0.0032	0.0038
19	F	21	0.0024	0.0033
20	F	20	0.0058	0.0059

According to table 2, Beta brainwave data is significantly increased after drinking the coffee Moreover. it can be clearly observed that the level of attention is increased with the Beta brainwave after drinking coffee.

A. Effectiveness Validation Results

TABLE III. SAMPLES AFTER T-TEST

Status	*Mean*	*df*	*S.D.*	*N*	*P-value*	Confidences -95.0%
Before drink	0.002887	18	4.4586	20	0.0003	0.05
After drank	0.003713					

When P <0.05 is considered statistically different. Hence the 0 value hypothesis was rejected. The data illustrated that the beta brainwave of volunteers after drinking the coffee is increased significantly.

B. Clustering Result

According to the method of Partitioned clustering, the best clustering result is shown in Table IV. It can be seen that three effective levels (k=3) can be determined in this study including low, medium, and high levels.

TABLE IV. CLUSTER INSTANCES

Classes to Clusters	*No. of Clusters (%)*
(0)Medium	9 (45%)
(1) Low	1 (5%)
(2)High	10 (50%)

From Table IV, large clusters, medium clusters and low clusters of the effectiveness of human Beta brainwave were represented by clusters number 2, 0, and 1, separately. Medium clusters, low clusters, and large clusters accounted for 45%, 5%, and 50% of the total respectively.

The confusion attributes are also shown in Table V.

TABLE V. CONFUSION ATTRIBUTE: LEVEL

Classes to Clusters	*0*	*1*	*2*
(1) Low	0	1	2
(0)Medium	8	0	3
(2)High	1	0	5

Instances were sorted into three levels, six participants are at a high level, and eleven participants are at the medium level, and three instances are at the low level. In conclusion, the correct classified clusters are one, eight, five instances for low, medium, and high clusters respectively.

In brief, the experiment starts with Table I. Then the raw data is processed by using the Equation 1 and the results of Table II. Table III shows what there is a statistically different between before and after drinking. In addition, Table IV shows that the clustering results can be classified into three columns; High, Medium and Low Clusters. Based on the experimental results, Table V, there is approximately 70% accuracy of the human beta wave that is influenced and appeared to be higher after drinking coffee. Therefore, the accuracy results agree well with the hypothesis

V. CONCLUSION

It is evident that the participants who drank coffee have higher levels of Beta Waves. Moreover, the classification method states that how much caffeine from Arabica coffee affected on Beta waves within. Previous studies have shown that the level of attention in the human brain is controlled by Beta frequency and caffeine can increase Beta frequency. However, there are more than a hundred species of coffee identified,

Consequently, since the coffee products are chosen from the research local, the results of this research implement to

prove the mental medicinal properties and relatively increase the Arabica value of the local product.

Furthermore, for the more concrete result to support the above hypothesis, the future work will use with 14 channel EEG to replace the one channel EEG, it could be more comprehensive and detailed collection of brainwave signals.

REFERENCES

[1] Lara, D. R. (2010). Caffeine, mental health, and psychiatric disorders. Journal of Alzheimer's disease, 20(s1), S239-S248.

[2] Wolde, T. (2014). Effects of caffeine on health and nutrition: A Review. *Food Science and Quality Management*, *30*, 59-65.

[3] Alharbi, W. D., Azmat, A., & Ahmed, M. (2018). Comparative effect of coffee robusta and coffee arabica (Qahwa) on memory and attention. *Metabolic brain disease*, 1-8.

[4] Aepli, A., Kurth, S., Tesler, N., Jenni, O. G., & Huber, R. (2015). Caffeine consuming children and adolescents show altered sleep behavior and deep sleep. *Brain Sciences*, *5*(4), 441-455.

[5] Anderson, J. R., Hagerdorn, P. L., Gunstad, J., & Spitznagel, M. B. (2018). Using coffee to compensate for poor sleep: impact on vigilance and implications for workplace performance. *Applied ergonomics*, *70*, 142-147.

[6] Chei, C. L., Loh, J. K., Soh, A., Yuan, J. M., & Koh, W. P. (2018). Coffee, tea, caffeine, and risk of hypertension: The Singapore Chinese Health Study. European journal of nutrition, 57(4), 1333-1342.

[7] Landolt, H. P., Dijk, D. J., Gaus, S. E., & Borbély, A. A. (1995). Caffeine reduces low-frequency delta activity in the human sleep EEG. Neuropsychopharmacology, 12(3), 229.

[8] Snel, J., & Lorist, M. M. (2011). Effects of caffeine on sleep and drink coffee in the morning can affect people's night sleep cognition. In Progress in brain research (Vol. 190, pp. 105-117). Elsevier.

[9] HIM, A., DENIZ, N. B., & ÖNGER, M. E. (2018). The effect of caffeine on neuron number of rats exposed to 900-MHz electromagnetic field. Turkish Journal of Veterinary and Animal Sciences, 42(3), 198-204.

[10] van Koert, R. R., Bauer, P. R., Schuitema, I., Sander, J. W., & Visser, G. H. (2018). Caffeine and seizures: A systematic review and quantitative analysis. Epilepsy & Behavior, 80, 37-47.

[11] Cappelletti, S., Daria, P., Sani, G., & Aromatario, M. (2015). Caffeine: cognitive and physical performance enhancer or psychoactive drug? Current neuropharmacology, 13(1), 71-88.

[12] Katona, J., Ujbanyi, T., Sziladi, G., & Kovari, A. (2016, October). Speed control of Festo Robotino mobile robot using NeuroSky MindWave EEG headset based brain-computer interface. In Cognitive Infocommunications (CogInfoCom), 2016 7th IEEE International Conference on (pp. 000251-000256). IEEE.

[13] Navalyal, G. U., & Gavas, R. D. (2014). A dynamic attention assessment and enhancement tool using computer graphics. Human-centric Computing and Information Sciences, 4(1), 11.

[14] Edla, D. R., Mangalorekar, K., Dhavalikar, G., & Dodia, S. (2018). Classification of EEG data for human mental state analysis using Random Forest Classifier. Procedia Computer Science, 132, 1523-1532.

[15] van Son, D., Schalbroeck, R., Angelidis, A., van der Wee, N. J., van der Does, W., & Putman, P. (2018). Acute effects of caffeine on threat-selective attention: moderation by anxiety and EEG theta/beta ratio. Biological psychology, 136, 100-110

[16] Pasman, W. J., Boessen, R., Donner, Y., Clabbers, N., & Boorsma, A. (2017). Effect of caffeine on attention and alertness measured in a home-setting, using web-based cognition tests. JMIR research protocols, 6(9).

[17] Siepmann, M., & Kirch, W. (2002). Effects of caffeine on topographic quantitative EEG. Neuropsychobiology, 45(3), 161-166.

[18] On, F. R., Jailani, R., Norhazman, H., & Zaini, N. M. (2013, March). Binaural beat effect on brainwaves based on EEG. In Signal Processing and its Applications (CSPA), 2013 IEEE 9th International Colloquium on (pp. 339-343). IEEE.

[19] van Son, D., Schalbroeck, R., Angelidis, A., van der Wee, N. J., van der Does, W., & Putman, P. (2018). Acute effects of caffeine on threat-selective attention: moderation by anxiety and EEG theta/beta ratio. Biological psychology, 136, 100-110.

[20] Jung, J. Y., Lee, H. W., Jang, I. S., Suk, K., & Lee, M. G. (2014). Caffeine Maintains Arousal Level and Prevents Change of Electroencephalogram Spectral Powers with Time at Rest. Journal of Korean Sleep Research Society, 11(1), 5-10

[21] Robillard, R., Bouchard, M., Cartier, A., Nicolau, L., & Carrier, J. (2015). Sleep is more sensitive to high doses of caffeine in the middle years of life. Journal of Psychopharmacology, 29(6), 688-697.

[22] Okello, E. J., Abadi, A. M., & Abadi, S. A. (2016). Effects of green and black tea consumption on brain wave activities in healthy volunteers as measured by a simplified electroencephalogram (EEG): a feasibility study. Nutritional neuroscience, 19(5), 196-205.

[23] Barry, R. J., Clarke, A. R., & Johnstone, S. J. (2011). Caffeine and opening the eyes have additive effects on resting arousal measures. Clinical Neurophysiology, 122(10), 2010-2015.

[24] Diukova, A., Ware, J., Smith, J. E., Evans, C. J., Murphy, K., Rogers, P. J., & Wise, R. G. (2012). Separating neural and vascular effects of caffeine using simultaneous EEG–FMRI: differential effects of caffeine on cognitive and sensorimotor brain respons

[25] Yang, L., & Deng, M. (2010, October). Based on k-means and fuzzy k-means algorithm classification of Precipitation. In Computational Intelligence and Design (ISCID), 2010 International Symposium on (Vol. 1, pp. 218-221). IEEE.

[26] Hot, E., & Popović-Bugarin, V. (2015, November). Soil data clustering by using K-means and fuzzy K-means algorithm. In Telecommunications Forum Telfor (TELFOR), 2015 23rd (pp. 890-893). IEEE.

[27] Bhalerao, G. V., & Sampathila, N. (2014, November). K-means clustering approach for segmentation of corpus callosum from brain magnetic resonance images. In Circuits, Communication, Control and Computing (I4C), 2014 International Conference on (pp. 434-437). IEEE.

[28] Mayo Clinic (2017). Caffeine content for coffee, tea, soda and more Retrieved April 14th, 2017, from https://www.mayoclinic.org/healthy-lifestyle/nutrition-and-healthy-eating/in-depth/caffeine/art-20049372.

[29] Hawaiian Energy Sports (2011). Coffee and Caffeine. Which Brewing Method Has the Most? Retrieved August 21th, 2018, from http://www.hawaiianenergysports.com/coffee-journal/2011/8/19/coffee-and-caffeine-which-brewing-method-has-the-most.html.

[30] ABC Health and Wellbeing(*2013*). Caffeine is our favorites legal drug, but what does it do to your body, and how much is too much? Retrieved December 16th, 2013, from http://www.abc.net.au/health/library/stories/2006/04/27/1829125.htm.

[31] NeuroSky(2016). How to convert raw values to voltage? Retrieved Mrach 22Th, 2016 from http://support.neurosky.com/kb/science/how-to-convert-raw-values-to-voltage.

Authentication Model using the Bundled CAPTCHA OTP Instead of Traditional Password

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***Abstract*—** In this research, we present identity verification using the "Bundled CAPTCHA OTP" instead of using the traditional password. This includes a combination of CAPTCHA and One Time Password (OTP) to reduce processing steps. Moreover, a user does not have to remember any password. The Bundled CAPTCHA OTP which is the unique random parameter for any login will be used instead of a traditional password. We use an e-mail as the way to receive client-side the Bundled CAPTCHA OTP because it is easier to apply without any problems compare to using mobile phones. Since mobile phones may be crashing, lost, change frequently, and easier violent access than e-mail. In this paper, we present a processing model of the proposed system and discuss advantages and disadvantages of the model.

Keywords—CAPTCHA OTP, Traditional Password, Authentication

I. INTRODUCTION

Among the password authentication, the secure password setting [1] is based on the length of passwords and characters used to set the password. If a user selects words which is easy to guess or use frequently, the security level of authentication is reduced.

Many researchers have invented a safe and low cost authentication method to reduce the process or method of identity verification. There is a use of the password that the user has, and combine with the OTP (One Time Password) which randomized by the server, to prevent hacker data capture. This is because an encrypted passwords using HTTPS are not as secure as they should be [2]. The researchers Lamport [3] and Shimizu [4] have proposed password hashing for authentication whereas N.M. Haller [5] have proposed password hashing using a hashing function. However, these research depend on the 'traditional password' to help the authentication more secure. The users still have to remember the complex password.

In this paper we proposed the authentication model using the "Bundled CAPTCHA OTP" instead of the traditional password. This model can prevents password capture, and reduce user's tasks. We use e-mail as a way to send the Bundled CAPTCHA OTP picture to the user. Therefore, the hacker is difficult to capture the "Bundled CAPTCHA OTP" and do a replay attack because it will be changed in every sessions[2].

In this paper, we will discuss the basic theories and related research in Section 2. The proposed model will be presented in Section 3. Discussion and evaluation will be drawn in Section 4. We lastly conclude the paper in Section 5.

II. BACKGROUND AND RELATED WORKS

The Covr Security [6] is a non-password authentication method that is used for trading or electronic transactions. This platform is based on a smartphone and uses a 6-digit access code. The Covr Security sends the password to the smartphone via IP instead of SMS. It does not control user in web applications and network devices because it focuses on applications in the field of mobile application.

Mohamed Hamdy Eldefrawa, Muhammad Khurram Khan, and Khaled Alghathber presented One-Time Password System with Infinite Nested Hash Chains [7], It is a way to bring One Time Password (OTP) to a hash for endless encryption. N.M Haller present the S/Key One-time password system [5] which uses a hashing function checking the password for the value of the hash.

An authentication is a way to check who is accessing the system. The user will be required to prove that he/she is a real user; for example, his/her identity is in the university registration system. You will need to login using your username and password to prove yourself as a real user. And the authentication mechanism can also be done in several ways, such as using the following to prove identity.

- "What you have", such as a credit card or ATM card.
- "What you know", such as Password or PIN
- "What you are" (by using biometric), such as fingerprints. Retinal scan or face scans.

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However, these methods can be a combination use, to enhance the security of the system. Take "what you have" combine with "what you know" to be more effective, like swiping credit cards. The user must have a credit card and password to use the card securely.

CAPTCHA [8] [9] (Completely Automated Public Turing Computer and Humans Apart) is a technique used to test the user as a human, not automatic program (bot) by converting letters to images or distorted characters. Sometimes the letters (or numbers) are twisted. If hackers are attacking a CAPTCHA, they must write a special program that can read the distorted letters or numbers displayed on the screen, and then translate it correctly. If web programmers create messier distorted letter, it is more difficult to attack. Consequently, the security of the system will be increased.

OTP (One Time Password) [10] [11] is a one-time password to login in order to verify and confirm ownership of personal information in the system. To access the system again, the user must use a new set of OTP code. The OTP will be changed every time. Therefore, using OTP will help to protect and secure the system.

III. PROPOSED MODEL

In this Section, we will recall the traditional password authentication including CAPTCHA and OTP in Subsection A, and we will then explain the proposed model in the Subsection B.

A. Authentication using a Traditional Password

Considering an authentication by using the traditional password, the process of authentication will have a sequence of steps as follows.

Phase-I [Client]

1. User inputs the Username into the login form.
2. User inputs the Password into the login form.
3. User inputs the CAPTCHA into the login form.
4. User presses the login button.

Phase-II [Server]

5. Server checks the client's Username, client's Password, and client's CAPTCHA. If these fields are incorrect the server will send an error message to the user, and the user has to refill the correct values of these fields. If these fields are correct the server will continue to the next step.

6. Server generates a random OTP, and send the OTP to user's e-mail or user's SMS.

Phase-III [Client]

7. User opens the e-mail / SMS, and finds the OTP.
6. User and fills the OTP into the login page.

Phase-IV [Server]

7. Server checks the client's OTP. If the OTP is incorrect the server will send an error message to the user, and the user has to refill the correct values of the OTP. If the OTP is correct the server will send the main page to the user. In some systems, if user fill an incorrect OTP, the user may be forced to begin from the first step in Phase-I.

In the process of an authentication using traditional password, the user (client) needs to complete the username, password and CAPTCHA, follow by press a login button. This takes four steps for the user. In step 5, the server checks the username, password, and the CAPTCHA sent by the user. If these fields are incorrect the server will send an error message to the user, and the user has to refill the correct values to these fields. If these fields are correct the server will continue to step-6 by generating a random OTP, and send the OTP to user's e-mail or user's SMS. Consequently, the user has to take more two steps which are (1) opening user's e-mail / SMS in order to find the OTP, and (2) filling the OTP into the login page. Finally, the server will send the login page to the user if the OTP sent by the user is correct. Therefore, we can assume that in the process of an authentication using traditional password, the client needs to take 6 steps.

B. Authentication using the "Bundled CAPTCHA OTP"

We have designed the novel authentication model by bundling or merging the CAPTCHA and the OTP together into the one called "Bundled CAPTCHA OTP". We use the bundled CAPTCHA OTP instead of traditional password and other factors. The bundled CAPTCHA OTP will be generated by server and sent to the user's e-mail. The user has to register his/her e-mail address to the system before logging in. Thus, the e-mail will act as a possession factor for the user. Only owner of the e-mail can access the OTP. This means that the proposed method uses the possession factor to make the secure authentication. Moreover, the CAPTCHA help to prevent brute force attacks. Combining (bundling) the CAPTCHA and the OTP together can reduce number of factors needed by the system. Consequently, number of steps in the authentication process will be reduced as well. Our proposed model is different from Detchasit Pansa's model [12] because our proposed model does not depend on user's password.

Figure 1 shows the process of the proposed model. The process starts with the process number 1, client sending the username to the server so that the server knows and verifies who wants to login.

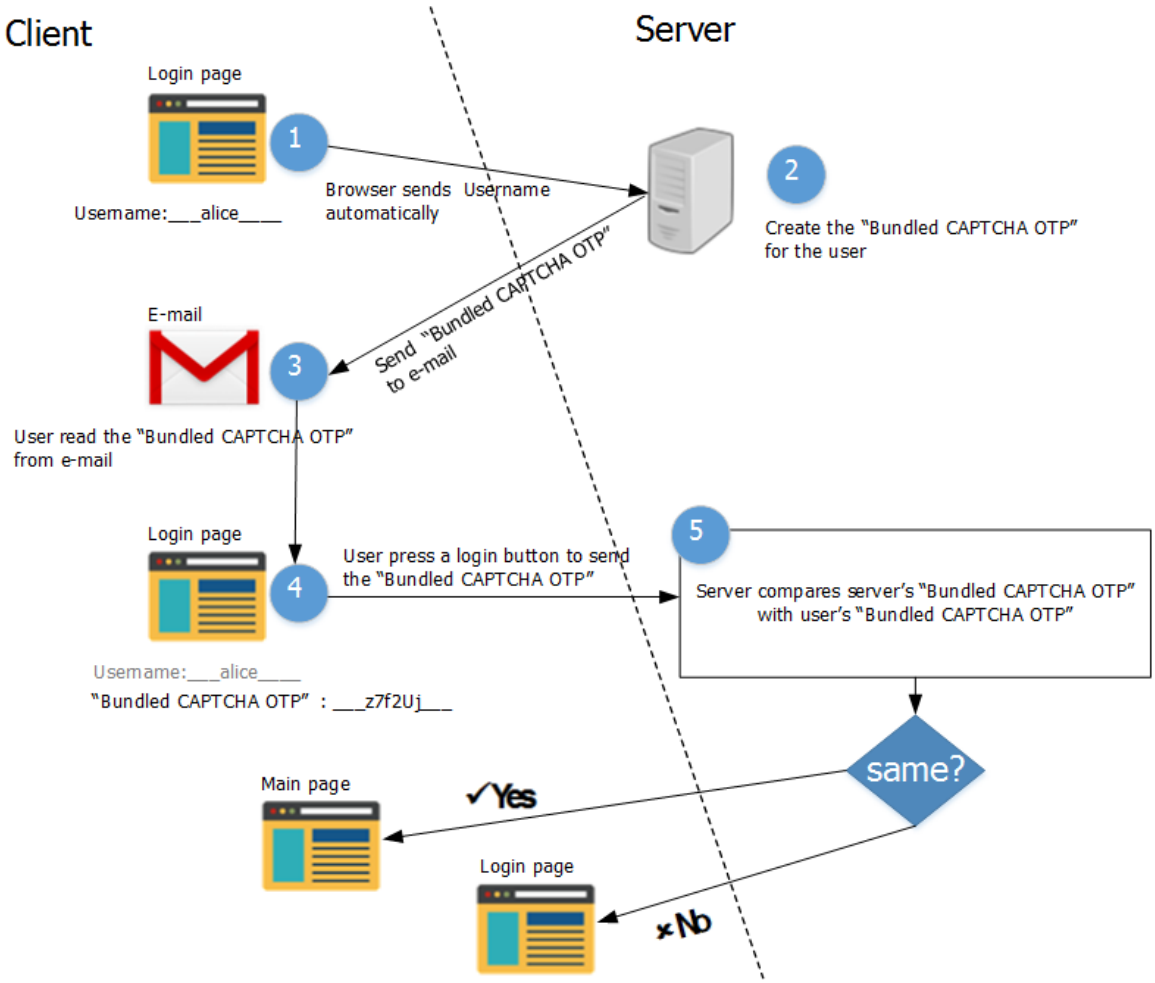

Fig. 1. Model of authentication using the 'Bundled CAPTCHA OTP' insread of the traditional password

In process number 2, once the Server has received the username and verified that any user wants to authentication and username are available in server's database, a picture of the Bundled CAPTCHA OTP is sent to the e-mail of the user who wants to authenticate.

In process number 3, the client must open the mailbox to read the Bundled CAPTCHA OTP value sent from the server. The user will enter the value in the login page according to process number 4.

In process number 5, the server compares the Bundled CAPCHA OTP sent by the client with the Bundled CAPTCHA OTP on the server side. If they are matched, the system will allow the client to pass the authentication. If the comparison result is not matched, the client will not be allowed pass the authentication.

IV. DISCUSSION AND EVALUATION

According to the propose model, steps needed by user have been reduced from 6 to 4 steps. The four steps are follows:

- Entering the Username
- Check e-mail for reading the Bundled CAPCHA OTP
- Entering the Bundled CAPCHA OTP into the login form
- Pressing the 'Login' button on the login form

In this model, the e-mail is the use of "What you have" and a number or a word in the Bundled CAPTCHA OTP is "What you know". This similar to using an ATM card (or a key card) with a PIN. With the proposed model, users do not

need to remember complex passwords. They also do not need to protect their password from hacker.

Therefore, the proposed Bundled CAPTCHA OTP is more advanced and easy to use in comparison to the traditional password authentication.

TABLE I. A COMPARISON BETWEEN THE PROPOSED MODEL AND TRADITIONAL PASSWORD AUTHENTICATION

	Model			
	Traditional Password	Traditional Password + CAPTCHA	Traditional Password + CAPCHA + OTP	The proposed model
Security	Low	Low	High	High
Ease of use	Easy	Easy	Hard	Easy

Table I provides a comparison of three traditional password security and usage scenarios: (1) Traditional Password (2) Traditional Password + CAPTCHA (3) Traditional Password + CAPTCHA + OTP with (4) The proposed model (Bundled CAPTCHA OTP). According to the table, we found that the proposed model is more secure, and easier to use in comparison to the other traditional authentication models.

We evaluated the efficiency of the proposed method by measuring the time duration ('t') of the authentication. We record the time point which users entering the username as 't1', and then record the time point which the authentication is completed as 't2'. The time consumption ('t') for the authentication is t=t2-t1. We test with approximately 10 websites (5 websites use only password, and 4 websites use password and CAPTCHA or OTP). We also test approximately 30-40 times for each website and calculate average values of time consumption ('t'). We found that the proposed method does not take longer than websites which use the traditional scheme (password and CAPTCHA or OTP) as shown in Table II.

TABLE II. A COMPARISON OF TIME CONSUMPTION ('T') BETWEEN WEBSITES USING TRADITIONAL PASSWORD AUTHENTICATIONS AND THE PROPOSED METHOD

The tested websites	Category		Average values of time consumption (seconds)
	Normal Password	Password + CHAPTCHA or OTP	
www.facebook.com	✓	×	18.18
www.icloud.com	✓	×	20.26
www.sanook.com	✓	×	16.74
www.amazon.com	✓	×	14.84
www.mediafire.com	✓	×	16.74
www.2chatcha.com	×	✓	31.32
www.payeer.com	×	✓	28.56
www.faucethub.io	×	✓	26.49
www.freedoge.co.in	×	✓	27.63
The proposed method	×	×	27.01

Moreover, the Bundled CAPTCHA OTP (proposed in this paper) is easy to use because the users does not need to remember the complex passwords as have been used in the traditional authentication schemes.

V. CONCLUSION AND FUTURE WORKS

In this research, we have designed authentication model by combining a CAPTCHA and a One Time Password (OTP) altogether for easier operation with higher security. The system and users take fewer steps. Moreover, the users do not have to remember complicated passwords. We have designed a simple, step-by-step authentication model call the "Bundled CAPTCHA OTP". The proposed model use less resources, operate quickly. In future work, we plan to apply the Bundled CAPTCHA OTP to operate with biometric authentication, e.g., eye retina or human DNA to improve a level of security in the future world.

REFERENCE

[1] Wiedenbeck, S., et al., PassPoints: Design and longitudinal evaluation of a graphical password system. International journal of human-computer studies, 2005. 63(1-2): p. 102-127.

[2] Haller, N., et al., A one-time password system. 1998.

[3] Lamport, L., Password authentication with insecure communication. Communications of the ACM, 1981. 24(11): p. 770-772.

[4] Shimizu, A., A dynamic password authentication method using a one-way function. Systems and computers in Japan, 1991. 22(7): p. 32-40.

[5] Haller, N., The S/KEY one-time password system. 1995.

[6] Covr Security. 2018; Available from: https://www.covrsecurity.com/.

[7] Eldefrawy, M.H., M.K. Khan, and K. Alghathbar, One-time password system with infinite nested Hash chains, in Security Technology, Disaster Recovery and Business Continuity. 2010, Springer. p. 161-170.

[8] Von Ahn, L., et al. CAPTCHA: Using hard AI problems for security. in International Conference on the Theory and Applications of Cryptographic Techniques. 2003. Springer.

[9] Mori, G. and J. Malik. Recognizing objects in adversarial clutter: Breaking a visual CAPTCHA. in Computer Vision and Pattern Recognition, 2003. Proceedings. 2003 IEEE Computer Society Conference on. 2003. IEEE.

[10] Rayes, M.O., One-time password. Encyclopedia of Cryptography and Security, 2011: p. 885-887.

[11] Adams, C., One-Time Password, in Encyclopedia of Cryptography and Security. 2005, Springer. p. 446-446.

[12] Detchasit Pansa, and Thawatchai Chomsiri. "Integrating the Dynamic Password Authentication with Possession Factor and CAPTCHA". Proc. 2018 Joint 10th International Conference on Soft Computing and Intelligent Systems and 19th International Symposium on Advanced Intelligent Systems, 5-8 December 2018, Toyama, Japan, p. 530-535, 2018.

Design of Blockchain Lottery for Thai Government

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Abstract— **This research represents a model of buying and selling lotteries system on Blockchain by using Ethereum network to determines the conditions for the purchasing of the lottery and reward the prize winner. Our system uses Ethereum coins to buy and reward the prize for convenience in term of speed and also reduce the problems which is unable to be controlled by the government. For example, lottery agents (intermediaries) may sell the lottery at over-price, and reward the winners at a lower than appropriate rate. Additionally, the most important problem is the verification of the real owner of the lottery.**

Keywords—Cryptocurrency; Blockchain; Network Security; Computer Network; Peer to Peer; Lottery

I. INTRODUCTION

Nowadays, Blockchain has increasingly influenced our way of life. Blockchain is a disruptive financial-related technology which widely known by people due to the fact that Blockchain has a decentralized database system yet highly secure. Its database is packed with trustable data structures such as Data, Hash and Previous Hash which prevent the people with bad intention from stealing the information or foraging the data and penetrating into the system is almost impossible because the data is stored and scattered in a copy on everyone's machine. This is to cut off the intermediate who hold the whole piece of information. Everyone can hold their own data without the need to rely on the intermediaries. When the document is updated, the copies of the document of the other holders will also be updated as well. This system is called a "distributed system". The number of people on the network depends on the type of Blockchain. The public Blockchain is the type that people around the world has access to the information. The private Blockchain system is another system that is used within the organization. Blockchain is a safe technology and highly reliable.

This is the reason why we integrated Blockchain with the process of purchasing and selling of lotteries. The current system has intermediary which is entirely issued and managed by the government lottery office. In the process of selling lottery, there are merchants and the intermediaries to sell the lottery to people in each area. This system leads to a lot of problems because the government department wants those intermediaries to set the sale prize as 80 THB per lottery ticket. But some of the intermediaries sell the lottery at a price that exceeds the government' specific price which is a corruption including the other kinds of fraud. Hence, reliability of the information depends on the intermediaries (which is the government department of lottery in this case). As a result, we took Blockchain technologies to solve the current lottery fraud issue and taking the fairness.

II. BACKGROUND AND RELATED WORKS

Blockchain is a technology that brings reliability and security without the need to rely on the intermediaries to operate during making a transaction [1]. It is a type of data structure that allow any player to make a digital transaction and share it to other players. Blockchain works as a chain of blocks of data continuously, and shares to everyone else and everyone has authorization in using the data. When the block of data is recorded within the Blockchain, it is very difficult to change [2]. Every time when there is someone who wants to add the information everyone in the network that has a copy of Blockchain can run the algorithm to verify the transaction. The transaction will be accepted only when most of the members in the system agreed that it is authentic.

Ethereum: [3] ETH is a digital currency that was invented by Vitalik Buterin. It was originally developed from Bitcoin but it has more unique and special characteristics such as the speed of transaction verification. The average time of the speed of transaction verification is just 12 seconds which is very fast in comparison to the Bitcoin (which took 10 minutes). Another ability of Ethereum is Smart Contracts which allow us to write a program on the system of Ethereum or Blockchain. There are many organizations that starting to implement this system to reduce the financial procedures needed and increase the transparency to their business.

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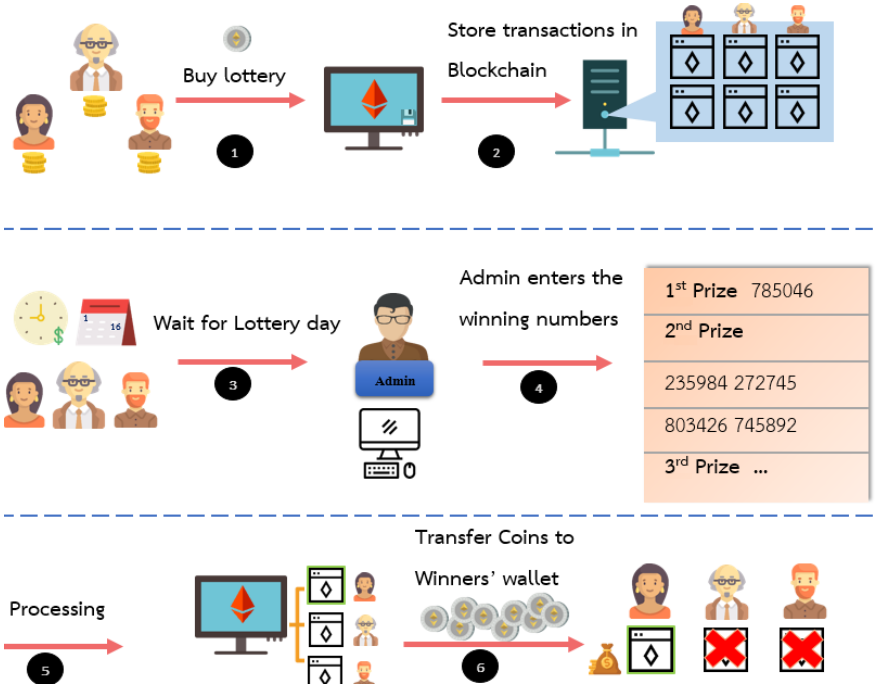

Figure 1. Proposed Model

III. DESIGN

The researchers found that lottery trade [4-6] has confronted several problems such as selling price, lottery prize claim or payout, and lottery possession. Our team designed a system of lottery trade on Ethereum network to address the above-mentioned problems and troubles by designing the system with ease of use and security. Our study had been started from investigation in factors causing a problem of over-pricing lottery; what is the government's definition of over-pricing? The findings of this issue are groups of middlemen that need more profits than the price determined by government. These people arbitrarily increase the selling price of lottery, and consequently cause consumer's lottery purchase on overpriced. Furthermore, researcher team purchased the lottery from many middlemen in many places. These surveys indicate that most of lottery are sold with over pricing more than the given price of the government. In addition to other problems, lottery prize claim and possession, these two issues caused a crucial trouble with talk of the town case of Mr. Preecha, a teacher, and Mr. Jaroon who arrogated to claim the ownership of a set of lottery tickets that was very difficult for investigating the real owner because of no record or player's signature at the back of those tickets verified.

Our lottery trading system (the first version on Ethereum network) can be distributed the operational works as following:

(1.) Sets of sequence number from 000000 to 999999 are functional generated by setting one number per set. Total sets are 1,000,000 sets with the price 80 THB token (price of 1 THB token equals to 1 Thai baht) per set.

(2.) In lottery claiming and payout, lottery provider called the Government Lottery Officer (GLO) shall administratively deduct by 20% of profit obtained from lottery sales, and pay out by 80% back to players with the following calculation; '(20/100) * sold amount', and '(80/100) * sold amount' respectively. The result is the lottery profits and the residual share shall be prize paid out back to the players (buyers).

(3.) Lottery winning number announcement on the first version of our proposed model is still manual method which requires the Lottery web administrators to do filling out all winning numbers every times of lottery date.

(4.) In case that there is the winner, the system shall execute the payout transaction by transferring coins (cryptocurrency) to the winner's wallet as a ratio mentioned in (2.). However, in case of no winner in that match, the system will end its operation in that due, and do the renewal by resetting the set of new sequence numbers on lottery trading system.

A. Work flow of the proposed model

Initially, customer must have the address of Ethereum first to purchase the lottery. However, if they don't have any address in the system yet, the system will provide the sign-up page for the customer through the website which links with the subscription. Once the address is ready, the transaction will be started. The customer then will be required to input the address and choose the number and amount of lottery ticket that the customer wants to buy. Consequently, the system will calculate the price. Once the purchasing process is complete. The transaction then will be recorded to Blockchain. On the day of issue (1st and 16th of every month) the Lottery administrator will enter the winning number into the 'reward checking system'. The system will work only twice a month, and will retrieve

all of the lottery tickets that are purchased and sold and check those number with the reward lottery number in which the administrator fills into the system. If a customer win prize, the system will calculate the amount of the reward in proportion of the sale amount.

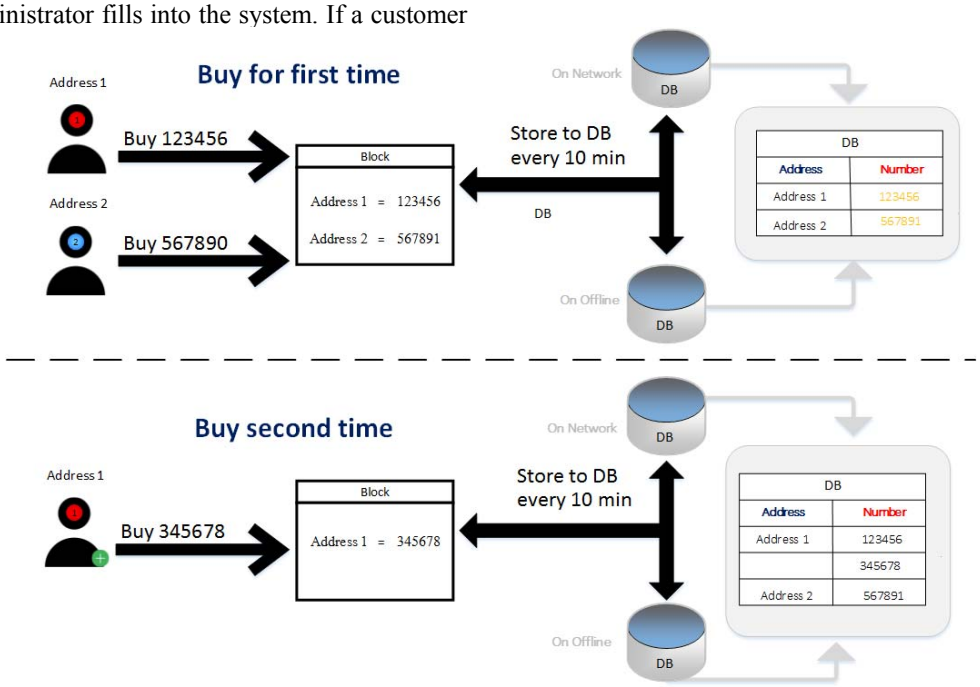

Figure 2. Trading log

B. Trading log

Trading operation can be divided into 2 parts as follows:

(1.) First time for buy a lottery: When purchase a lottery for the first time, the system will assign customers Ethereum address. When customers finished a filling for number and amount that customers want to purchase, the system will save transaction into Blockchain. It then retrieves the data from Blockchain stored in database. Transferring this information will make every trading occurs. A table in database will have a column 'Address' and column 'Number' for keeping an information of customers. If it is a purchase for the first time, the system will add new Address and new Number of customers to database.

(2.) Buy more a lottery: The system will check Address of customers' input which is presented in the system. If the Address is exists, the system will add new purchase information of customers into database. In every times of purchasing, a system will count the number of the purchase.

C. How to create Ethereum wallet for customers.

Trading of lottery on Ethereum Network are required an Address for filling in the details before start to trading lottery and you can have an Address by subscribe to the website Ethereum wallet (www.myetherwallet.com).

In this system, Ethereum wallet is created for the customer. The customer will then input a password on the system. Consequently, the system will send information to www.myetherwallet.com and retrieve a private key and Address to show the customer for the purchase of a lottery.

D. Determination of lottery number selling and awards announcement.

A set of lottery ticket is generated from 000000 to 999999 in a total of 1,000,000 sets. The determination of each set will be defined how many number can be purchased in each set per one address by the Lottery administrator. The determination of number of purchases must be appropriate. The lottery awards announcement of the Government Lottery Office in Thailand is divided into several prizes. In case of unit sold-out, the lottery prizes will be determined per unit as following conditions:

1st prize with a value of 6,000,000 Thai baht by 1 prize. The Government Lottery Office of Thailand will charge their profit at 40% of all sold lottery tickets .The lottery awards announcement of the Government Lottery Office in Thailand is divided into several prizes. In case of unit sold-out, the lottery prizes will be determined per unit as following conditions:

(1.) The administrator inputs the data of numbers on the table of the lottery awards announcement by inputting only winning numbers and announcement date of those numbers.

(2.) When the awards announcement table is set, the information will be retrieved from the tables of lottery trade and awards announcement to check in each announcement time as follows:

(2.1) check if there is any lottery winner. Unless, the system will be ended its operation. However, in case of the winner found, it will be run on the next step.

(2.2) data processing and lottery awards announcement for customers.

Once the prize processing has been completed, transfer the prizes to the customer winners.

IV. ANALYSIS

In this research we invented the purchasing and selling lottery system by using Ethereum Blockchain. Our system concentrates on solving the problems of the existing lottery purchasing and selling process. Beginning with the overprice issue.

Beginning with the overprice lottery which exceeds the price limit of the government. Our system can solve this problem by allowing the issuer to sell their lotteries without relying on the merchant. By doing this, the government can sell by themselves and can track the sell amount in each period easier because the system has recorded every selling and buying transaction.

The next issue is that the verification of the lottery ownership which is a chronic existing problem. In the proposed system, we will force the user to identify the address of the buyer to deduct buyer's balance when the lottery is purchased and to transfer the prize-pool money back to users if they won the lottery. By doing this, the ownership problem can be reduced as mentioned.

This can reduce the problem that the owner of the lottery doesn't check that they win the prize and don't claim the prize as well. Another problem might seem to be a little problem but it could actually cause a crucial loss to the customer is the problem of unable to find the number that they want. As we already mentioned at the beginning that each of the intermediaries and the merchant will get a certain set of lotteries number which made the customer need to search to many places to find the number that they want to buy. However, the lottery market on Blockchain allows the user to buy the number that they want without the need to search for it and they can buy as much as they want at one transaction. From the purchase-sale to the reward claiming, every process will be done virtually on Blockchain except the awards announcement process that will still be using the traditional awards announcement method. This system reflects the transparency of purchasing and selling and can track each prize period that how many lotteries have been sell and the amount of prize won as well.

The processing function will be run only twice a month (every times that the prize/award is announced). The administrator has to enter the reward winning numbers into the system in order to process the function. In the future, we will develop an automatic rewarding system to prevent filling the incorrect number and transfer the prize.

We compare the system of lottery trade on Blockchain and traditional lottery, the summary of differences shows follows.

Table I. Comparison between Lottery Trade on Blockchain and Traditional Lottery

Detail	Lottery Trade on Blockchain	Traditional Lottery
Verified owner from buying lottery	✓	✗
The exact price	✓	✗
Cash reward immediately	✓	✗
Middleman	✗	✓
Convenient for the buyer	✓	✗

V. CONCLUSION

In this research, we have introduced the concept of purchasing and selling lottery on Blockchain and using the Ethereum network. This system will change the original lottery buying and selling process in every aspect such as the buying process without intermediaries, claiming the prize without the need to visit the government department. The only thing that is still the same is the way the prize is announced which is difficult to chance. In general, our system can reduce almost every main problems of the traditional lottery and it provides fairness to the consumer as well.

REFERENCES

[1] Liao, Da-Yin, and XueHong Wang. "Design of A Blockchain-based Lottery System for Smart Cities Applications". San Jose, CA, USA, 2017.

[2] M. Swan. "Blockchain: Blueprint for A New Economy". California: Sebastopol, O'Reilly Media, 2015.

[3] The Ethereum Project. 14 September 2017. https://www.ethereum.org.

[4] S. Nakamoto. "Bitcoin: A Peer-to-Peer Electronic Cash System". 2008.

[5] T. Laurence. "Blockchain for Dummies". Hoboken, New Jersey: John Wiley & Sons, 2017.

[6] T. Wang, J. Chen, G. Liu, R. Ooi, B. and Tan K. Dinh. "BLOCKBENCH: A Framework for Analyzing Private Blockchains" Proc. ACM International Conference on Management pp. 1085-1100, 2017.

JS Digital Assets Trading System

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Abstract— **Blockchain technology is made to be strong and durable as well. Each block of information is stored and chained with other blocks strongly using hashing technique. Blockchain technology cannot be controlled by any one, and no one can destroy it.**

In this study, we have designed the intellectual property trading system using Blockchain as the data source. We have brought an example of e-book trading system on Blockchain that encrypts e-books which confirms that only customers and authors can access the e-book files.

Keywords—Cryptocurrency; Blockchain; Network Security; Computer Network; Peer to peer; e-book

I. INTRODUCTION

Over the years, many innovations have changed the world. Even now, we are in the midst of quiet transition of Blockchain [1] database which collects data in the form of blocks. The beginning of Blockchain is the digital currency Bitcoin [2] trial, which currently has millions of users worldwide and has a market cap of 10,000 - 20,000 million USD. Amid the growth of Bitcoin is now possible to distinguish the Bitcoin architecture behind the scenes for all types of organizations. This is the origin of Blockchain technology, which every major financial institution interested in this moment.

The next big breakthrough after the Blockchain split from Bitcoin was the development of an open source platform "Ethereum" [3], a platform for developers to create distributed programs on the Blockchain.

Currently, there are many Blockchain applications available. They have a lot of improvements. One of the major changes that will take place this year is the transition to 'proof of stake' Blockchain instead of 'proof of work' Blockchain. About the two concepts of mechanisms to prevent system abuse, the 'proof of work' requires tremendous processing power whereas the 'proof of stake' can eliminate the need for large-scale computing power, and provides security to the system at a fraction of the cost.

II. BACKGROUND AND RELATED WORKS

The basic principle used by Blockchain technology cryptography using 'Public Key' and 'Private Key' [3]. Public Key is the number that the system has created randomly. It is called user's address and is stored in Blockchain. When transactions are transferred through applications such as Bitcoin occur, transaction data is also sent to the network directly to that address. Then, the user has to enter a Private Key which will act as a password to claim information owners, and access Bitcoin or other digital assets.

Once the transaction data has been verified and validated, it will be saved to the blocks within the Blockchain network. It will not be able to make any changes or modifications to the data by an unauthorized person. Because of this, Blockchain technology [4-6] is very secure. At present, no one can steal secret data stored in Blockchain without a password or Private Key used to decrypt it.

Therefore, Blockchain is an open technology for design and deployment to prevent fraud. Transparency in data validation can increase reliability, and save on operating costs as well. There is a process for converting conventional electronic data into a form that people cannot read. Typically, encryption is performed before data storage or before data transfer. By using electronic data with a key (a random number derived from mathematical process). This step is called 'Encryption'. To read the data, the process uses encrypted data with another decryption key through the mathematical process as well. The result is the original data. This step is called 'Decryption'. The Encryption/Decryption can be classified in two ways:

1. Symmetric Key Encryption (or called 'Symmetric Key Cryptography'), the sender and the receiver must agree on what format to use for encrypting the data. What kind of encrypted data the recipient and the sender agree on? The secret is that the sender and the receiver agree to use the encryption technique. For example, if you see the letter A, change it to B or see the letter B, then change it to C, etc.

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There are many algorithms for Symmetric Key Encryption such as DES, 3DES, and AES.

2. Asymmetric Key Encryption (or called 'Asymmetric Key Cryptography') was invented by Whitfield Diffie, a Stanford University researcher in the United States in 1975. This encryption uses the 'key pair' consisting of a Private Key and a Public Key. If any key is used for encryption, another one key must be used for decryption. For encryption and decryption with the pair of keys, mathematical functions are used. It has been proven that the Asymmetric Key Encryption is more secure in comparison to the Symmetric Key Encryption. There are many algorithms for Asymmetric Key Encryption such as RSA and ECC.

In this research, we proposed the JS-DATS ('Jakkrit and Sutthiphong' Digital Assets Trading System) by using Asymmetric Key Encryption which can be applied to encrypt and decrypt e-book PDF files as be shown in Figure 1.

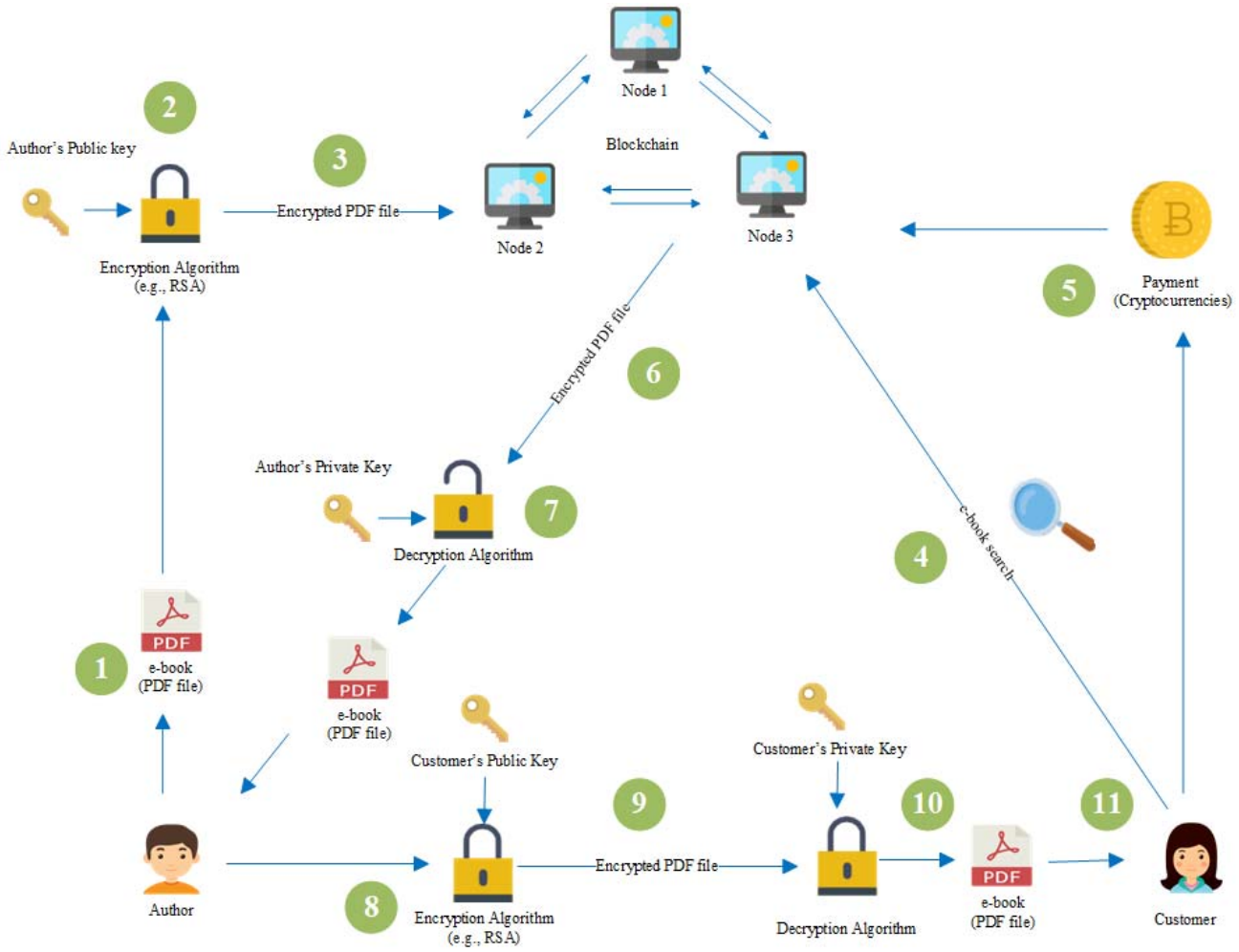

Figure 1. Proposed Model

III. DESIGN

The proposed model has been divided to many Phases and Processes as follows:

Phase-1

- Process 1 Author has a desire to bring an e-book PDF file into the system.
- Process 2 Encryption algorithm is used to prevent unauthorized access to e-book data. The author uses author's Public Key to encrypt the PDF file.
- Process 3 The cipher (encrypted) PDF file sent by the author will be stored on the Blockchain.

Phase-2

- Process 4 Customer searches the e-book in the Blockchain for the desired book.
- Process 5 The customer will pay the money using Cryptocurrencies. In the first version, the system accepts major global coins, such as Bitcoin, ETH and P-coin, and sends trading information to the system.

Phase-3 System receives order information.

- Process 6 System transmits cipher (encrypted) PDF file to the author.

Phase-4 Author receives a request for a book purchase from the system.

- Process 7 The author uses his/her Private Key for decryption. The reason for using author's Private Key is because in Process 2, the PDF file has been encrypted using author's Public Key. According to principle of Asymmetric key encryption, author's Private Key is used in reverse for decryption.
- Process 8 The author encrypts the PDF file with customer's Public Key. The encrypted file sent is only available to the customer who can decrypt it. Although there is a hacker intercepting the encrypted PDF file transferring between the author and the customer, the hacker will not be able to decrypt the encrypted file because the author encrypts with customer's Public Key, which to decrypt the file must use customer's Private Key only.
- Process 9 The customer downloads the encrypted PDF file.
- Process 10 The customer takes the decryption algorithm using customer's Private Key to decode because Process 8 we have encryption with customer's Public Key.
- Process 11 The customer can read e-books safely.

IV. PROS AND CONS

The advantages

- The proposed JS-DATS ('Jakkrit and Sutthiphong' Digital Assets Trading System) model is running based on Blockchain, making the system more available because, in the distributed system (Decentralization), if any node is crashed, others nodes still be alive and ready to serve customers.
- The information collected on Blockchain will be encrypted, and difficult (or impossible) to be hacked, changed and stolen.
- A digital currency payment allows the author of e-books to get their money (coins) immediately when transaction has confirmation.
- It is very transparency because users can trace transactions to investigate that who has been trading from anyone to whom.

The Disadvantage

- A PDF file has been encrypted/decrypted about 4 times, and sent across networks about 3 times too as following.
    - Author encrypts the e-book PDF file with the author's Public Key, and then sends (and stores) it in Blockchain.
    - When the customer buy the e-book, the system will send an e-book PDF file (in Blockchain) to the author. Then, the author decrypts the e-book PDF file with author's Private Key
    - Consequently, the author encrypts the e-book PDF file with customer's Public Key and sends it to the customer.
    - The customer decrypts the file using customer's Private Key

    However, our research team has provided the reason that we chose to do this in order to maintain security issue, permanent archiving on the system, and preventing the loss of e-book PDF files if stored on author's computer.
- The author must be always active. The reason is that the e-book PDF file that is stored on the Blockchain is encrypted with the author's Public Key. Thus, only the authors can decrypt it using author's Private Key. Moreover, the author has to encrypt the e-book PDF file (using customer's Public Key) in order to send it to a customer securely (The e-book PDF file will be decrypted using customer's Private Key).

In the next version, we will conduct an implementation and improve the model for a better performance. With the

new improvement, the author don't need to do any process even online his/her computer or mobile phone all the time.

V. CONCLUSION

In this study, we have designed the intellectual property trading system using Blockchain as the data source. We have brought an example of an e-book trading system on Blockchain that encrypts an e-book which confirms that only customers and authors can access the e-book file.

Trading system via digital coins is well-known all over the world, such as Bitcoin, ETH, or P-coin. The point that we focus on the confidentially of intellectual property that is permanent stored and does not get downloaded or stolen without the permission of the copyright holder of the intellectual property.

REFERENCES

[1] M. Swan. "Blockchain: Blueprint for A New Economy". California: Sebastopol, O'Reilly Media, 2015.

[2] S. Nakamoto. "Bitcoin: A Peer-to-Peer Electronic Cash System". 2008.

[3] The Ethereum Project. 14 September 2017. https://www.ethereum.org.

[4] T. Wang, J. Chen, G. Liu, R. Ooi, B. and Tan K. Dinh. "BLOCKBENCH: A Framework for Analyzing Private Blockchains" Proc. ACM International Conference on Management pp. 1085-1100, 2017.

[5] Bagley, J. (2016). What is Blockchain Technology? A Step-by-Step Guide For Beginners: An inDepth guide by BlockGeeks. Retrieved March 21, 2017,

[6] William Mougayar Author, The Business Blockchain (Wiley, 2016). Investor. Analyst. Speaker. Startup Management. 3x entrepreneur. HP, Cognizant. Blockchain theorist & strategist. Jun 10, 2017

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IoT based speed control of Smart Fan

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Abstract*—This paper explains an efficient speed control method of an electric fan module using Smart Android or IOS phone. Espino and Arduino circuits are used in this process to achieve the objective of this paper. Wi-Fi connection is used as a communication protocol between fan, Espino board and smart phone. The goal is to develop an existing fan into a smart fan, thereby the user can regulate the fan speed from his or her foot step. The final prototype fan model significantly improves ease of use for senior citizens and disabled persons. The proposed method is simple and provides room for further improvement.

Keywords— Phase angle control, Espino controller, Zero Crossing Detection, Triac control.

I. INTRODUCTION

Home Automation has become a popular topic in the modern-day technology. Each person tends to use automated devices in his or her daily life due to multiple reasons ranging from safety to ease of handling. The small-scale industrialists, therefore, have focused to increase their market to the public in a more efficient way.

Smart Technology has been chosen by many researchers working on different methodologies to achieve their objectives. For examples, S. Shimamura and his team worked on Smart fan robot, which automatically detects and tracks a person using thermal camera and RGB-D camera [1]. Another research work was done on human tracking system via ultrasonic distance sensors to detect a person only up to 3 meters [2]. PWM technique is also used to control the fan speed by changing the duty cycle according to room temperature [3]. In addition, Md Mozasser Rahman, Mohd Fahrul and Shahrul Sidek developed a smart fan, which operates based on the presence of human, ambient temperature and the position of humans [4]. Another project is conducted to control home appliances using smart phone with Wi-Fi as communication protocol and Raspberry Pi as a server system [5]. M.A.A. Mashud and his co-authors have conducted different tests and concluded that the fan speed can be controlled by room temperature using PT-100 sensor [6]. Similar work was done on automatic fan speed control using PIC microcontroller. The authors used a special feature called Buzzer, which generates alarm if the temperature becomes overheat [7]. Tarun kumar Das and Yudhajit Das have designed a room temperature and humidity controller by using two fuzzy logic controllers. Their model was operated in 8 to 44 ^{o}C range of temperature and they demonstrated that their model worked properly in 18 to 26^{o}C temperature range in order to maintain the user's comfort level [8]. Hamid M.B. Metwally has introduced a new method of speed control of induction motor by connecting power electronic circuit in series with main winding only, making auxiliary winding current constant at its rated value. This showed an increase in efficiency of a fan motor at low speeds and high starting torque at any speed value [9].

Similarly, smart home appliances are well-fitted in home automation industry with limitless of technology development, which is way better than original system and lead to replacement. Moreover, the automatic control in electric power systems are capable to save electricity by switching off the appliances remotely when not in use or at home, which is better than original electric power systems.

In addition, one of the famous home automation solutions is to use a dedicated system connected to an application installed on the user's smartphone. The combination of these two hardware and software allows greater control of home automation and puts it all in the user's hand.

II. PROBLEM STATEMENT

The main problem with existing conventional fans like ceiling fan, table fans, pedal fans, etc. is that the speed can only be controlled stepwise. The user also has to control it manually each time whenever the fan speed needs to be changed; which can be a serious issue for senior or disabled persons. In addition, the power consumption in these types of conventional fans is high given the amount of air flow produced. Our proposed method can solve this problem effectively and provide a smart speed control in a much efficient way. The final prototype fan can increase user's comfort level as it can be controlled remotely with good Internet connection.

III. THE TECHNICAL APPROACH

Nowadays, the concepts of Internet of Things play an integral role in finding the solution to different problems. In the same way, our technical approach is to control the fan motor by using a Smart Phone. Figure 1 shows the block diagram of the IoT based fan motor control. As shown in the block diagram, the Message Queuing Telemetry Transport (MQTT) protocol is used as a server. Once the server receives commands from clients, it will process and send the data to the microcontroller (Espino board) via internet. The Internet can be a Wi-Fi direct, a Hotspot, a LAN, etc. The Control Algorithm is developed by using Arduino Integrated Development Environment (IDE) software. The fan motor can be controlled using either mobile application (both Android and IOS platforms) or web browser. MQTT dashboard is used as a

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mobile application and is connected to the MQTT server. The Seek Bar is chosen as a tool to adjust the fan speed ranging from 0% (stand still) to 100% (full speed).

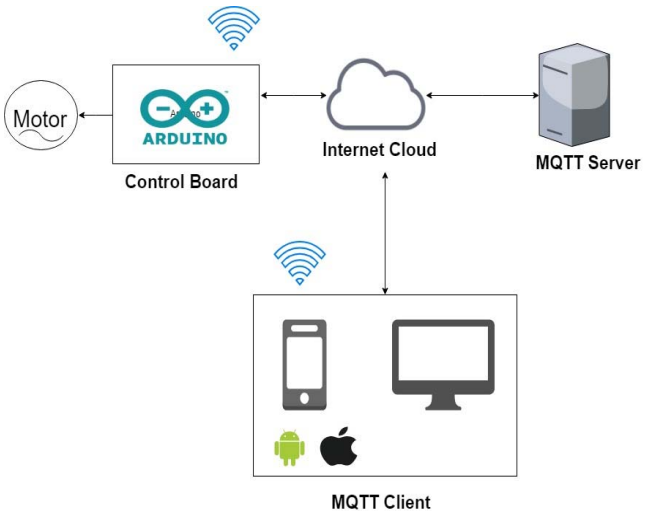

Figure 1: Block Diagram of the Proposed IoT based Motor Control

How to set up MQTT server:

Initially register for MQTT free server, then download the application in a smart phone and configure it with url, username and password. MQTT dashboard has two functions: subscribe and publish. In case of the Mobile Application, MQTT dashboard application needs to be downloaded on a smart phone. Then, create connection to the MQTT server by filling the following data: Client ID, Server URL, Port, Username and Password. After successful configuration, the MQTT dashboard is connected to the MQTT server. Next, select any one type of eight components: "Text", "Button", "Switch", "SeekBar", "Combo Box", "Color Picker", "Multi Buttons" and "Time Picker" to operate the speed input command and then the fan speed is controlled using that component. Here, the SeekBar is chosen as a tool to adjust the fan speed ranging from 0% (stand still) to 100% (full speed). The topic i.e., /ESP32_1/DIMMER is used to send input speed command from a smart phone to MQTT server and also via same topic the Espino controller draws the commands from MQTT server.

IV. Proposed Method and Methodology

This method includes Phase angle control, which provides simple and economical method to control the average voltage of an AC supply. The proposed circuit is carried out with the PCB design, construction and development. The idea was generated from problems faced by users in day-to-day life and can be solved by concepts of advanced technology. The complete schematic diagram is shown in Figure 2.

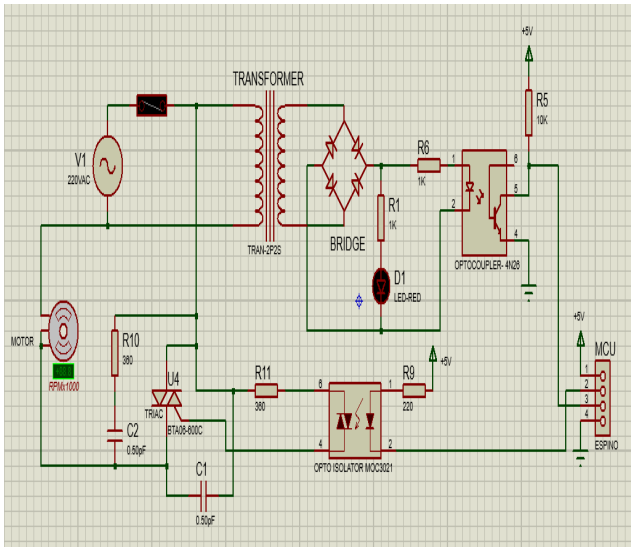

Figure 2: Schematic Diagram of the Proposed Model

A. Zero Crossing Detection

The ZCD is mainly used to change the delay time by generating synchronous pulse with respect to the AC supply voltage. The pulse occurs at 0, 180 and 360 degrees. Alternating sinusoidal voltage (230V) is stepped down to 6V by step-down transformer and is applied to the diode bridge. The diode bridge in the circuit flips the negative half cycle of the sine wave input to positive continuous sine wave output. The voltage from bridge is applied to the Opto-coupler (4N26) to check for the zero crossing of an AC voltage waveform.

B. Espino and Triac Control

Espino controller board is ideal for the development of the IoT as a destination for sensor readings or for controlling the device over Wi-Fi. The Espino controller measures the delay time based on the output pulse generated by 4N26 opto-coupler. The Espino controller changes the delay time according to setting values in the control algorithm. These triggering pulses are given to Opto diac (MOC3021), which interfaces between Espino and high powered TRIAC circuit for AC load control. Small pulse from pin 2 Espino is applied to the pin 1 and 2 of MOC3021. The light produced by LED flashes the diodes so that TRIAC gets activated and the regulated power is applied to the motor terminals to achieve the desired speed of the fan. This process continues till the Espino draws the next speed input command from the MQTT server. The cycle repeats for all the reference speed inputs. The main advantage of this controller is that it can be programmed via the USB port without connecting additional programs.

C. IoT based control

This paper focuses on the control of a fan speed by using Wi-Fi direct and providing all the configuration details like Client ID, Server name, Port number, user name, password and topic and the speed levels of fan. This can be monitored and operated through smartphones, tablets and laptops as well. The proposed method has a unique feature to control a fan using multiple smart devices. The developed control algorithm is used to control the fan's

motor speed. The main advantage of this method is that the user can control the fan speed by indicating the set point (speed input command) via a smart phone. Therefore, the motor can be efficiently controlled by using Wi-Fi direct from anywhere and anytime with good Internet connection.

V. Results & Discussions

The performance of fan using the proposed IoT based method is developed and tested. The experimental results are selected for different motor speed input values by using Android smart phone as explained below. The total time period of the output voltage waveform when motor running at full speed is 20ms, which is equal to 360 degrees.

A. EXPERIMENTAL SET UP

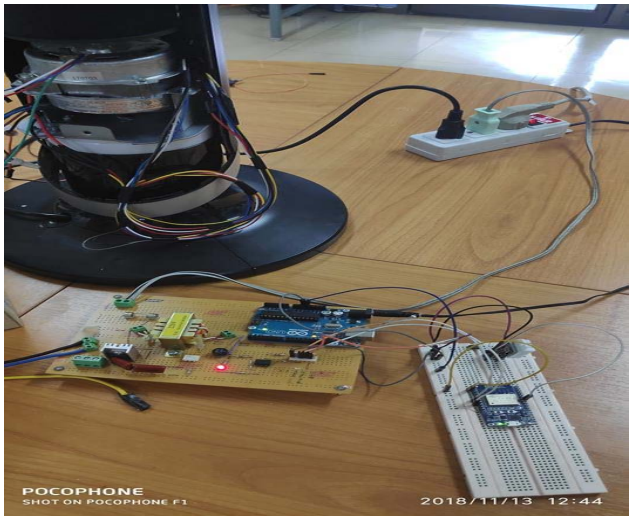

Figure A1: Experimental Set Up with Fan Motor and Proposed PCB.

The above figure depicts the hardware circuit design on PCB with main components such as Espino controller, Opto-coupler, Opto-isolator, Triac and Arduino board.

B. EXPERIMENT RESULTS

Figure B1: 20 % Speed Input from Smart Phone and Speed Output from Tachometer.

The indication of speed input through smartphone that is 20% This lead to the power transmission that affected the different motor terminals. It results to the speed level of fan, which is measured by tachometer. The outcome of measured speed in this case was 919 RPM.

Figure B2: 50 % Speed Input from Smart Phone and Speed Output from Tachometer.

Similarly, when the speed input through a smart phone is changed to 50% then the power transmitted to the motor terminals increases. Thereby the speed of motor gets increased with. The speed measured at this input is 1293 RPM.

Figure B3: 100 % Speed Input from a Smart Phone and Speed Output from Tachometer.

In this case, the speed input is changed to 100% from a smart phone, where the power delivered to the motor terminals increases again and there by the speed of the motor is increased to the maximum value. The speed measured at this input is 1347 RPM.

The experiment was conducted five times and the results were averaged and listed in the table 1 as shown below.

TABLE 1. AVERAGE SPEED VALUES OF PROPOSED FAN MODEL

S. No.	Speed Input from Smart Fan(%)	Tachometer reading (RPM)
1	10	767
2	20	920
3	30	1210
4	40	1240
5	50	1290
6	60	1296
7	70	1300
8	80	1311
9	90	1318
10	100	1347

TABLE 2. AVERAGE SPEED VALUES OF THE FAN USING REMOTE CONTROL

S. No.	Mode of original Fan	Tachometer reading (RPM)
1	Low	650
2	Medium	1030
3	High	1335

C. ADVANTAGES OF THE PROPOSED METHOD OVER REMOTE CONTROL METHOD

- By this method the fan can be operated efficiently at any speed ranging from 1% to 100% of its rated speed, whereas in Remote control method the fan speed can be varied only in three modes i.e. Low, Medium and High.
- Also, frequent change of battery is needed for the remote to function. In this method no remote is required to control the fan, the smart phone acts as remote control for which no specific battery is needed. This results in zero running cost of the fan.
- The remote has certain distance limit to function whereas our method has no distance limit to control, the user can control the fan speed from anywhere in the world.
- Finally, by this proposed method the fan speed can be controlled more precisely and efficiently than by using remote control.

VI. CONCLUSION

To conclude, the proposed method has been successfully implemented and satisfied results are obtained. Care has been taken to make the circuit simple, practical and economical with high reliability. The proposed method has achieved the main objective i.e. to control the speed of the fan using smart android of iOS mobile.

In future, several improvements can be made in order to upgrade this work with other features like speed change according to the human presence and movements, closed loop feedback control and temperature based control.

VII. ACKNOWLEDGEMENT

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REFERENCES

[1]. S. Shimamura, K. Matsumoto, N.Maeda, T.Kodera, W. Nakagawa, Y. Shinozuka, M.Sugimoto and H.Saito, " Smart Fan: Self-contained Mobile Robot that performs Human detection and tracking using thermal Camera," International Conference on Artificial Reality and Telexistence Eurographics Symposium on Virtual Environments, 2014.

[2]. Tajrin Ishrat, Mohammad Anisur Rahaman and Arif Ahammad, "Smart Fan for Human Tracking," the 9th International Forum on Strategic Technology (IFOST), October 21-23, 2014, Cox's Bazar, Bangladesh.

[3]. Vaibhav Bhatia and Gavish Bhatia, "Room temperature based Fan Speed Control System using Pulse Width Modulation Technique," International Journal of Computer Applications (0975-8887) Volume 81-No5, November 2013.

[4]. Md. Mozasser Rahman, Mohd Fahrul Radzi Bin Zakaria and Shahrul Na'im Sidek, "Sensory and Control System for Smart Fan," International Journal of Control, Automation and Systems, Vol.4 No.3, July2015, ISSN 2165-8277 (Print), ISSN 2165-8285 (Online).

[5]. Pavithra. D and Ranjith Balakrishnan, "IoT based Monitoring and Control System for Hom Automation," Proceedings of 2015 Global conference on Communication Technologies (GCCT 2015).

[6]. M.A.A. Mashud, Dilruba Yasmin, M.A. Razzaque and M.H. Uddin, "Automatic Room Temperature Controlled Fan Speed Controller using PT-100," International Journal of Scientific & Engineering Research, Volume 6, Issue8, August-2015, ISSn 2229-5518.

[7]. Zairi Ismael Rizman, Kim Ho Yeap, Nuraiza Ismail, Norizan Mohamad and Nur hafizah Rabiah Husin, "Design of Automatic Temperature Control System for Smart Fan using PIC," international Journal of Science and Research (IJSR), India Online ISSN:2319-7064.

[8]. Tarun Kumar Das and Yudhajit Das, "Design of a Room Temperature and Humidity Controller using Fuzzy Logic," American Journal of Engineering Research (AJER) e-ISSn:2320-0847 p-ISSN:2320-0936, Volume-02, Issue-11, pp-86-97.

[9]. Hamid M.B. Metwally, "New method for speed control of single phase induction motor with improved motor performance," Energy Conversion and Management 42 (2001) 941-950.

Very Short-Term Photovoltaic Power Forecasting Considering the Stochastic Factors.

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***Abstract*—This paper proposes photovoltaic (PV) power forecasting model, which is applied Gaussian blur algorithm filtering technique, for estimating power output and create stochastic forecasting model. As a result, affected power can be forecasted from stochastic factors with machine learning and artificial neural network. This work focuses on a very short-term forecast for 5 minutes ahead. As it uses only endogenous data, no exogenous data is needed.**

To evaluate the model, the result has been compared to the persistence model, which has a good accuracy for a short-term forecasting. It has been shown that the proposed PV forecasting considering the stochastic factors gained higher accuracy than the persistence model.

Keywords—Neural Network, Solar PV generation power forecast, Stochastic factor

I. INTRODUCTION

Photovoltaic (PV) power generation has the property of uncertainty, and depends on many stochastic environmental factors, such as, cloud movement, solar irradiance, and atmospheric conditions. In the power grid, it is very important to accurate forecast of future output from PV power plant, so that the authority can manage the grid to provide enough power for consumption. Many researchers focus on forecasting the power output, which generates using various techniques, and inputs to gain high forecasted output accuracy. However, the origin of input, a forecasting type, and a forecasting horizon should have been considered.

There are two groups based on the input origin. For the first group, the models use endogenous data (current or lagged time series generated by PV power plant [1][2]). For the second group, the models use exogenous data (from meteorological measurements [3], satellite data [4], numerical weather prediction (NWP) [5], and neighboring PV plants [6]).

The PV power forecasting can also categorized into two groups based on forecasting type. The first one is a direct forecasting of power that PV should generate. Another one is an indirect forecasting, which forecasts the solar irradiance and then uses other simulation software to calculate power output of the PV.

Most of PV power forecasting research have focused on the direct forecasting with various techniques include persistence[7], statistical approaches[8], machine learning approaches[9], and hybrid techniques[10]. Mitsuru et al [11] has already studied both direct and indirect methods to compare their efficiencies. It has been found that the direct forecasting gains higher accuracy than indirect forecasting.

Some works have gained a high accuracy in one area but in the same set of variables might have gained a low accuracy at different geographic of PV power plants. They have had to gather and test to find the suitable variables for each area. To obtain the desired variables of meteorological data the sensors were used at PV power plants. To get accurate data, the sensors must be properly maintained which is a tedious work to do. Thus, some researchers focused on PV power forecasting, which was using only endogenous data without exogenous data are [1,2,8,9,12]

In PV power generation, it has been already shown the effect of stochastic factors in power output data. As a result, this work focuses on creating forecasting model with endogenous data and predicting the affected power by stochastic factors. In solar power generation, as shown in Fig. 1, a dash line shows the power that should be generated by PV if there are no stochastic factors. The PV power starts to generate when the sun rises and steadily increases to maximum power when the sun is at its peak in the daytime then gradually decrease until the sun sets, where there is no more power generated. The shape of power output graph is a bell shape curve. However, in the real world, the power output was affected from stochastic factors. This causes the power output generation unsteady. As can be seen in Fig. 1, normal line is not the same complete bell shape curve as a dash line.

In this work, we propose the forecasting model, which use only endogenous data that is power output collected in 5 minutes' interval. The model for power output without stochastic factors and the model to predict the affected power by stochastic factors form applying artificial neural network (ANN), which was used in various forecasting works [8]. All Experiments developed in Python with the aid of Keras and Sci-Py.

The remainder of the paper is organized as follows:
In Section II, methodology used in the paper is presented include the dataset explanation used in experiments and knowledge relate to the power forecasting considering the stochastic factors. Results and discussion are presented in section III. Finally, the conclusion is drawn in section IV.

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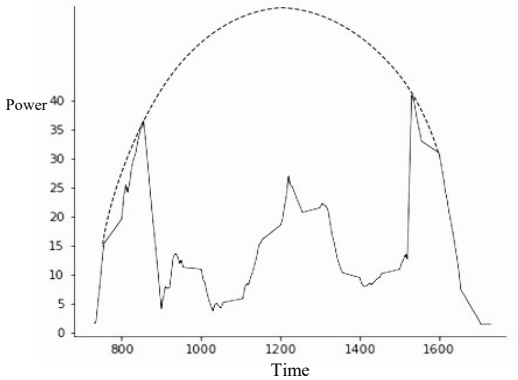

Fig. 1. PV power output graph. Dash line represented expected power output, where there is no stochastic factors affected. The normal line is a measured power output affected from stochastic factors.

II. METHODOLOGY

A. Dataset.

This work used a public dataset from the National Renewable Energy Laboratory (NREL) [13], collected in 5 minutes' interval from flat-plate PV modules installed in three different climatic locations (Cocoa, Florida; Eugene, Oregon; and Golden, Colorado) in the United States of America. The selected PV data were from Eugene, Oregon between the year 2013 and 2014. The missing values were filled using linear interpolation. Then the dataset size was reduced by choosing a subset of time between 9:00 to 17:00. The 2013 data was used for modelling and 2014 was used for model validation. All the data in the experiment was normalized with Feature Scaling.

B. Persistence model

Persistence model is one of the simplest models for the forecasting of time series, and commonly used for benchmarking performance with other models [14]. As it is stated in the name, it explains that the future values of the time series are calculated assuming the conditions remain unchanged. Thus, the time series under this study is stationary.

The persistence assumes that the forecasted power will be the same as the last measured value. For example, for 5 minutes ahead horizon, the power at 9:05 will be the same as power at 9:00 as in (1).

$$\hat{P}(t+\Delta t) = P(t) \quad (1)$$

$\hat{P}(t+\Delta t)$ is the predicted power in a time interval of Δt.
$P(t)$ is the measured power at time t.

C. Proposed model.

Coimbra et al. [14] explained that the PV power output is not stationary as in persistence model. They proposed that the output power are the compositions of expected power output under clear sky conditions and affected power from stochastic factors as shown in (2)

$$P(t) = P_{cs}(t)+P_{st}(t) \quad (2)$$

$P_{cs}(t)$ is the expected power output under clear sky conditions

$P_{st}(t)$ is affected power from stochastic factors.

Our work used idea as show in (2), have the expected power forecasting model in clear sky condition and affected power forecasting model from stochastic factors but apply Gaussian blur filtering technique in clear sky model modelling.

Proposed model is shown in Fig. 2. The measured power P were transformed with Gaussian blur filtering technique. The expected power P_{cs} under clear sky condition was generated from previous process. Then, a clear sky model for P_{cs} was created. After P_{cs} data was obtained, it was used to calculate P_{st} by decomposing P_{cs} from P. Consequently, an ANN was applied to create a stochastic forecasting model. Therefore, there were two models, which were a clear sky model and a stochastic forecasting model. Both models were used to forecast the PV power output.

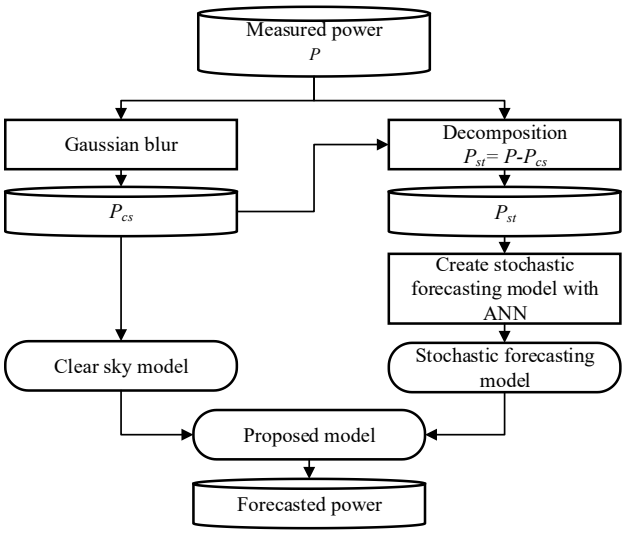

Fig. 2: Proposed model consists of 2 models. One is the Clear-Sky model to forecast the expecting power output under clear sky conditions. Another is a Stochastic Forecasting Model to forecast affected power from stochastic factors.

1) Clear-Sky Model.

The factors effect power output from PV power plant include the location, the time, the PV technology and atmospheric conditions. Thus, the power output depends on mentioned factors except current sky conditions can be easily modeled. The power output which not depends on stochastic factors, assumes clear sky conditions and create a clear sky model. Usually, clear sky models can be predicted from Radiative Transfer model[15] and the European Solar Radiation Atlas (ESRA) model[16].

In Coimbra et al. [14], they manually create clear sky model from historical data but our work using clear sky model by apply filter technique, Gaussian blur to remove the noise data in PV power output and calculate new data to be expect power output from neighboring PV historical data. To create the model first we represent power output as a pair of $P(Day, Time)$. *Day* is transform to be day sequence start from 0 to 365. *Time* is measured power time in 24 hours clock time. For example in Fig. 3a is measured power output of subset January 2013, *Day* from 0 to 30 and

Time from 9.00 to 17.00 represent in surface graph, which is very fluctuate not smooth as expected power in clear sky conditions. Second apply Gaussian blur to measured data, calculate with neighbor *P*(*Day, Time*). The data from this calculation are clear sky model as a function $P_{cs}(Day,Time)$ which represent in graph shown in Fig. 3b. Both Fig. 3a and Fig. 3b are create in python program and create function $P_{cs}(Day,Time)$ to be used for experiment later.

2) Stochastic forecasting model.

An ANN was used in stochastic forecasting modeling from P_{st} data. The input of ANN was P_{st} data in a time-series format, for example, two lagged time series, sequence of affected power $P_{st}1, P_{st}2, P_{st}3, P_{st}4, P_{st}5$ were transformed three inputs patterns $\{ P_{st}1, P_{st}2\}_1$-$\{ P_{st}3\}_1$, $\{ P_{st}2, P_{st}3\}_2$-$\{ P_{st}4\}_2$, $\{ P_{st}3, P_{st}4\}_3$-$\{ P_{st}5\}_3$.

To find the suitable ANN parameters, input formats between two lagged and five lagged time series were tested with 1 hidden layer ANN containing different numbers of hidden nodes, as shown in Table I. To assess the performance of the experiments, Root Mean Square Error (RMSE) and Coefficient of Determination (R^2) or Pearson's coefficient were used.

In Table I. the parameter of ANN was tested to find the suitable parameter, which 2 lagged time series format and 5 hidden nodes were chosen to be used in stochastic forecasting model.

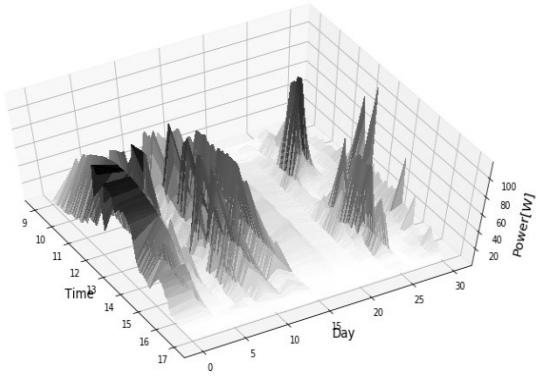

Fig. 3a

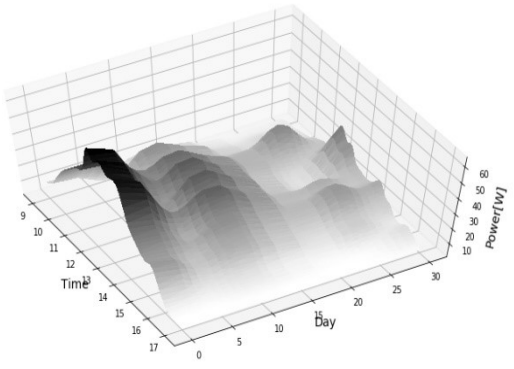

Fig. 3b

Fig. 3a: Actual power output as a function of (*Day, Time*). Fig. 3b: the expected power output from Gaussian blur filtering technique as function of $P_{cs}(Day,Time)$.

TABLE I.
ANN PARAMETER EXPERIMENT

PARAMETER				
Number of hidden node	2 lagged		5 lagged	
	RMSE	***R^2***	***RMSE***	***R^2***
3 nodes	8.50	0.84	8.50	0.84
5 nodes	**8.15**	**0.86**	8.26	0.85
7 nodes	8.07	0.86	8.16	0.86

III. Results And Discussion

The developed forecasting model was applied for a very-short time power generation forecast with the dataset in January 2014. The performance was compared against the persistence model. The proposed model can forecast power output by the composition of clear sky model with Gaussian blur and stochastic forecasting model with ANN. Fig. 4 shown the forecasted power by the proposed model produces better result than persistence model especially when stochastic factors affect the PV power generation.

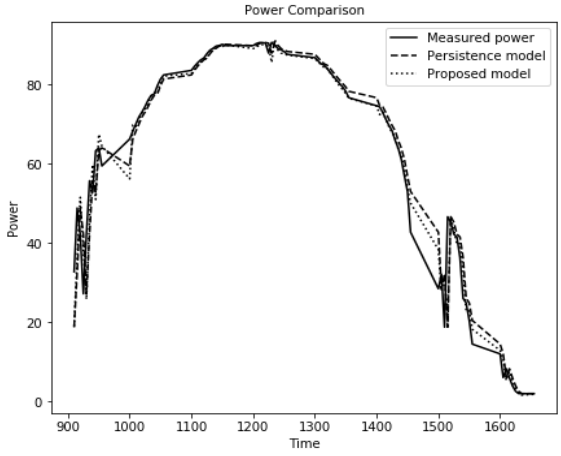

Fig. 4. Typical result in forecasted power output in Januaray 2014. Show measured power, forecasted power by the proposed model and forecasted power by persistence model.

The forecast results are shown in Table II. It can be seen that the proposed model outperforms the persistence model with $R^2 = 0.95$, while persistence model gain 0.89 and less error. The proposed model has a better performance because the model can handle stochastic factors better than persistence model, which uses the assumption that future conditions will have the same conditions as a previous measure and yield the same output. In the case of severe fluctuation of stochastic factors, the assumption of persistence model cannot perform as good as the proposed model, which aims to handle stochastic factors relate to PV power generation.

TABLE II.
PERFORMANCE EVALUATION

Model	***RMSE***	***R^2***
Persistence model	8.87	0.89
Proposed model	**7.80**	**0.95**

IV. CONCLUSION

This work proposes PV power forecasting model which considers the stochastic factors in PV power generation using only endogenous data. The model forecasts expect power under clear sky condition and affected power from stochastic factors in PV generation, then combines both calculation results to predict power output in 5 minutes' future. From the experiment, the model obtained $R^2 = 0.95$ and $RMSE = 7.80$, which outperformed the persistence model. It shown that considering stochastic factors can increase the forecasting performance compare to the method without it.

This work used normal Gaussian Blur and ANN from Python library without any special modification. In future, a suitable estimation approximation function will be investigated, and tests for other ANNs will be perform to gain a better forecasting performance.

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REFERENCES

[1] M. Rana, I. Koprinska, and V. G. Agelidis, "Forecasting solar power generated by grid connected PV systems using ensembles of neural networks," in *2015 International Joint Conference on Neural Networks (IJCNN)*, 2015, pp. 1–8.

[2] H. Wang *et al.*, "Deterministic and probabilistic forecasting of photovoltaic power based on deep convolutional neural network," *Energy Convers. Manag.*, vol. 153, pp. 409–422, Dec. 2017.

[3] S. Leva, A. Dolara, F. Grimaccia, M. Mussetta, and E. Ogliari, "Analysis and validation of 24 hours ahead neural network forecasting of photovoltaic output power," *Math. Comput. Simul.*, vol. 131, 2017.

[4] S. Pfenninger and I. Staffell, "Long-term patterns of European PV output using 30 years of validated hourly reanalysis and satellite data," *Energy*, vol. 114, pp. 1251–1265, Nov. 2016.

[5] D. P. Larson, L. Nonnenmacher, and C. F. M. Coimbra, "Day-ahead forecasting of solar power output from photovoltaic plants in the American Southwest," *Renew. Energy*, vol. 91, pp. 11–20, Jun. 2016.

[6] A. Tascikaraoglu, … B. S.-P. S., and undefined 2016, "A short-term spatio-temporal approach for Photovoltaic power forecasting," *ieeexplore.ieee.org*.

[7] S. Dutta *et al.*, "Load and Renewable Energy Forecasting for a Microgrid using Persistence Technique," *Energy Procedia*, vol. 143, pp. 617–622, Dec. 2017.

[8] S. I. Vagropoulos, G. I. Chouliaras, E. G. Kardakos, C. K. Simoglou, and A. G. Bakirtzis, "Comparison of SARIMAX, SARIMA, modified SARIMA and ANN-based models for short-term PV generation forecasting," in *2016 IEEE International Energy Conference (ENERGYCON)*, 2016, pp. 1–6.

[9] H. Zhu *et al.*, "A Power Prediction Method for Photovoltaic Power Plant Based on Wavelet Decomposition and Artificial Neural Networks," *Energies*, vol. 9, no. 1, p. 11, Dec. 2015.

[10] E. Ogliari, A. Dolara, G. Manzolini, and S. Leva, "Physical and hybrid methods comparison for the day ahead PV output power forecast," *Renew. Energy*, vol. 113, 2017.

[11] M. Kudo, A. Takeuchi, Y. Nozaki, H. Endo, and J. Sumita, "Forecasting electric power generation in a photovoltaic power system for an energy network," *Electr. Eng. Japan*, vol. 167, no. 4, pp. 16–23, Jun. 2009.

[12] M. Rana, I. Koprinska, V. Agelidis, and 2016, "Univariate and multivariate methods for very short-term solar photovoltaic power forecasting," *Elsevier*.

[13] B. Marion *et al.*, "New data set for validating PV module performance models," in *2014 IEEE 40th Photovoltaic Specialist Conference (PVSC)*, 2014, pp. 1362–1366.

[14] H. T. C. Pedro and C. F. M. Coimbra, "Assessment of forecasting techniques for solar power production with no exogenous inputs," *Sol. Energy*, vol. 86, no. 7, pp. 2017–2028, Jul. 2012.

[15] R. W. Mueller *et al.*, "Rethinking satellite-based solar irradiance modelling: The SOLIS clear-sky module," *Remote Sens. Environ.*, vol. 91, no. 2, pp. 160–174, May 2004.

[16] C. Rigollier, O. Bauer, and L. Wald, "On the clear sky model of the ESRA — European Solar Radiation Atlas — with respect to the heliosat method," *Sol. Energy*, vol. 68, no. 1, pp. 33–48, Jan. 2000.

[17] J. Antonanzas, N. Osorio, R. Escobar, R. Urraca, F. J. Martinez-de-Pison, and F. Antonanzas-Torres, "Review of photovoltaic power forecasting," *Sol. Energy*, vol. 136, pp. 78–111, Oct. 2016.

Demand response strategy for promoting distributed power consumption based on resident load participation

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***Abstract*—Firstly, this paper introduces the concept of user-side energy management system. Secondly, it establishes the output model of wind power, photovoltaic distributed power and residential load model. Subsequently, a demand response plan with the goal of maximizing distributed wind power and photovoltaic consumption is developed. Finally, the Monte Carlo method is used to simulate the user's electricity consumption behavior. The simulation results of the actual example show that the proposed scheme can effectively promote distributed power consumption, improve the load curve and realize various economic benefits.**

Keywords—energy management system; demand response; load model; load curve; economic benefits

I. INTRODUCTION

As a special form of distributed power generation, household distributed power can directly supply power to the end users of the grid, which can meet the increasing electricity demand of residents and alleviate the peak load pressure of the distribution network [1]. However, the intermittence of the distributed power output may cause or worsen the power quality problem at the end of the distribution network [2]. Demand response technology can guide users to use electricity reasonably, promote the consumption of distributed power sources, delay or avoid investment in power transmission equipment transformation, achieve balance of power supply and demand, and improve power supply capacity of distribution network.

The existing distributed power consumption in China mainly focuses on the large-scale new energy generation grid-connected technology[3], and its objective function is mostly based on economic indicators, while the research on small-scale distributed power on the residential side is few. Foreign studies are mostly based on households, mainly focusing on household power management system[4] and residents' load participation demand response[5], which is characterized by small population density and less impact on the distribution network, which is quite different from the development of domestic distributed power supply.

II. USER-SIDE ENERGY MANAGEMENT SYSTEM

As shown in Fig. 1, the user-side energy management system includes a smart socket, a two-way smart meter, a human-machine interaction interface, a mobile control terminal and a communication module, which can realize two-way interaction of information such as power flow and service flow between the user-side and the power grid,

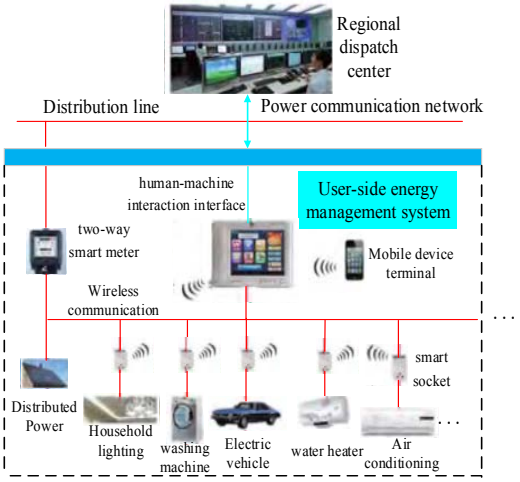

Fig. 1. Schematic diagram of household energy management system

facilitate the user's participation in power dispatching, and realize efficient and intelligent energy utilization.

III. DISTRIBUTED GENERATION OUTPUT MODEL

A. Household Distributed Photovoltaic Output Model

The gateway metering device and the power generation metering device are installed at the grid connection point, which can effectively measure the photovoltaic output power, the user power consumption and the photovoltaic grid-connected power. The output power of photovoltaic power generation varies with light intensity, ambient temperature, etc., and its output model is:

$$P_{\mathrm{PV}}^{t} = \eta_{\mathrm{PV}} n_{\mathrm{PV}} S_{\mathrm{PV}} K_{\mathrm{PV}} \left[1 - 0.005\left(\theta_{out}^{t} - 25\right)\right] \quad (1)$$

In the formula, P_{PV}^{t} is the photovoltaic output power, η_{PV} is the photoelectric conversion efficiency of the photovoltaic device, n_{PV} is the number of photovoltaic panels, S_{PV} is the area of photovoltaic panels, K_{PV} is the intensity of solar radiation, θ_{out}^{t} is the outdoor temperature.

B. Wind power output model

The output power of the wind power generator mainly depends on the wind speed and changes with the wind speed. The mathematical relationship between the output power P_w and the wind speed v is as follows:

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$$P_{\mathrm{w}}=\begin{cases}\frac{v-v_{ci}}{v_{cr}-v_{ci}}P_r & v_{ci}\le v\le v_{cr}\\ P_r & v_{cr}\le v\le v_{co}\\ 0 & v<v_{ci};\ \ v>v_{co}\end{cases} \tag{2}$$

In the formula, v_{ci}, v_{cr} and v_{co} are respectively the cut-in wind speed, rated wind speed and cut-out wind speed of the wind turbine. P_r is the rated power of the wind turbine.

IV. Resident Load Demand Response Characteristics

A. Resident Total Load Model

Starting from the time series of residents' load, considering the user's behavior habits, the load state matrix S is proposed. The matrix elements are composed of the electricity usage probability of the resident load, and the actual electricity consumption of the residents obeys the secondary distribution of S. Different types of load characteristics are combined into a mathematical model of the total load of electricity consumption.

$$S=\begin{bmatrix}S_{11} & S_{12} & \cdots & S_{1T}\\ S_{21} & S_{22} & \cdots & S_{2T}\\ \vdots & \vdots & & \vdots\\ S_{n1} & S_{n2} & \cdots & S_{nT}\end{bmatrix} \tag{3}$$

$$P_e=\begin{bmatrix}P_{1e} & & & \\ & P_{2e} & & \\ & & \ddots & \\ & & & P_{ne}\end{bmatrix} \tag{4}$$

$$P=P_eS=\begin{bmatrix}P_{11} & P_{12} & \cdots & P_{1T}\\ P_{21} & P_{22} & \cdots & P_{2T}\\ \vdots & \vdots & & \vdots\\ P_{n1} & P_{n2} & \cdots & P_{nT}\end{bmatrix} \tag{5}$$

$$P(t)=\sum_{i=1}^{n}P_{it} \tag{6}$$

In the formula, n is the number of types of electrical load, S_{it} indicates the electricity consumption probability for the i-th power load during the t-th period, P_{ie} represents the rated power of the i-th load, P_{it} indicates the Electric power consumption for the i-th power load during the t-th period, T represents the number of periods in the statistical period, $P(t)$ is the total load of residents in t period.

B. Load Transfer Model

The demand response to promote distributed power consumption is realized through the transfer of residents' load. The demand response transfer load $Pin(t)$ at time t consists of two parts, namely, the load transferred from the previous period to the t period and the load transferred from the t period to the equipment. The equation is expressed as follows:

$$P_{in}(t)=\sum_{k=1}^{N_{DR}}x_{kt}P_{1k}+\sum_{l=1}^{j-1}\sum_{k=1}^{N_{DR}}x_{k(t-l)}P_{(1+l)k} \tag{7}$$

In the formula, N_{DR} is the number of load categories involved in the transfer interaction, x_{kt} is the number of devices that the kth class device starts to run at time t, P_{1k} is the load power value of the k-type equipment during the first working period, $P_{(1+l)k}$ is the load power value of k-type equipment in the $1+l$ working period, j is the maximum value of equipment operation duration, k is the type of load involved in the transfer interaction, $0<k<N_{DR}$.

Similar to the transfer load, The demand response transfer load $Pout(t)$ at time t also consists of two parts, namely, the roll-out load amount caused by the roll-out equipment at the previous moment and the reduced load amount of the roll-out equipment at the T moment. The equation is expressed as follows:

$$P_{out}(t)=\sum_{k=1}^{N_{DR}}y_{kt}P_{1k}+\sum_{l=1}^{j-1}\sum_{k=1}^{N_{DR}}y_{k(t-l)}P_{(1+l)k} \tag{8}$$

In the formula, y_{kt} is the transfer-out quantity of the k-type equipment that starts to operate in the t-th period. The $P_{DR}(t)$ expression of the resident load curve after considering the demand response interaction is as follows, where $P(t)$ is the load curve expression before the demand response:

$$P_{DR}(t)=P(t)+P_{in}(t)-P_{out}(t) \tag{9}$$

V. Resident Demand Response Strategy for Residential Load to Promote Distributed Power Consumption

A. Demand response model for residential load to promote distributed power consumption

1) Maximize the goal of distributed power consumption

$Z(t)$ is defined as the output of the distributed power supply which is injected into the grid in reverse in t-period. If the total $Z(t)$ of each period is minimized, the maximum absorption of the distributed power supply is achieved. The objective function of maximizing the consumption of distributed generation is as follows:

$$\min\sum_{t=1}^{T}Z(t) \tag{10}$$

$$Z(t)=\begin{cases}0; & P_{DG}(t)<P_{DR}(t)\\ P_{DG}(t)-P_{DR}(t); & P_{DG}(t)>P_{DR}(t)\end{cases} \tag{11}$$

In the formula, $P_{DG}(t)$ is the distributed power output power of t period, which satisfies equation (9).

2) Constraints

a) Load balance

$$P_{grid}(t)=P(t)-P_{DG}(t) \tag{12}$$

b) Load peak

$$P_{\min}<P_{DR}<P_{\max} \tag{13}$$

In the formula, P_{max} is the upper limit of load, P_{min} is the lower load limit.

c) Transfer load

In this strategy, the load transfer amount is set according to the residents' living plan, and the total transfer load PST that meets the users' wishes is:

$$P_{ST} = \sum_{i=1}^{I}\sum_{k=1}^{K} P_{ik} \tag{14}$$

In the formula, I is the number of resident users participating in the interaction, K represents the number of devices that each resident has set up to participate in the interaction, P_{ik} is the load of the electrical equipment. Where P_{ST} satisfies the following inequality $P_{out} < P_{ST}$:

$$P_{out} = \sum_{i=1}^{T} P_{out}(t) \tag{15}$$

The above formula is an interactive model based on the objective function of distributed power consumption maximization under constraint conditions.

B. Demand response strategy

The specific steps of demand response strategy for resident load participation in day ahead scheduling are shown in Fig. 2.

VI. CASE ANALYSIS

A. Description of the case

The study uses a residential area as an example to simulate distributed energy consumption. There are 100 residents in the residential area. The general travel rule of electric vehicles is to go to work during the day and charge after work at about 18:00. Table I shows the household load parameters and usage of residents. The number of photovoltaic panels installed in the community is 400, and the total capacity is 400kW. There are 20 wind turbines in the community. The total capacity of the wind power system is 200kW. The cut-in wind speed, cut-out wind speed and rated wind speed are: 3m/s, 25m/s and 12m/s. Example Simulation

1) Residential electricity simulation

This paper uses the load state probability matrix S to characterize its statistical characteristics. According to the load state probability matrix S, the Monte Carlo simulation method is used to generate the power load data of 100 users for simulation.

Fig. 3 shows the total load of the community and the total output of the distributed power supply. The peak value of the residential electricity load curve is 20:00 point 822.3kW, and the maximum peak output power of the distributed power supply is 15:00 points 548.4kW. As can be seen from the figure, when the interaction is not implemented, the distributed power supply of the new energy community will have a certain negative impact on the network, which may cause certain negative impacts on the grid.The maximum distributed power output occurs around 15:00 in the afternoon. The maximum electricity load of residents is about 20:00. At 18:00-23:00 in the evening, the

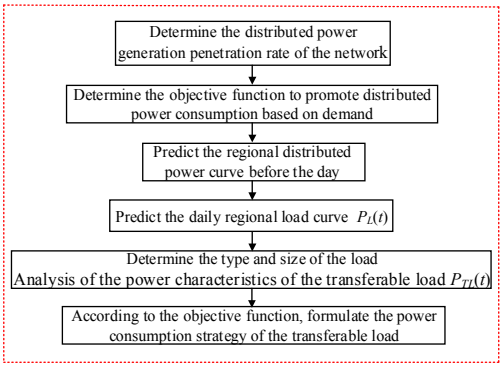

Fig. 2. Demand response strategy for resident load participation in day ahead scheduling

TABLE I. HOUSEHOLD LOAD PARAMETERS AND USAGE OF RESIDENTS

Electrical equipment	Period of use	Average power /kW
Air conditioner	00:00-24:00	2.5
Washer	19:00-21:00	2
Dishwasher	11:00-12:00	1.8
	18:00-19:00	1.8
Dryer	21:00-23:00	2
Heater	00:00-24:00	3
electric vehicle	18:00-23:00	5
Rice cooker	11:00-12:00	0.7
	18:00-19:00	0.7
Television、lighting	00:00-24:00	2

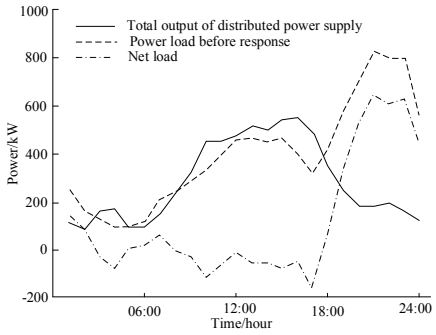

Fig. 3. Total load of district and total output curve of distributed generation

electricity load is far greater than the distributed power output load, which forms a large peak load of 642.8kW.

2) Resident load participation demand response simulation

Because the washing machine and dryer use electricity flexibly, at the same time electric vehicles that do not travel can be transferred to daytime charging. Therefore, we consider the interaction between washing machine and electric vehicle. Simulation is carried out according to different scenarios. The scene is set as follows:

Scene 1: The load of the washing and drying machine participates in the interaction. Assume that 60% of the washing machine and dryer can participate in day-ahead scheduling; Scene 2: The washing machine and electric vehicle load participate in the interaction. Suppose that 20% of the electric vehicles have different travel rules and

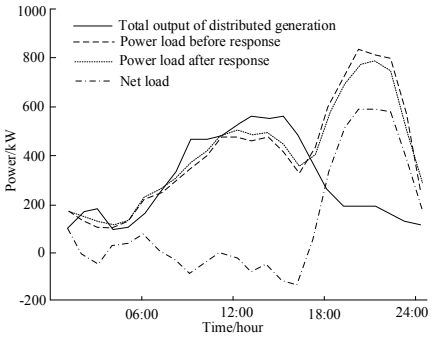

Fig. 4. Load curve after scene one response

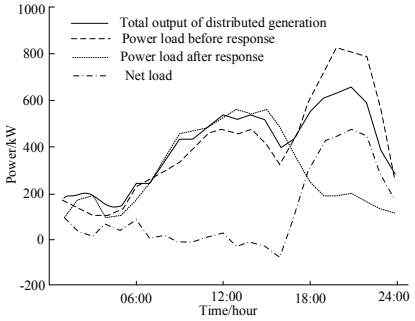

Fig. 5. Load curve after scene two response

can be charged during the day and participate in the day ahead scheduling.

The simulation results of resident load electricity in scenario 1 are shown in Fig. 4. After the washing and drying machine participates in the day-ahead dispatch, the power transfer of different users' washing and drying machines is also different. Some changes have taken place in the net user load, with a minimum of - 138.3 kW at 16:00, and a net load of less than 0 kW between 7:00 a.m. and 16:00 p.m. and between 2:00 a.m. and 3:00 a.m., during which the reverse power fluctuation of the user is small.

The simulation results of scene 2 residential load power consumption are shown in Fig. 5.As shown in Fig. 5, according to the simulation results and the original data comparison, the daytime net load curve changes have changed significantly, the user side distributed power consumption significantly increased, the minimum net load occurred at around 16:00, for -88.1kW. The time interval of less than 0kW for a net load is about 7 hours and is shortened. Distributed power network power fluctuation is more gradual.

Comparing the maximum and minimum net load and corresponding time under three different conditions: no day-ahead dispatching, washing and drying machine participating in day-ahead dispatching, washing and drying machine and electric vehicle jointly participating in day-ahead dispatching, the results are shown in Table II. The maximum net load of residential users decreases after the load participates in the interaction of distributed generation, the corresponding time is delayed for a period of time. After the optimal load dispatch, the increased power consumption of distributed generation is 221.4 kWh and 517.9 kWh, and the utilization ratio of distributed generation is increased by 25.1% and 58.7% respectively. In summary, without affecting the normal life of residents, the capacity of distributed generation absorption has been significantly improved after the implementation of demand response.

3) User Benefit Analysis

The motive force for users to participate in the response is economic efficiency, which can improve users' enthusiasm to participate in the interaction through electricity price and subsidy policies. Set the TOU price as: Peak period 12:00-15:00, 18:00-22:00, 0.59yuan/kWh; Normal times 6:00-12:00, 15:00-18:00, 22:00-24:00, 0.46yuan/kWh; Valley period 0:00- 6:00, 0.31yuan/kWh. Distributed power supply network price is 0.18yuan/kWh, and subsidy price is 0.2yuan/kWh.

TABLE II. COMPARISON OF NET LOAD ANALYSIS

Scene	Minimum net load /kW	Time	Maximum net load /kW	Time
No response	-165.2	16:00	642.7	20:00
Scene one	-138.3	16:00	579.4	21:00
Scene two	-88.1	16:00	547.5	21:00

TABLE III. DAILY ELECTRICITY EXPENSES OF RESIDENTIAL AREAS

Scene	Regardless of government subsidies /yuan	Consider government subsidies /yuan
Before interaction	2759.28	1562.80
Scene one	2630.92	1427.58
Scene two	2490.87	1147.19

Table III shows the daily electricity expenditure in different scenarios of the residential area based on TOU price without consideration of subsidies and subsidies. It can be seen that under the simultaneous action of TOU price and subsidy policy, more electricity costs will be reduced for users. At the same time, the grid price of distributed generation is lower than the TOU price, which is conducive to the promotion and implementation of demand response strategy.

VII. CONCLUSION

This paper proposes a demand response strategy to promote distributed power consumption in smart campuses. The strategy fully considers the user's electricity habits and willingness, establishes the resident power state probability model, analyzes the load demand response characteristics, and proposes a demand response scheme aiming at maximizing distributed power consumption. It is verified by examples and simulations that the two types of load transfer modes can effectively improve the ability of distributed power consumption. When the multiple loads participate in the scheduling, the capacity of the distributed power consumption is significantly improved. Finally, an example is used to analyze the benefits of user participation interaction, which shows the demand response based on TOU electricity price and policy subsidy, which reduces the user's energy consumption cost and helps to promote the implementation of demand response strategy.

REFERENCES

[1] Xiao. H, Pei. W, Kong. L, “Decision analysis and economic benefit evaluation of microgrid output considering photovoltaic power surplus,”Power System Automation, 2014, 38(10): 10-16.

[2] You. Y, Liu. D, Zhong. Q, “Distributed power coordination control based on active distribution network on multiple time scales,” Power System Automation, 2014, 38(9): 192-198.

[3] Wang. P, Liu. X, Li Y, “Research on daily scheduling and operation simulation of large capacity wind power access system considering user side interaction,” Proceedings of the CSEE, 2013,33(22): 35-44.

[4] BYUN J, HONG I, PARKS.,“Intelligent cloud home energy management system using household appliance priority based scheduling based on prediction of renewable energy capability,” IEEE Trans on Consumer Elevtronics,2012,58(4):1194-1201.

[5] ALIZADEH M, CHANG T H, SCAGLIONE A. “Grid integration of distributed renewables through coordinated demand response,” 51st IEEE Conference on Decision and Control, December 10-13, 2012, USA:3666-3671.

[6] AITA Yoshitaka,OBARA Shin'ya. Dynamic characteristics of a small-scale distributed power network with integrated gasification combined cycle. The Proceedings of Conference of Hokkaido Branch,2016,2016.54(0).

[7] M. S. Rahman,M. A. Mahmud,H. R. Pota,M. J. Hossain,T. F. Orchi. Distributed Multi-Agent-Based Protection Scheme for Transient Stability Enhancement in Power Systems. International Journal of Emerging Electric Power Systems,2015,16(2).

[8] Michał Zeńczak. Method of estimating the exposure of the natural environment to 50 Hz electric and magnetic fields in power systems with distributed and centralized generations. Archives of Electrical Engineering,2016,65(2).

[9] G. Benysek,M. Jarnut,SZ. Werminski,J. Bojarski. Distributed active demand response system for peak power reduction through load shifting. Bulletin of the Polish Academy of Sciences Technical Sciences,2016,64(4).

[10] C. N. Bhende,A. Kalam,S. G. Malla. Mitigation of Power Quality Problems in Grid-Interactive Distributed Generation System. International Journal of Emerging Electric Power Systems,2016,17(2).

Stochastic Optimal Power Flow of Integrated Power and Gas Energy System Considering Carbon Trading Mechanism

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***Abstract*—Under the background of energy internet and low-carbon power, integrated energy system has become an important carrier of energy saving and emission reduction, among which the connection between the electric power systems and the natural-gas systems is the closest. Aiming at the stochastic optimal power flow of the integrated power and gas energy system, the carbon trading mechanism is introduced into consideration of various randomness factors. A chance-constrained programming model considering carbon trading mechanism is established. Minimizing the sum of integrated energy system generation energy costs and carbon trading costs becomes the objective function of the model. A heuristic algorithm is used to solve the problem. An example is given, whose operation states under different confidence levels are analyzed and the operating states of two models considering carbon trade are compared. It is verified that the proposed model is effective in improving the safety, low carbon and economy of the integrated power and gas energy system.**

Keywords—carbon trading mechanism; integrated power; Gas Energy System; power flow

I. INTRODUCTION

Since the development of human society, the energy utilization mode with fossil fuel combustion as the main form has made environmental problems increasingly prominent and low carbon has become an inevitable trend of energy utilization. In recent years, with the rapid development of natural gas power generation and the construction of low-carbon sustainable energy systems, the integrated power and gas energy system has gradually attracted widespread attention from experts and scholars at home and abroad.

The optimal power flow is the basis of economic dispatching, planning and operation, reliability analysis and other issues of the integrated power and gas energy system. The optimal power flow problem of gas turbine and electro rotating coupled power system is studied[1-2]. There are many stochastic factors in the integrated power and gas energy system. According to these factors, a chance-constrained programming model is established and the optimal power flow problem is studied[3]. However, none of the above documents fully takes into account the additional environmental costs in the process of energy production.

In this paper, the chance-constrained programming model is used to study the optimal power flow problem. In view of the environmental cost problem, the carbon trading mechanism is introduced and the chance-constrained programming model considering the carbon trading mechanism is established.

II. INTEGRATED POWER AND GAS ENERGY SYSTEM

The integrated power and gas energy system is composed of natural gas system, power system and coupling components, which realizes the conversion of different energy forms and complementary advantages, improves the stability and reliability of energy utilization. The natural gas system is mainly composed of pipelines, pressure stations, connection nodes and other basic components. For the ideal adiabatic gas pipeline k, the first and last node points are m and n, its steady-state flow rate $f_{k,mn}$ can be expressed as:

$$f_{k,mn} = S_{mn} c_{mn} \sqrt{S_{mn}\left(\pi_m^2 - \pi_n^2\right)} \tag{1}$$

$$S_{mn} = \begin{cases} 1 & \pi_m \geq \pi_n \\ -1 & \pi_m \leq \pi_n \end{cases} \tag{2}$$

where, $f_{k,mn}$ is the natural gas flow from the first node m to the last node n in the natural gas pipeline k. c_{mn} is a constant related to pipe efficiency, temperature, length, inner diameter, compression factor, etc. π_m and π_n are the pressure values of the nodes m and n, respectively. S_{mn} indicates the direction of pipeline flow, S_{mn}=1 corresponds to positive direction and S_{mn}=-1 to opposite direction.

In order to reliably transmit natural gas and compensate for the pressure loss downstream of the natural gas network caused by friction, a certain number of pressurized stations are needed in the natural gas network. The most important part of the pressure station is the compressor which increases the natural gas pressure.

Similar to the node power balance in the power system, the node flow balance equation in the natural gas system can be listed according to the law of conservation of flow, expressed in the form of a matrix:

$$\left(A+U\right) f + w - T\tau = 0 \tag{3}$$

Among them, A is the node-pipeline correlation matrix, U is the node-compressor correlation matrix, T is the node-compressor energy consumption correlation matrix, f is the pipeline and through the compressor flow vector, τ is the compressor consumption flow vector, w is the node net injection natural gas flow vector, for the gas source point injection flow, load flow, combustion. Algebraic sum of consumption flow of gas turbines.

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There are many kinds of coupling elements between natural gas system and power system. The coupling relationship of gas turbines can be expressed as follows:

$$\varphi\left(P_{GT,i}\right)=K_{2i}P_{GT,i}^{2}+K_{1i}P_{GT,i}+K_{0i} \tag{4}$$

Among them, $\varphi(P_{GT,i})$ is the flow rate of natural gas consumed by gas turbine i, $P_{GT,i}$ is the active power output of gas turbine i and K_{2i}, K_{1i} *and* K_{0i} are the consumption coefficient of gas turbine i.

III. CHANCE-CONSTRAINED PROGRAMMING MODEL UNDER CARBON TRADING MECHANISM

The chance-constrained programming model takes into account the economic efficiency while dealing with the stochastic factors of the integrated power and gas energy system and ensuring the safe operation of the system. In addition, the investment in carbon trading mechanism fully mobilizes the enthusiasm of power generation enterprises in energy conservation and emission reduction.

A. Objective function

$$\begin{aligned}\min\left(F_1+F_2\right)=\min\sum_{i\in\Omega_{GF}}\left(a_iP_{GF,i}^{2}+b_iP_{GF,i}+c_i\right)+\\ \sum_{j\in\Omega_g}C_{g,j}w_{g,j}+P_{co_2}\left(E-D\right)\end{aligned} \tag{5}$$

Among them, F_1 is the operating cost of the system, Ω_{GF} is the set of thermal power units. a_i, b_i and c_i are the parameter of the consumption characteristic curve of thermal power unit i. $P_{GF,i}$ is the active power output of thermal power unit i, Ω_g is the set of gas source points. $C_{g,j}$ is the cost coefficients of j for natural gas supply, $w_{g,j}$ provides natural gas flow for j at the gas source point, P_{CO2} is the the price of carbon trading, E is the carbon emission of generator and D is the amount of carbon emissions allocated to the generator set.

B. Constraint condition

Constraint conditions are divided into expectation constraints and opportunity constraints. Among them, the expected value constraints include power grid generator output constraint, node voltage constraint, line power constraint, natural gas network gas source point natural gas supply constraint, node pressure constraint and compressor compression ratio constraint, which are expressed as follows:

$$\begin{cases}P_{G\min,i}\le P_{G,i}\le P_{G\max,i}\\ Q_{G\min,i}\le Q_{G,i}\le Q_{G\max,i}\\ V_{\min,i}^{2}\le e_i^{2}+f_i^{2}\le V_{\max,i}^{2}\\ P_{1\min}\le P_1\le P_{1\max}\\ w_{g\min,i}\le w_{g,i}\le w_{g\max,i}\\ \pi_{\min,m}\le\pi_{\mathrm{m}}\le\pi_{\max,m}\\ R_{\min,k}\le\dfrac{\pi_n}{\pi_m}\le R_{\max,k}\end{cases} \tag{6}$$

In the form: $P_{Gmax,I}$, $P_{Gmin,I}$, $Q_{Gmax,I}$, $Q_{Gmin,i}$ and $Q_{Gmin,i}$ are the upper and lower limits of the active output of the generator i and the upper and lower limits of the reactive output, respectively. $Vmax,i$ and $Vmin,i$ are the upper and lower limits of voltage amplitude of node i, respectively. P_1 is line power, P_{1max} and P_{1min} are the upper and lower limits of line power, respectively. $w_{gmax,i}$ and $w_{gmin,i}$ are the upper and lower limits of gas supply point i gas supply, respectively. $\pi_{max,m}$ and $\pi_{min,m}$ are upper and lower limits of nodal m pressure, respectively. $R_{max,k}$ and $R_{min,k}$ are the upper and lower limits of the compressor k compression ratio, respectively.

The nodal voltage of power system and the nodal pressure of natural gas system are changed into chance constraints, which can be expressed as follows:

$$\begin{cases}p_r\left\{V_i\le V_{i,\max}\right\}\ge P_{V,\max}\\ p_r\left\{V_i\ge V_{i,\min}\right\}\ge P_{V,\min}\\ p_r\left\{\pi_j\le\pi_{j,\max}\right\}\ge P_{\pi,\max}\\ p_r\left\{\pi_j\ge\pi_{j,\min}\right\}\ge P_{\pi,\min}\end{cases} \tag{7}$$

Among them, $p_r\{\cdot\}$ is the probability of chance constraint $\{\cdot\}$, V_i is the voltage of node i, $V_{i,max}$ and $V_{i,min}$ are the upper and lower limits of the node i voltage, respectively. $P_{V,max}$ and $P_{V,min}$ are the confidence levels of upper and lower limit constraints of voltage, respectively. The upper and lower limits of the j pressure of the node are the $\pi_{j,max}$ and $\pi_{j,min}$, respectively. $P_{\pi,max}$, $P_{\pi,min}$ are the confidence levels of the upper and lower limits of the pressure, respectively.

C. Random factors

This paper mainly considers the randomness of wind power output, power load and natural gas load. The probability density functions are expressed as:

Among them, $f(\cdot)$ is probability density function, v is wind speed, K is shape parameter, c is scale parameter, E_L is power load/natural gas load. u_{E_L} and σ_{E_L} are the expected value and standard deviation of electric / natural gas load, respectively.

$$f\left(v\right)=\frac{K}{c}\left(\frac{v}{c}\right)^{K-1}\exp\left[-\left(\frac{v}{c}\right)^{K}\right] \tag{8}$$

$$f\left(E_L\right)=\frac{1}{\sqrt{2\pi}\sigma_{E_L}}\exp\left[-\frac{\left(E_L-\mu_{E_L}\right)^{2}}{2\sigma_{E_L}^{2}}\right] \tag{9}$$

IV. HEURISTIC ADJUSTMENT ALGORITHM

A. Semi-invariant

Semi-invariant is a kind of numerical characteristic of random variable, which can be obtained from the moment of random variable not higher than the corresponding order.

1) Semi-invariant of power load and natural gas load.

The power load and natural gas load in the Electricity-Gas interconnected integrated energy system obey normal distribution. The central moments of each order can be expressed as follows:

$$M_v = \begin{cases} \sigma_{E_L}^v (v-1)v \\ 0 \qquad v \end{cases} \tag{10}$$

Among them, M_v is the v order central moment of the electrical load/natural gas load. Represents double factorial.

According to the relation between each order semi-invariant and central moment given in [4-5], $k_1 = u_{E_L}$ is an electric load/natural gas load first-order semi-invariant and $k_2 = \sigma_{E_L}$ is a second order semi-invariant, the rest of the semiinvariants are all 0.

2) The semi-invariant of wind power output.

First, N samples of that are obtained from Monte Carlo sampling technique according to the distribution function, then calculate the moment of origin X_v of each order:

$$x_v = \frac{1}{N}\sum_{i=1}^{N} x_{si}^v \quad v = 1, 2, \cdots \tag{11}$$

Then the semi-invariant k_v of each order is obtained by the relationship between the semi-invariants of the orders and the origin moments:

$$\begin{cases} k_1 = x_1 \\ k_{v+1} = x_{v+1} - \sum_{j=1}^{v} C_v^j \chi_j k_{v-j+1} \end{cases} \tag{12}$$

Where, C^j_v is the number of combinations of j elements from v different elements and X_j is the moment of origin of j order.

B. Heuristic algorithm

In this paper, a heuristic algorithm based on semi-invariant method and interior point method is adopted to transform the opportunity constraint into an equivalent deterministic constraint and the iterative solution is conducted. The specific steps are as follows:

Without considering the volatility, the expected value of the random variable is substituted into the model to form the deterministic optimal power flow model. The internal point method is used to solve the problem and the system benchmark operating point is obtained. In this paper, the solution of the random optimal power flow is assumed to be near the benchmark operating point.

The semi-invariant method and Cornish-Fisher series method are used to calculate the probability flow at the base running point and obtain the positional function of the output random variable.

The quantiles of the output random variables at the confidence level of the chance constraints are compared with the boundaries of the variables. If the constraints are violated, the computational boundaries of the variables are adjusted, the deterministic optimal power flow is re-solved and the reference point is updated. The strategy of boundary adjustment is as follows：

If $Z(P_{x,max})>x_{i,max}$, adjust the upper limit of the output random variable x_i:

$$\overline{x_i} = \overline{x_i} \cdot \max\left\{1 - \frac{Z\left(P_{x,\max}\right) - \overline{x_i}}{\overline{x_i}}, 1-\alpha\right\} \tag{13}$$

If $Z(1\text{-}P_{x,min})<x_{i,min}$, adjust the lower limit of the output random variable x_i:

$$\underline{x_i} = \underline{x_i} \cdot \min\left\{1 + \frac{\underline{x_i} - Z(P_{x,\min})}{\underline{x_i}}, 1+\alpha\right\} \tag{14}$$

Among them, x_i is the output random variable, that is, the node voltage of the power system or the node pressure of the natural gas system. $\overline{x_i}$, x_i are the upper and lower limits of the calculation of output random variables and the initial value is the actual and lower limits. α is the adjustment parameter. In order to prevent the unreasonable adjustment of the upper and lower limits of the random variable, it may take 1% to 5%.

The probability density function of the output random variable is obtained by repeating the above process until there is no constraint violation.

V. CASE STUDY

A. Example Description

In this paper, an example is given in reference [6]. The modified IEEE 30-node power system and Belgium 20-node natural gas system are coupled by a gas turbine group in this paper. Then, this paper builds an integrated power and gas energy system. This paper expands the load by 40%, sets G_1 and G_2 as gas turbines, connected to natural gas network nodes 4 and 12, respectively. Power system node 28 connects to wind farm with rated power of 20 MW, the tangent wind speed, rated wind speed, cut-out wind speed are 2 m/s, 10 m/s, 20 m/s.

B. Security Analysis

This paper calculates the probability density curve between the voltage of the power system node 12 and the pressure of the natural gas network node 16 when the confidence level is 80% and 90%, respectively, compares with deterministic optimal power flow results. The probability density curves of node voltage and pressure are shown in Fig. 1 and Fig. 2, respectively.

Fig. 1 and Fig. 2 show that the voltage of node 12 is 1.038 p.u., reached its upper limit. The pressure of natural gas system node 16 is 4.582 MPa, which is close to its lower limit. When the system is disturbed, the node voltage and pressure will exceed the limit. The chance-constrained programming model can reduce the threshold risk of node voltage and pressure significantly and the higher the level of confidence, the greater the distance between the expected value and the limit, which limits the range of fluctuations, so its volatility is reduced. It can be seen that the proposed model is helpful to improve the security of the system.

In order to further analyze the impact of confidence level on the safe and stable operation of the system. The operating cost of the system, the number of iterations of heuristic algorithm and the computing time of the heuristic are compared under different confidence levels. The results are shown in table 1.

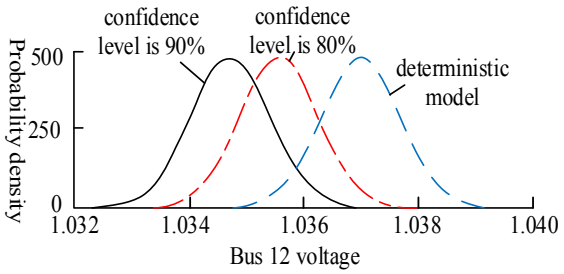

Fig. 1. Fig.1 Probability density curves of Node 12 voltage

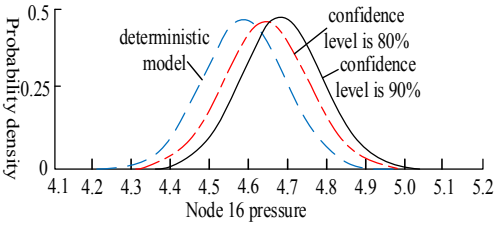

Fig. 2. Fig.2 Probability density curves of Node 16 pressure

TABLE I COMPARISION OF CALCULATIVE RESULTS UNDER DIFFERENT CONFIDENCE LEVELS

Confidence level/%	Operating costs/$	Number of iterations	Calculating time/s
Deterministic model	343 870.593 2	—	0.295
86	343 874.329 7	4	1.306
92	343 875.569 8	6	1.866
98	343 876.215 6	7	2.193

Table I reveals that the higher the level of confidence, the higher the operating cost of the system. In addition, the higher the level of confidence, the more the number of iterations of the heuristic algorithm and the more difficult convergence.

C. *Economic Analysis*

In order to illustrate the validity and superiority of the chance-constrained programming model considering carbon trading mechanism, this paper studies two models. The model 1 only studies the low-carbon economic model of the power system of a simple thermal power unit considering carbon trading mechanism. Model 2 is the model proposed in this paper. We assume the price of carbon trading is $42, the two models mentioned above are calculated. The two models' system operation cost and carbon emissions results are shown in Table II. The output of the generator is compared as shown in Fig. 4.

Table II reveals that the generator of model 1 are thermal power units, whose carbon emission intensity is 1.2t/(MW·h). It produces higher carbon emissions is 297.35t. Because of the low price of coal, the cost of energy consumption is also very low. The assigned amount of carbon emissions per unit of active contribution is 0.798t/(MW·h), which is less than the carbon emission intensity of thermal power units. Therefore, we have to go to the carbon trading market to purchase excess carbon emissions, so that the carbon transaction cost becomes the main cost of power generation accounting for 82.76% of the total cost. The carbon emissions of Model 2 is limited to 212.90t, which is a 28.40% reduction. So we know the carbon trading mechanism will bring huge economic benefits to power generation enterprises.

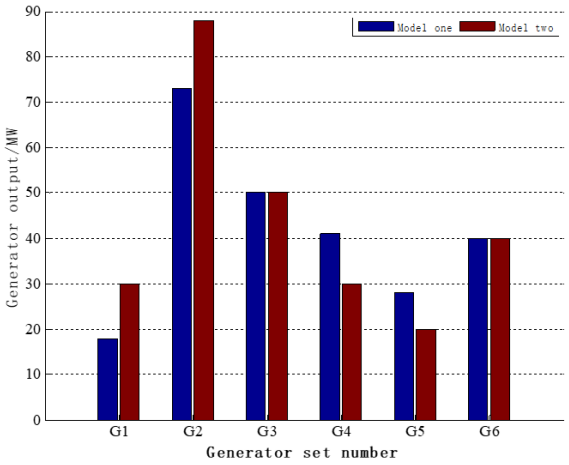

Fig. 3. Fig.3 Comparison of generators output under different models

TABLE II SYSTEM OPERATION COST AND CARBON EMISSION COMPARISON UNDER DIFFERENT MODELS

Model	Carbon emission/t	Energy cost/$	Carbon trading cost/$	Total cost of power generation/$
one	297.35	874.72	4198.70	5370.77
two	212.90	4120.98	597.08	4930.96

Fig. 3 reveals that the output of model 2 generators' G1 and G2 is higher than model 1, the output of generators' G3 and G4 is lower than model 1, which is belong to thermal power units. This is due to the higher intensity of model 1's carbon emissions and the carbon emission intensity of model 2 is lower than thermal power units. It can also generate carbon revenue. Therefore, the output of the generators set is transferred to the gas turbine units with less carbon emission.

VI. CONCLUSION

In this paper, carbon trading mechanism is introduced to solve the problem of stochastic optimal power flow in integrated power and gas energy system and proposes a chance-constrained model considering carbon trading mechanism. The conclusions are as follows:

Aiming at a number of random factors for integrated power and gas energy system, this paper studies the optimal power flow problem by using the chance-constrained model. It is verified that the proposed model can improve the security of the system.

This paper analyzes and compares the carbon emissions and system power generation cost of the low carbon economic model between the integrated power and gas energy system and the power system of pure thermal power unit. The integrated power and gas energy system considering the natural gas network can not only reduce carbon emissions, but also reduce the generation cost of the system when the price of carbon trading is appropriate. It shows its superiority and has a good development prospect.

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REFERENCES

[1] Z. P.; Lee, S.;"Probabilistic load flow computation using the method of combined cumulants and Gram-Charlier expansion," IEEE Trans. P. Sys, 2004, pp.676-682.

[2] D. Lin. S. Liang. C. Hou He, "Multi-index evaluation of integrated energy system with P2G planning," Elec. P. Auto. Equip, 2017, pp.110-116.

[3] Z. Si De. H. W. Zhi Nong. S. Guo Qiang. Z. Hai Xiang. C. Sheng,"Stochastic optimal power flow of integrated energy system based on chance-constrained programming , " Elec. P. Auto. Equip, September 2018.

[4] Zhang. L, Zhou. C, Ma. M, Solving multi-Objective optimization problem based on particle swarm algorithm, Computer Research and Development: 2004, 41(7), pp.1286-1291..

[5] F. Hong. Z. Yi. J. Yi Xiong, "Study on electric power stochastic power flow model and method ," J. S H. Unive. Elec. P, 2012, pp.313-316.

[6] WEI Zhinong,ZHANG Side,SUN Guoqing.Carbon trading based low-carbon economic operation for integrated electricity and natural gas energy system.Automation of Electric Power Systems,2016,40(15):9-16.

[7] Cajethan M. Nwosu,Stephen E. Oti,Cosmas U. Ogbuka. Transient and steady state performance analysis of power flow control in a DFIG variable speed wind turbine[J]. Journal of Electrical Engineering,2017,68(1).

[8] Alireza Ahmadimanesh,Mohsen Kalantar. Topological based active and reactive power losses allocation method in both pool and bilateral-based electricity markets using power flow[J]. International Journal of Emerging Electric Power Systems,2017,18(2).

[9] S. Surender Reddy,P.R Bijwe. Multi-Objective Optimal Power Flow Using Efficient Evolutionary Algorithm[J]. International Journal of Emerging Electric Power Systems,2017,18(2).

[10] Jia Cao,Zheng Yan,Guangyu He. Application of Multi-Objective Human Learning Optimization Method to Solve AC/DC Multi-Objective Optimal Power Flow Problem[J]. International Journal of Emerging Electric Power Systems,2016,17(3).

Research on distributed Power supply Operation Strategy based on improved BBO-PSO algorithm considering demand response

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***Abstract*—Aiming the problem of ditributed energy resources and demand response coordinated planning, set up a comprehensive coordinated planning model that considers system-side economics and demand response.Using the Biogeographic-Based Optimization (BBO) and particle swarm optimization (PSO) to improve the fusion algorithm to solve the IEEE33 node example. The user's income is the biggest and the system fluctuation is stabilized, The price response and the demand response of the incentive are coordinated. The results show that the planning model considering the demand response improves the economics of the distributed power distribution network planning..**

Keywords—distributed power; demand response; particle swarm optimization; Biogeographic-Based Optimization

I. INTRODUCTION

With the development of battery energy storage technology and technology economy, The equivalent lifetime of lithium-ion batteries and lead-carbon batteries is lower than the peak and valley price difference. It provides market environment and application conditions for battery energy storage to participate in system regulation. Battery energy storage technology has attracted wide attention due to its convenient installation and flexible configuration and has been applied in different scenarios such as demand response and microgrid, large wind / optical storage power station [4-7]. In this paper, the coordination of energy storage battery and load, the coordination of multi-point energy storage battery, the coordination optimization of distributed power supply under demand response is studied .The corresponding optimization model and solution are put forward.

II. REGULATION AND RESPONSE CHARACTERISTICS OF ENERGY STORAGE BATTERY

A typical battery energy storage system is connected to the external grid via a power electronic converter, when the converter adopts PQ control mode, grid voltage as reference voltage, given an inner loop reference current according to the PQ control target. The output current is adjusted by PI and transformed by dq, the PQ control of the energy storage converter is shown in Fig. 1.

$$P = 3U \cdot I \cdot \cos\varphi \qquad (1)$$

$$Q = 3U \cdot I \cdot \sin\varphi \qquad (2)$$

In these formula: P , Q are the active and reactive power of the three-phase converter respectively; U, I are Three phase converter port phase voltage, phase current; φ is phase angle. Because the output voltage of three-phase converter is grid voltage, the input or output of active power and reactive power can be controlled by controlling the output current of three-phase converter. Table I shows the technical characteristics of the main battery energy storage technology.

As far as the regulating rate of battery energy storage system is concerned, in addition to the time required for information exchange in conventional monitoring system, the dynamic response characteristics of battery body and converter are the main factors that affect the regulating rate. The dynamic response characteristics of several main battery energy storage technologies [10] are given in Table 1. It can be seen that the bulk response time of the battery energy storage system is between millisecond and the response time of the energy storage converter as a power electronic device is also in the millisecond level. Therefore, the battery energy storage system has the characteristics of fast response when adjusting the response on the demand side. It is feasible to participate in the demand side auxiliary service after its capacity reaches a certain scale.

TABLE I. TECHNICAL CHARACTERISTICS OF MAIN BATTERY ENERGY STORAGE TECHNOLOGY

Energy storage mode	output power	discharge period	response time	cycle life / number of times
lead-acid cell	0~50MW	Seconds to hours.	>20ms	12000
Liquid flow cell	30KW ~3MW	Seconds to 10 hours.	20ms to several seconds	>12000
sodium-sulfur cell	50KW ~8MW	Seconds to hours.	20ms to several seconds	2500
Iron-lithium battery	0~50MW	Seconds to hours.	<20ms	>2500

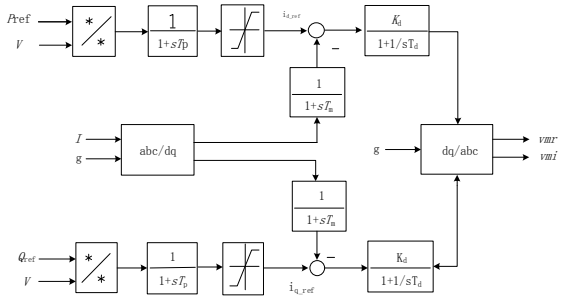

Fig. 1. Schematic diagram of household energy management system

III. DISTRIBUTED ENERGY STORAGE PARTICIPATING IN DEMAND RESPONSE STRATEGY

Demand response refers to all kinds of demand-side adjustment resources, including energy storage facilities, according to the price signals given by the market. （ Time-sharing price, Real time price, Peak price ） Change its inherent mode of electricity, change and transfer the load at a certain time to respond to the power supply, in order to achieve its own economic operation and ensure the security and stability of the power grid dual objectives. In time-sharing price mode , On the one hand, the power sector divides 24 hours a day into peak, flat and low periods, and sets different electricity prices for each time period. On the other hand, based on the time-sharing price, by means of energy storage and negative control, the user optimizes the power consumption plan and transfers the load of the higher price period to the lower time period, thus reducing the overall power cost. For the multi-point distributed battery energy storage facility under the same investment and operation, the concrete steps to participate in the time-sharing price response are as follows:

(1)Forecast the load demand for each period of the next cycle according to the type of electrical equipment and production and living demand.

(2) Considering the total energy storage capacity and state of the energy storage cells at each point, the time-sharing price signals are taken as a whole to optimize the power consumption plan in the next cycle with the aim of minimizing the power cost. At the same time, the overall charge and discharge plans of the energy storage cells are obtained.

(3) According to the whole charging and discharging plan of energy storage battery, the energy storage state, the limit of charge and discharge power and the corresponding network constraints are considered and the regulating amount of energy storage cell at each point is reasonably allocated.

A. Response Model of Energy Storage demand based on Time-sharing Price

Aim at minimizing the cost of electricity to users，the demand response model of energy storage battery based on time-sharing price is established. In this model, the distributed energy storage cells involved in the demand response are considered as a whole and the parameters involved are lumped parameters to describe the overall characteristics.

$$\min \sum_{i=1}^{N} a_i \cdot P'_{L,i} \tag{3}$$

In the (3): Set the period of power consumption to T, divided into N periods according to the step size Δt; a_i is timeshare price for the first time period; P'_L is net load for period i.

1) Net load balance constraint

$$P'_{L,i} = P_{L,i} + P_{E,i} \tag{4}$$

In the (4): $P_{L,i}$ is electricity use plan for period i; $P_{E,i}$ Battery charge and discharge plan for the first period of time(Charge to positive, Discharge is negative).

2) Load transfer constraint

$$\sum_{i=1}^{N} P_{L,i} = \sum_{i=1}^{N} P_{L0,i} \tag{5}$$

$$P_{L,i} \geq P_{LB,i} \tag{6}$$

In the (5) and (6): $P_{L0,i}$ is original load requirements for period i; $P_{LB,i}$ is base load requirements for period i（ unadjustable).

3) Battery charge and discharge power constraint

$$P_{E,\min} \leq \left| P_{E,i} \right| \leq P_{E,\max} \tag{7}$$

In the (7): $P_{E,max}$, $P_{E,min}$ are the upper and lower limits of charge and discharge power of energy storage battery are respectively.

4) Battery charge and discharge depth constraint

$$SOC_{\min} \leq SOC \leq SOC_{\max} \tag{8}$$

In the (8): SOC_{max}, SOC_{min} are upper and lower limits of charge and discharge power depth of energy storage battery. SOC is defined as:

$$SOC = \frac{E}{E_{\text{rate}}} \tag{9}$$

In the (9): E is current energy state of energy storage battery; E_{rate} is rated energy space for energy storage batteries.

B. Multi-point energy storage charge and discharge coordination optimization model

For the same investor, the core problem of multi-point distributed energy storage participating in the demand response is how to allocate the power of energy storage facilities at each point after the overall charging and discharging plan in section A is determined. In this section, aiming at minimizing the network loss, considering the charge and discharge power constraints, energy constraints, line overload constraints and node voltage constraints, a coordinated optimization model is established for multi-point energy storage system to participate in the demand response.

1) object function

$$\min \sum_{j=1}^{M} P_{loss,j} \tag{10}$$

In the (10): M is the number of lines; $P_{loss,j}$ is the line loss of line j.

2) Charge-discharge planning constraint

$$\sum_{k=1}^{K} P_k = \Delta P_E \qquad (11)$$

In the (11): K is the number of distributed energy storage battery facilities, P_{k} is Charge and discharge power of energy storage facilities at k_{th} place. ΔP_{E} is Total charge and discharge plan for demand response.

3) Power balance constraint

$$\sum_{i=1}^{N} P_{Gi} = \sum_{k=1}^{S} P_{Ek} + \sum_{\mathrm{j}=1}^{M} P_{\mathrm{j}} + \sum_{i=1}^{N} P_{Li} \qquad (12)$$

In the (12): N is the number of network nodes, M is the number of network branches, S is the number of energy storage facilities. P_{Gi} is generation power of as the i node; $P_{\mathrm{L}i}$ is the load power of the first node; P_{Ek} is the charge and discharge power of the k_{th} energy storage cell.

4) Single point energy storage battery charging and discharging power constraint

$$P_{\mathrm{k,min}} \le \left| P_{\mathrm{k}} \right| \le P_{\mathrm{k,max}} \qquad (13)$$

In the (13): $P_{\mathrm{k,max}}$, $P_{\mathrm{k,min}}$ are the upper and lower limit of charge and discharge power of k_{th} energy storage cell.

5) Charge and discharge depth constraint of single point energy storage battery

$$SOC_{\mathrm{k,min}} \le SOC_{\mathrm{k}} \le SOC_{\mathrm{k,max}} \qquad (14)$$

In the (14): $SOC_{\mathrm{k,max}}$, $SOC_{\mathrm{k,min}}$ are upper and lower limits of charge and discharge depth of k_{th} energy storage battery respectively

6) Line overload constraint

$$I_j < I_{j,\max} \qquad (15)$$

In the (15): I_j is the current of the j line and $I_{j,max}$ is the thermostable current of the j line.

7) Node voltage constraint

$$U_{\mathrm{i,min}} \le U_{\mathrm{i}} \le U_{\mathrm{i,max}} \qquad (16)$$

In the (16): $U_{\mathrm{i,max}}$, $U_{\mathrm{i,min}}$ are the upper and lower limit of node voltage at I, U_{i} is node voltage at I.

IV. CASE STUDY

A. Introduction to BBO-PSO algorithm

In the mutation operation of the basic BBO algorithm, each generation of mutation selects the amount of variation by random selection. It is only a variation of a certain habitat variable. This operation not only has a low mutation rate, but also has a poor mutation effect. Insufficient capacity to maintain population diversity. Kennedy and Eberharter were inspired to observe the population behavior of bird foraging and proposed that the iterative core of particle swarm optimization algorithm (PSO), the iterative core of PSO is the idea of updating particle velocity and position. In the (17), vtid represents the velocity of the first particle at the t iteration; xidt represents the position of the first particle at the t iteration; ω is the weight; and ptid is the individual optimal value of the I particle as pbest; ptgd is the local optimal value as gbest; c1 is a cognitive constant, c2 is an interactive social constant of population, r1 and r2 are the random value in (0,1).

In this paper, the purpose of improving the mutation operation of BBO algorithm by using PSO algorithm is to increase the mutation rate and increase the diversity of the population. Therefore, based on the local type of PSO, the selection of the global optimal solution is added to the outer loop. Although this may sacrifice some time to computer, it will maximize the transformation of the mutant non-elite solution in the hope that the mutation will be no less than the new solution of the elite solution. The modified PSO algorithm is used to replace the mutation operation of BBO and to improve the individuals with poor fitness. This improvement is equivalent to increasing the variation rate of the population and is more conducive to maintaining the diversity of the population.

$$\begin{cases} v_{id}^{t+1} = \omega v_{id}^{k} + c_1 r_1 (p_{id}^{t} - x_{id}^{t}) + c_2 r_2 (p_{gd}^{t} - x_{gd}^{t}) \\ x_{id}^{t+1} = x_{id}^{t} + v_{id}^{t+1} \end{cases} \qquad (17)$$

B. Essential parameter

In this paper, IEEE33 node distribution system is used as an example. The system wiring is shown in Fig. 2. The system has 32 branches, power supply network, the first reference voltage is 12.66kV, the total active power load is 3715kW, the total reactive power load is 2300kvar.

In the formula, n is the number of types of electrical load, S_{it} indicates the electricity consumption probability for the i-th power load during the t-th period, P_{ie} represents the rated power of the ith load, P_{it} indicates the Electric power consumption for the i-th power load during the t-th period, T represents the number of periods in the statistical period, $P(t)$ is the total load of residents in t period.

IEEE33 Node Distribution system has 32 load nodes. Distributed power can be installed except power node 0. Therefore, the optimization dimension D=32. parameter setting of BBO-PSO algorithm is implemented as: the number of habitat n=300, The Maximum immigration and removal rate I,E was 1, 0. System mobility P_{mod}=0.8, weight ω= 0.4, the cognitive constant c_1, race interaction social constant c_2 and neighborhood interaction society constant c_3 are set to 1. After migration, the number of elite individuals retained is set as Z=10, the mutant operation elite individual retention number of individuals is set as K=5.

The parameter records of the optimization model are shown in Table II.

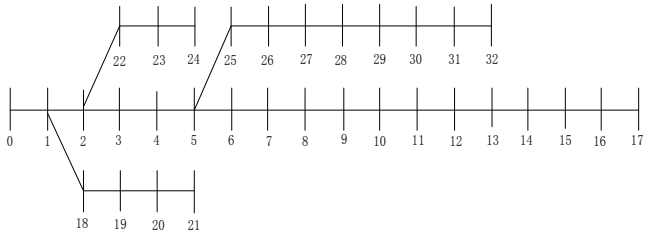

Fig. 1. IEEE33 Node distribution system

C. *Example result*

According to the BBO-PSO algorithm introduced in the third section of this paper, the location and capacity of the distributed power supply in the distribution network are optimized.

Compare the costs in both cases, taking into account the response of the requirement, as shown in Table 4.

From Table III and Table IV, we can see that the coordinated planning of distributed power supply considering demand response can effectively reduce the investment cost and operation cost of distributed power generation, cut the operation cost of power network and improve the economy of power network.

TABLE II. THE PARAMETER RECORDS OF THE OPTIMIZATION MODEL

Parameter name	parameter values
DG power rating Pm /kW	10
DG power factor	0. 9
DG Unit capacity investment cost ［Yuan / （kW • h)]	0. 714
DG Unit capacity operation and maintenance cost / ［Yuan / （kW • h)]	0. 081
DG Fixed investment average cost factor	0.35
Unit price / ［Yuan / （kW • h)]	0.313
DG Total electricity loss L.E （%）	10
Annual maximum load loss hours Tmax /h	4200
Annual maximum load utilization hours Tmax /h	4200
Outsourced electricity price / ［ Yuan I Cl coin / • h)]	0.455
Increase the unit incentive cost of load / ［Yuan / （kW • h)]	1
Unit compensation cost of lack of electricity load / ［ Yuan / kW • h)]	2

TABLE III. LOCATION AND CAPACITY OF POST DISTRIBUTED POWER INSTALLATION BEFORE AND AFTER CONSIDERATION OF DEMAND RESPONSE

Regardless of requirement response						
Installation node number	4	9	23	24	3	gross capacity
Installation capacity /kW	80	40	120	160	80	480

TABLE IV. LOCATION AND CAPACITY OF POST DISTRIBUTED POWER INSTALLATION BEFORE AND AFTER CONSIDERATION OF DEMAND RESPONSE

Consideration of demand response						
Installation node number	4	7	23	25	30	gross capacity
Installation capacity/kW	60	20	120	120	60	380

TABLE V. COST COMPARISON BEFORE AND AFTER CONSIDERING DEMAND RESPONSE (UNIT: 10,000 YUAN)

Cost name	Regardless of requirement response	Consideration of demand response
DG Investment and Operation cost	227.75	259.45
Line operation cost	99.40	96.95
Loss cost	57.43	55.72
Outsourced electricity cost	1198.89	1173.57
amount to	1526.04	1585.69

V. CONCLUSION

In order to deeply study the comprehensive planning model and solution method in distributed generation, the objective function of demand response is added to the coordination planning model of distribution network with generation. In this paper, BBO-PSO algorithm is used to study the coordination and optimization of multi-point distributed battery energy storage system in response to grid demand. Considering the demand response, the coordinated optimization model can reduce the investment of distributed power and the operation cost of distributed power and distribution network. It is effectively improve the economy of operation with distributed power. The effectiveness of the model is verified by a IEEE33 node example, which is used for the battery energy storage system to manage the auxiliary service on the power demand side. The application of service market provides technical support.

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REFERENCES

[1] Xiao. H, Pei. W, Kong. L, “Decision analysis and economic benefit evaluation of microgrid output considering photovoltaic power surplus,”Power System Automation, 2014, 38(10): 10-16.

[2] You. Y, Liu. D, Zhong. Q, “Distributed power coordination control based on active distribution network on multiple time scales,” Power System Automation, 2014, 38(9): 192-198.

[3] Wang. P, Liu. X, Li Y, “Research on daily scheduling and operation simulation of large capacity wind power access system considering user side interaction,” Proceedings of the CSEE, 2013,33(22): 35-44.

[4] BYUN J, HONG I, PARKS.,“Intelligent cloud home energy management system using household appliance priority based scheduling based on prediction of renewable energy capability,” IEEE Trans on Consumer Elevtronics,2012,58(4):1194-1201.

[5] ALIZADEH M, CHANG T H, SCAGLIONE A. “Grid integration of distributed renewables through coordinated demand response,” 51st IEEE Conference on Decision and Control, December 10-13, 2012, USA:3666-3671.

[6] Hamed Hosseinnia,Behrouz Tousi. Optimal operation of DG-based micro grid (MG) by considering demand response program (DRP). Electric Power Systems Research,2019,167.

[7] AmirAli Nazari,Reza Keypour. A two-stage stochastic model for energy storage planning in a microgrid incorporating bilateral contracts and demand response program. Journal of Energy Storage,2019,21.

[8] Shililiandumi Naiman,Nerey H. Mvungi,Diana Severine Rwegasira,Imed Saad Ben Dhaou,Aron Kondoro,Anastasia

Anagnostou,Amleset Kelati,Simon J.E. Taylor,Hannu Tenhunen. A Demand-Response Scheme Using Multi-Agent System for Smart DC Microgrid. International Journal of Embedded and Real-Time Communication Systems (IJERTCS),2019,10(1).

[9] Energy; New Energy Study Results from Aalto University Described (Utilising demand response in the future Finnish energy system with increased shares of baseload nuclear power and variable renewable energy). Energy Weekly News,2018.

[10] Information Technology - Industrial Informatics; New Findings in Industrial Informatics Described from Sharif University of Technology (Commercial Demand Response Programs in Bidding of a Technical Virtual Power Plant). Energy Weekly News,2018.

Optimal configuration of the hybrid energy storage system for reducing the amount of discarded photovoltaic

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***Abstract*—With the development of industry, more fossil energy is consumed to generate electricity, which increases carbon emissions. To reduce carbon emissions, renewable energy generation systems such as photovoltaic system are being used. However, the randomness and volatility of photovoltaic will affect the stable operation of power system, which results in a large number of photovoltaic is discarded. The energy storage system has the characteristics of flexible control and fast response, which can help the power grid to increase stability. In this paper, five-point estimation Method is used to disperse photovoltaic output. A hybrid multi-objective particle swarm optimization algorithm is proposed, which introduces the Non-dominated Sorting Genetic Algorithm of elite strategy combined with the probabilistic power flow. The optimal location and capacity of the energy storage unit can be found by minimizing the operating cost of the system and improving the voltage distribution. Finally, through the case analysis of the IEEE-30 node system, it is proved that the optimized configuration can reduce the voltage offset, reduce the operating cost of the system and reduce the amount of the system discarded photovoltaic. The economic advantage of the hybrid energy storage is also verified.**

Keywords—photovoltaic; optimal configuration; hybrid energy storage system; hybrid multi-objective particle swarm optimization algorithm

I. INTRODUCTION

With the shortage of traditional fossil fuels and the increasing environmental problems caused by fossil energy power generation, the use of renewable energy has been rapidly developing [1]. As a clean and pollution-free renewable energy power generation technology with good economic efficiency [2], photovoltaic power generation has been widely used all over the world. The large-scale grid-connected photovoltaic has a great influence on the operating characteristics of the system [3], the uncertainty of photovoltaic will increase voltage fluctuations and reduce system operation stability [4]. State Grid data shows that, in the first half year, the PV operating area cumulative discarded amount of the State Grid is 3.305 billion kWh, which increased 91% and the proportion of discarded light is 12.1%, which rose by 2.05%. [5].

Based on the particle swarm optimization algorithm to consider the optimal configuration of hybrid energy storage, the mixed energy storage system combined with their complementary advantages has a better effect on the stable operation of micro gird than the single energy storage [6], not considering the energy storage optimization of large power grids and the absorption of renewable energy for power generation when increasing energy storage [7]. The single energy storage optimization of wind power grid-connected system doesn't consider the advantages of PV grid-connected system and hybrid energy storage [8]. Most of the scholars consider to increase the stability of the system to allocate the energy storage from the grid side, energy storage can help reduce the amount of wind capacity allocation, which has an effect on wind energy absorption [9].

In conclusion, most of the former scholars studied the energy storage configuration of wind power grid-connected system and the research on PV grid-connected is less; The research on hybrid energy storage is mostly used in micro grid, which is considered to be less in power system; When optimizing energy storage configuration, particle swarm optimization (PSO) is used but further optimization is not made; In the study of photovoltaic grid-connected system, the actual situation of much discarded photovoltaic isn't considered and the consideration of increasing photovoltaic dissipation is lacked.

II. PHOTOVOLTAICS OUTPUT DISCRETIZATION

For photovoltaic power discretization treatment, a continuous set of PV power data is discretized through 5PEM, According to [7], five sets of estimates are obtained:

$$\begin{aligned} P_1 &= P_{rob}\{P(T_a)=0\} = P_{rob}(T_a < T_{NOC}) + P_{rob}(T_a \geq T_r) \\ P_5 &= P_{rob}\{P(T_a)=P_r\} = P_{rob}(T_{NOC} \leq T_a < T_r) \\ P_2 &= y_2(1-P_1-P_5) \\ P_3 &= y_3(1-P_1-P_5) \\ P_4 &= y_4(1-P_1-P_5) \end{aligned} \tag{1}$$

As for the PV system, its output power (P_{PV}) is strictly influenced by the ambient temperature (T_{amb}) and equivalent solar irradiance(R), which can be expressed:

$$P_{PV} = P_{PV,STC} \times \frac{R}{R_{STC}} \times (1-\gamma.(T_a - T_r)) \tag{2}$$

$$T_a = T_{amb} + \frac{R}{R_{STC}} \times (T_{NOC} - 20) \tag{3}$$

where P_{PV},R_{STC} is the maximum power under the standard test condition, R_{STC} represents the solar irradiance level under the standard test condition, γ is a coefficient and T_r, T_a and T_{NOC} are the reference temperature of the PV cells, the actual temperature of PV cells, and the temperature of

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PV cells under the normal operating condition, respectively.

III. Optimization Model of Energy Storage System in Photovoltaic Grid-Connected Systems

The optimal configuration of the energy storage system refers to finding the best energy storage configuration location and capacity to achieve a minimum operating cost of the system and maintain a good voltage level. The optimal configuration of the energy storage system is a nonlinear integer optimization problem with constraints. And the position and capacity of the energy storage configuration are discrete variables.

A. The target function of energy storage optimization configuration

The optimal configuration of energy storage system is a multi-objective optimization problem. The objective function is to achieve the minimum operating cost of the system and ensure the best voltage quality. The objective function is:

$$\left.\begin{aligned} \min f_1 &= \sum_{i=1}^{5} \Pr ob_i . \mathrm{Cos} t_i \\ \min f_2 &= \sum_{k=1}^{n} \left(\frac{V_k - V_k^{spec}}{\Delta V_k^{\max}} \right)^2 \end{aligned}\right\} \tag{4}$$

where n is generator node points; V_k^{spec} is expected voltage; ΔV_k^{max} is maximum current offset; P_{robi} is probability operating costs of scene i; $Cost_i$ is total cost of scene i.

$$\begin{aligned} \mathrm{Cos} t_i &= \sum_{j=1}^{NG} C(P_{Gj}) + C_{pv} + C_s = \\ &\sum_{j=1}^{NG} (a_j + b_j \cdot P_{Gj} + c_j \cdot P_{Gj}^2) + c^{oppv} \cdot P_{pv} + c^{ops} \cdot P_{storage} \end{aligned} \tag{5}$$

where NG is total number of generators; $C(P_{Gj})$ is consumption cost of generator j; C_{pv} is total cost of PV unit; C_s is cost of energy storage systems; a_j,b_j , c_j are consumpton factor of generators; C^{oppv} is operating cost of PV unit; P_{pv} is active output of PV units; c^{ops} is operating cost of energy storage system; $P_{storage}$ is configuration capacity of energy storage system.

The objective function f_1 in (4) is to optimize the energy storage of the photovoltaic grid-connected system and the expected operating cost of the system is minimal; The large-scale grid-connected photovoltaic will cause voltage fluctuations in the system nodes and affect the stable operation of the system. The objective function f_2 is to minimize the voltage offset and ensure the good quality of the voltage.

B. The constraints of energy storage optimization configuration

Constraints include equal constraints and inequality constraints. The equal constraints refer to the node's power balance constraints, including active power balance and reactive power balance. The formula is:

$$\left.\begin{aligned} P_i - V_i \sum_{j=1}^{N} V_j (G_{ij} \cos \delta_{ij} + B_{ij} \sin \delta_{ij}) = 0 \\ Q_i - V_i \sum_{j=1}^{N} V_j (G_{ij} \sin \delta_{ij} - B_{ij} \cos \delta_{ij}) = 0 \end{aligned}\right\} \tag{6}$$

where P_i is active output of node i ; Qi is reactive power of node i ; V_i 、 V_j is voltage amplitude of node i,j; $\delta_{ij} = \delta_i - \delta_j$ is phase difference between node i and node j; G_{ij} , B_{ij} are the real part and imaginary part of i_{th} and j_{th} row in the node admittance matrix.

The inequality constraints include node voltage constraints, transformer junction constraints and generator reactive power constraints. The formula is:

$$\left.\begin{aligned} V_{i\min} \le V_i \le V_{i\max} \\ T_{i\min} \le T_i \le T_{i\max} \\ Q_{Gi\min} \le Q_{Gi} \le Q_{Gi\max} \end{aligned}\right\} \tag{7}$$

where V_{imin} is the minimum voltage of node i ; V_{imax} is the maximum voltage of node i; Q_{Gimin} is the minimum reactive power output of generator i ; Q_{Gimax} is the maximum reactive power output of generator i ; T_i is the sub-joint of transformer i ; T_{imax} , T_{imin} are the upper and lower limits of the transformer sub-joint.

C. The optimization configuration target function of energy storage unit

Initial acquisition cost C_0:

$$C_0 = C_{BAT} N_{BAT} + C_{CAP} N_{CAP} \tag{8}$$

where C_0 is initial acquisition cost of the energy storage unit, which is determined by the quantity and price of the energy storage element's model and initial energy storage element; N_{BAT}, N_{CAP} are univalents of cascaded batteries and supercapacitors.

Replacement cost C_1:

$$C_1 = (k_1 - 1) C_{BAT} N_{BAT} + (k_2 - 1) C_{CAP} N_{CAP} \tag{9}$$

where C_1 is the replacement cost of the energy storage unit, which is related to the number of batches, models and the price and quantity of the storage element; C_{BAT} and C_{CAP} are the the replacement cost of the battery and supercapacitors ; N_{BAT} and N_{CAP} are the replacement batches of the battery and supercapacitors, respectively, for the entire life cycle.

Operating maintenance cost C_2:

$$C_2 = k_1 k_{BAT} C_{BAT} N_{BAT} + k_2 k_{CAP} C_{CAP} N_{CAP} \tag{10}$$

where C_2 is operation maintenance cost of energy storage unit, which is related to the type, operation life and other factors of the energy storage element; k_{BAT} and k_{CAP} are coefficients of operation maintenance costs of batteries and supercapacitors.

The target function of the capacity configuration of the energy storage unit is:

$$\mathrm{C} = \min \left\{ \frac{C_0 + C_1 + C_2}{Z} \right\} \tag{11}$$

where Z is the working time during the life cycle.

D. Optimal allocation constraints of energy storage units

Power balance constraints: the output power of supercapacitors and battery hybrid energy storage systems should be no greater than the rated power.

$$\begin{aligned} -P_{BAT} \le p_{BAT}(t) \le P_{BAT} \\ -P_{CAP} \le p_{CAP}(t) \le P_{CAP} \\ P_{BAT} + P_{CAP} \le P_{rate} \end{aligned} \tag{12}$$

where $P_{BAT}(t)$ and $P_{CAP}(t)$ are the output power of the battery and supercapacitors, respectively.

SOC constraints: the SOC of the battery and supercapacitor should be within a reasonable limit, the overcharge or over-release will lead to the decrease of storage life and the range of SOC of different type of energy storage medium is different, the specific situation should be analyzed. The hybrid energy storage unit should be met as followed:

$$\begin{aligned} k_{BAT_\min} E_{BAT} \le E_{BAT}(t) \le k_{BAT_\max} E_{BAT} \\ k_{CAP_\min} E_{CAP} \le E_{CAP}(t) \le k_{CAP_\max} E_{CAP} \\ E_{BAT} + E_{CAP} \le E_{rate} \end{aligned} \tag{13}$$

where k_{BAT_min},k_{BAT_max},k_{CAP_min} and k_{CAP_max} are maximum and minimum limits for battery and SOC of supercapacitors, respectively.

IV. Hybrid Multi-Objective Particle Swarm Optimization Algorithm

Hybrid Multi-Object Particle Swarm Optimization (HMOPSO) algorithm combines NSGA-II with probabilistic power flow to optimize the energy storage of PV grid-connected systems. The optimal location and capacity of the energy storage configuration are obtained. Using the multi-objective particle swarm optimization (PSO) algorithm to optimize the location and capacity of energy storage configuration and The Newton Raphson Method is used to deal with the equal constraints and inequality constraints. The specific optimization steps are as Follows:

1) The population P with N particles is randomly generated by HMOPSO to initialize the voltage, output power, energy storage position and capacity of all generator terminals in the system.

2) The velocity vectors of each particle are initialized by considering the constraints of the particles, and the optimal solution and the global optimal solution are initialized.

3) Discretization of PV power distribution to five-point distribution.

4) In three cases, five scenarios were created.

5) To calculate the probability flow, each particle calculates the adaptive value of each particle through the fitness function.

6) The optimal position of the optimal adaptive value is obtained. And the optimal solution and the global optimum are examined.

7) According to the individual optimal and global optimal solution, judging whether the system operation cost is minimized and the voltage offset is minimal, if yes, go to step 11).

8) Otherwise, continue to update the individual optimal and global optimal solution.

9) Replicate population P to population Q, and update the position and velocity of each particle to form a population R.

10) The population R is sorted by NSGA—II, and the best particles N are selected to update the population P to enter the next iteration.

11) Determine if all scenarios are optimized, otherwise go to step 4).

V. Case Study

This paper takes IEEE-30 node system as an example, the system wiring diagram is shown in Fig. 1, the generator is located at node 1, node 5, node 8, node 11 and node 13, respectively, where node 1 is a balanced node, node 5, node 8, node 11 and node 13 is a PV node, the rest of the nodes are PQ nodes, and access to PV with capacity of 100 MW at node 2.

In order to study the impact of grid-connected photovoltaic and energy storage configuration on the operation of the system, the following three cases are analyzed:

Case one: Considering only the influence of photovoltaic on the system, the probabilistic power flow method is used.

Case two: in the absence of photovoltaic grid, the optimal configuration of energy storage system is realized by optimal power flow and the completed configuration of energy storage system is applied to case one.

Case three: considering the influence of photovoltaic grid-connected system, the HMOPSO algorithm is used to optimize the configuration of energy storage.

The voltage changes at each node of the system shown in Table II, are considered only in the case of grid-connected photovoltaics. From the data in Table I, it can be seen that with the increase of PV capacity, the system has the problem of low voltage and high voltage. For example, node 2, when the PV grid-connected capacity is less than 45.79 MW, the voltage of the node is low. For node 11 and node 13, voltage up to 1.082MW, 1.071MW, the voltage is too high. The operating cost of the system is shown in Table I. With the increase of photovoltaic grid capacity, the operating cost of the system decreases gradually.

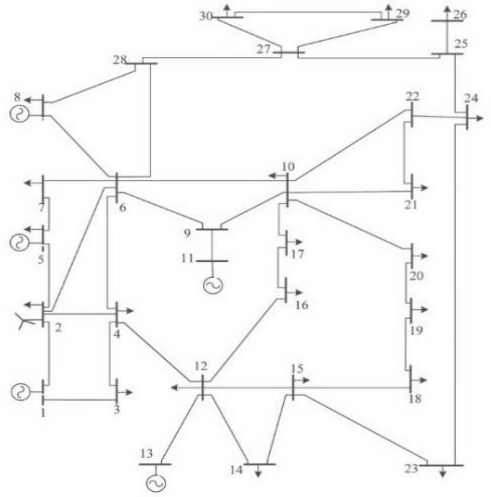

Fig. 1. IEEE-30bus system wiring diagram

TABLE I. EFFECT OF GRID-CONNECTED PHOTOVOLTAIC SYSTEM ON OPERATING COST

Photovoltaic/ MW	0	12．54	45．79	88．12	100
running cost	10626.5	10.235	9 344.1	8608.9	8577

TABLE II. EFFECT OF PHOTOVOLTAIC ON TERMINAL VOLTAGE OF GENERATOR

Photovoltaic / MW	0	12.54	45.79	88.12	100
Node			Voltage		
2	0.976	0.982	0.996	1.009	1.013
4	0.989	0.991	0.996	1.001	1.003
10	1.035	1.036	1.038	1.04	1.041
12	1.048	1.049	1.051	1.053	1.054
13	1.071	1.071	1.071	1.071	1.071
26	0.988	0.989	0.992	0.994	0.996
29	0.991	0.992	0.995	0.998	0.999
30	0.98	0.981	0.984	0.986	0.987

TABLE III. COMPARISON OF NODAL VOLTAGES

		Photovoltaic / MW				
Node	case	0	12.54	45.79	88.12	100
2	One	0.976	0.982	0.996	1.009	1.013
2	Two	1.013	1.034	1.009	1.054	1.02
4	One	0.989	0.991	0.996	1.001	1.003
4	Two	1.002	1.03	1.004	1.038	1.01
30	One	0.98	0.981	0.984	0.986	0.987
30	Two	0.988	1.022	0.992	0.994	0.998

TABLE IV. COMPARISON OF ACTIVE POWER LOSS IN SYSTEMS

Photovoltaic / MW	0	45.79	88.12	100
Case one	43.09	29.19	21.68	19.59
Case two	14.06	10.83	8.43	8.16

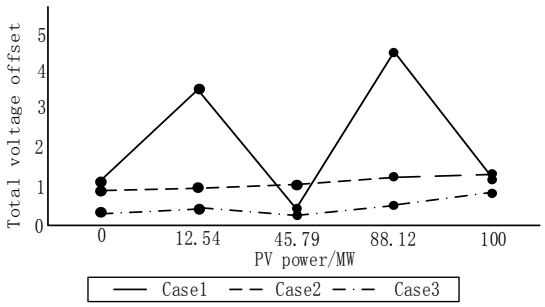

Fig. 2. Voltage offset contrast diagram

In case two, node 6, node 19, node 22 and node 23 are the best locations for energy storage, with energy storage capacity of 2.5 MW,18.2 MW,5.6 MW and 16MW, respectively. The comparison of node voltage in two cases is shown in Table III. By analyzing the data in Table III, it can be concluded that the voltage of node 2, node 4, node 26, and node 30 are increased in case 1. Compared with the data in Table IV, the active power loss of the system is obviously reduced after the optimized configuration of energy storage.

In case three, the energy storage capacity of some nodes becomes zero, which means that these nodes do not need to be configured for energy storage, and the storage capacity of the remaining nodes converges to the optimal value. The energy storage configuration of node 7, node 16 and node 30 is obtained. The capacity is 12.1MW, 9.7MW, 7.4MW, respectively.

The total voltage offset in different cases is shown in Fig. 2. The data show that the voltage offset of cases 1 and 2 is large. The total voltage offset of case 3 is small. HMOPSO algorithm can not only reduce the operating cost of the system but also make the voltage deviation minimum to ensure the good voltage quality.

Taking Node 7 as an example, the storage energy of single battery is used and the storage battery is 2279. Because the power density of battery is relatively low, in order to meet the demand of power supply under impact load, a large capacity battery is needed. Therefore, the cost of energy storage is high, up to 683700 yuan. In the hybrid energy storage mode, the power fluctuation is borne by supercapacitors, 30 supercapacitors are allocated. The capacity of batteries is reduced, only 337 units are required. The charging and discharging times of batteries are also reduced, which saving a large amount of energy storage cost, only 146100 yuan.

VI. CONCLUSION

PV has a positive effect on reducing carbon emissions and protecting the environment. However, its uncertainty has a great impact, so now a large number of photovoltaic is discarded. Energy storage can help improve the power quality of photovoltaic grid-connected systems. In this paper, a hybrid multi-objective PSO algorithm is proposed for the optimization of the energy storage configuration of the system, which combines the NSGA-II with the PV power flow to determine the location and capacity of the energy storage allocation. In this paper, the continuous PV output is discretized into a five-point distribution, which

combined with the probabilistic power flow calculation. The IEEE-30 node system as an example of simulation conducts simulation experiments. The experimental results show that the HMOPSO algorithm can make the system operating cost minimum and the minimum voltage offset under the premise of achieving the optimal storage capacity, Find the best location and configure the Capacity. That is, through the optimal allocation of energy storage. In the premise of ensuring the power quality of the system, the system increases the elimination of PV. Then, with node 7 as an example, it is proved that the hybrid energy storage with equal capacity is better than that of single energy storage.

REFERENCES

[1] Hang. X, Cheng. C, Ji. T, Optimized configuration of hybrid energy storage system capacity considering battery life, Chinese Journal of Electrical Engineering: 2013, 33(34), pp.91-97.

[2] Li. J, Jiang. L, Li. C, Control strategy design for converters of supercapaciter energy storage system, Journal of Northeast Electric Power University: 2017, 37(4), pp.32-38.

[3] Sang. B, Wang. S, Yang. B, Optimal allocation method for energy storage with smooth new energy output fluctuation, Chinese Journal of Electrical Engineering: 2014, 34(22), pp.3700-3706.

[4] Zhang. L, Zhou. C, Ma. M, Solving multi-Objective optimization problem based on particle swarm algorithm, Computer Research and Development: 2004, 41(7), pp.1286-1291..

[5] P. Murugan, S. Kannan, S. Baskar, Application of NSGA- Ⅱ algorithm to single-objective transmission constrained generation expansion planning, IEEE Transactions on Power Systems: 2009, 24(4), pp.1790-1797.

[6] Shen. G, Li. C, Xu. B, Considering the optimal configuration of energy storage in wind power grid-connected system, Journal of Northeast Electric Power University: 2018, 38(4), pp.1005-2992.

[7] Aeidapu Mahesh,Kanwarjit Singh Sandhu,Jagilinki Venkata Rao. Optimal Sizing of Battery Energy Storage System for Smoothing Power Fluctuations of a PV/Wind Hybrid System. International Journal of Emerging Electric Power Systems,2017,18(1).

[8] Jin Guang Yu,Tseng King Jet,Nguyen Hoan Thong. Cooperative operation of chemical-free energy storage system with solar photovoltaic for resilient power distribution in buildings — A case study. Intelligent Green Building and Smart Grid (IGBSG), 2014 International Conference on,2014.

[9] Salehi, V.,Radibratovic, B.. Ramp rate control of photovoltaic power plant output using energy storage devices. PES General Meeting | Conference & Exposition, 2014 IEEE,2014.

[10] Manojkumar, M.,Porkumaran, K.,Kathirvel, C.. Modeling of hybrid Wind Photovoltaic system with energy storage for rural application. Green Computing Communication and Electrical Engineering (ICGCCEE), 2014 International Conference on,2014.

[11] Koh, L.H.,Peng, Wang,Tseng, K.J.,ZhiYong, Gao. Reliability evaluation of electric power systems with solar photovoltaic & energy storage. Probabilistic Methods Applied to Power Systems (PMAPS), 2014 International Conference on,2014.

3D Character Modelling for K-Pop Dances: A Workflow Analysis

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***Abstract*—This research aims at addressing the workflow analysis of a 3D character modelling by using a 3D K-Pop dancing character animation as a case study. To be successful in 3D character animation, one must follow certain steps of character referencing, designing, modelling, deforming, rigging, simulating, and refining. All these steps are the core practice in character animation. Each step has its own requirements and principles. It is a professional practice to follow these steps. However, as for beginners, the steps can be quite complicated and lead to other issues in 3D character animation processes. Character movements are varying. They can be very similar or completely different according to the activities and scenes of that character. In order to set up a character for a unique movement such as a dance movement, one must reconsider all steps started from modelling to rigging processes. To solve the character animation issues, this research focuses on the modelling process. The analysis of 3D character modelling emphasises the modelling approach to highlight the issues for beginner for example, what should be avoided, what should be reorganised to be successful for a beginner.**

Keywords—3D character modelling, 3D character animation, 3D hair simulation, 3D modelling workflow

I. Introduction

In term of 3D character animation, there are certain steps to follow. These steps are combined to create a workflow of character creation. The first step is to find character reference [1]. References are so important for character creation. There is a thin line separating between a good and a great character. Reference is the key to take it beyond that line. A certain type of reference gives more impact than others [2]. The type that brings depth and characteristic to the character is the type that creator trying to achieve. Character that lacks in reference is the character that lacks in characteristic. It can be defined as a moving object but not a believable character.

The second step is the designing process. After gathering enough of information to build up a character, it is the time to start putting them together in order to design [3]. The third step is the modelling process. There are plenty of techniques and methods in term of modelling. Modelling artist must consider all the factors to define which is the most effective method to go. It depends heavily on type, movement, figure, and outcome of that particular character [4]. The fourth step is the deforming process. This step focuses on creating facial expression and in some cases hair, body parts, or clothes deformation [5]. It is important to finish this step before you start rigging the character in order to avoid error and unused nodes stored in the character's polygon.

The fifth step is the rigging process. Rigging is the preparation process to set up a character to be ready for movements. There are two type of assisting tools; inverse kinematics and forward kinematics. Each tool has its unique uses and does a different job on the joint movement [6]. The sixth step is the simulating process. Some characters require simulations of fur, hair, or outfits. One can get a similar result through rigging and deforming processes but it is very time consuming. Simulation helps animator to achieve a realistic animating result [7]. However, one should not over simulating objects. A decision of which is and which is not to be simulated needed to be made carefully. In some particular situations, other deforming methods are more suitable when we take computer environment into account. The seventh step is refining process. A character is needed to be refined to check whether there are still any animation issues and are ready to be animated.

This research analyses a workflow of 3D character modelling using a K-Pop dance character as a case study. This is to study any issues that an intermediate user experienced during following the processes.

II. Related Works

A. 3D Character Modelling Definition

In term of 3D computer graphic, character modelling is the development of a mathematical representation of 3D surfaces to create a particular object type so-called a character [8], [9]. This development is done with a 3D modelling application.

B. 3D Character Modelling Methods

Technology plays an important role in term of 3D modelling methods. There are many researches introducing new 3D modelling methods for the last two years. For example, a real time concurrent design of shape [10], virtual human bone modelling by interactive sculpting, mesh morphing and force-feedback [11], and 3D printing using 3D video data [12] were introduced. However, they are limited in a specific task and very costly to operate. This research focuses on the surface modelling which gives more flexibility and economical wise.

III. Three Dimensional Character Modelling

This research uses 3D character modelling for a K-Pop dance as the case study. The workflow follows the seven steps of 3D model creating process. The workflow starts with collecting and analysing the reference. The analysed references are used to assist the design process. A well-planned character modelling reduces cost and time

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consuming issues. The completed static model is ready to be deformed for animation. Rigging process takes the deformed character to be ready for body animation. In some cases, simulation is required for realistic result. The refining process gives a final touch to the process to recheck and correct any inaccuracy details of the model.

A. Referencing and Designing Process

The most effective way is to collect real life references. The reference can be collect from a video footage, photograph, painting, or a form of writing. This research uses a Korean singer as a key reference. From the photographs and video, the artist creates a cray model of his figure to give a better understanding of his physicality in 3D workspace. This is an important process. The cray model should be precise to the 3D CGI model, so it can help modelling process in term of character's depth and dimensions.

Fig.1. A cray model created from a real person reference. This model gives a better understanding in character dimensions

Form the cray model, artist draws the outline of character in 2D format. This format is used as the modelling reference. It can be imported as an image plane to be drafted and sculptured. The most important are the front and side drawings. These two drawings define depth and dimensions of character.

Fig.2 A series of drawing of front, side, and perspective of the character. The character pose is not necessary but should be in T-pose. Choosing the right pose for modelling is the key to the success of character modelling and animation.

B. Modelling Process

The well-prepared references and resources shorten a lot of modelling time. This research uses box modelling technique. This technique begins the modelling process with a primitive polygon shape. In this case is a primitive polygon cube. By sculpturing each body parts separately, head, body, arms, and legs are combined and sewed to create a completed body. Trying to keep the number of face at the minimum but still be able to echo the true shape is the key in character modelling.

Each face is separated by segments. The number of segment define the movement of that particular area of character. For example, the surface that cover elbow joints and knee joints need to have more number of segment per unit area than chest and hip. However, one should avoid over segmented body part. Unnecessary segments have nothing to do with the character aesthetic but only waste computer environment.

The process begins with creating image reference so-called image plane. The image planes can be created by any 2D drawing application. This research draws image planes according to references from a real person. T-pose is used as the character pose to capitalise the calculation of 3D paint weight system. It is important to keep front and side image plane with the same image ratio. Character position should be aligned precisely in both image. The head, eyes, ears, nose, mouth, shoulder, chest, hip, knees, and feet must be at the exact same level. These alignments are more convenient to do it in 2D drawing application rather than adjusting them

in 3D. An example of front and side image planes shows in Fig.3

Fig.3. An example of front and side image planes. It can be considered as a character blueprint.

This research uses the box modelling technique. Character body parts are divided into three categories; head, body, and limbs. Each part is modelled separately. Each part is sewed and combined together to create a full body character. By doing so, artist has more of freedom in term of modelling. The key is to prepare the join sections to carry exactly the same vertices and segments. This is to prevent an issue of broken surfaces after bind skinning process.

The aim is to make model looking realistic. However, the number of polygon faces should be kept at minimum. In order to control the number of polygon face, the model should be created in term of low polygon model. Adding extra segments and vertices to bring more detail is the next step. It should be planned up ahead which level of details is required. Balancing between making it looks as realistic as possible with zero unnecessary segments is the key.

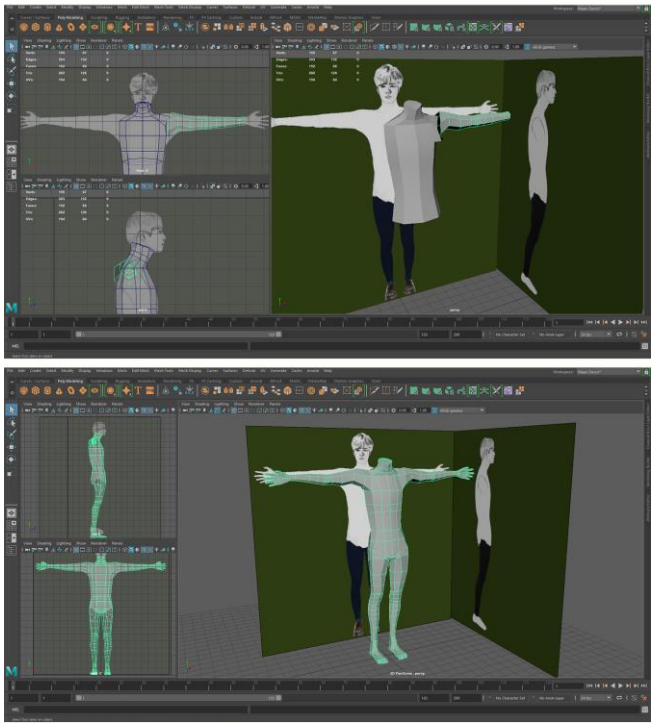

Fig.4. This example shows body and limbs modelling using image plane. They are created separately before combing together using sewing technique.

The head part is the most difficult part of character body. Character expresses their feeling mainly through facial expression. Head part alone carries more moving joints than the whole body combine.

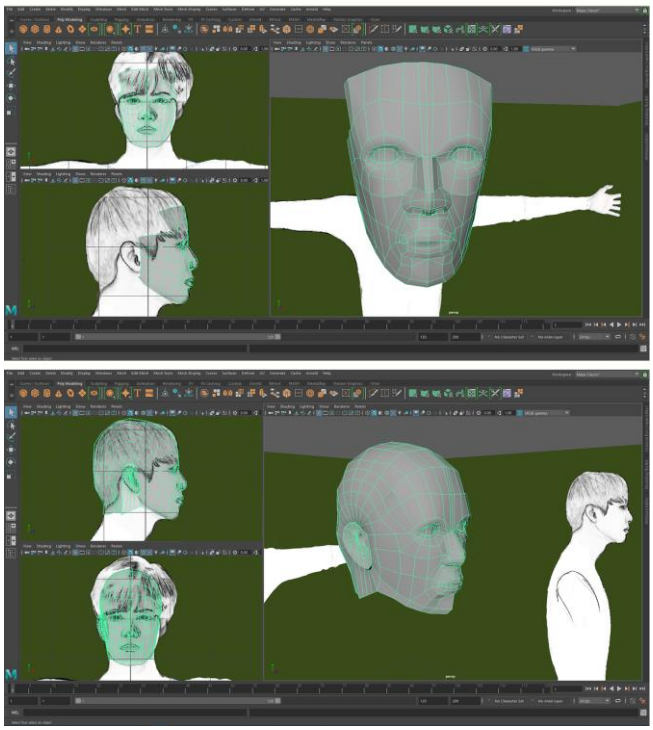

Fig.5. An example of head modelling. The process starts from the face part and continues in a circle to complete the whole head.

C. Simulating Process

This research starts the simulation early on. The reason behind this is to achieve the precise accuracy for the facial expression. Hair style is one of the identity of K-pop artist. It is so important to get it right, so the character looks stylish and identical. The provided hair system in 3D modelling application is quite limited. It can create a normal day to day hairstyle. A more advance hairstyle requires a more flexible hair system. A plug-in hair system is the answer to solve this issue. However, this research aims at an intermediate modeler, so another approach has been introduced. By using two provided hair system, a more advance hairstyle can be achieved. This research creates one system as a base hair system and put another hair system on top to create an identical K-pop hairstyle.

With the two system combined, the satisfy result can be achieved. By testing with the mid-tire graphic card and CPU, the hair moves smoothly without any issue. Separating layer for hair system to be able to turn in on and off is recommended.

After creating hair systems, the hair base needs to be attached to character's head. The base hair is required to be created first. This hair system acts as an area hair to cover a large portion of hair on the head skin. Fig.6 shows the base hair after applied to the character's head. This hair system brings character look quite close to the design but not close enough. The second hair system is required to be introduced to sharpen the look of character. The second hair system is placed over the first system. This hair system aims to give more depth in term of hair appearance. The second system does not require to cover all the hair area that the first system does. By creating layers of hair systems sit on each other can bring character to look as close to satisfaction level without

having to purchase an extra plug-in. As shown in Fig.7, the second hair system is placed on top of the first system to add depth to the hair.

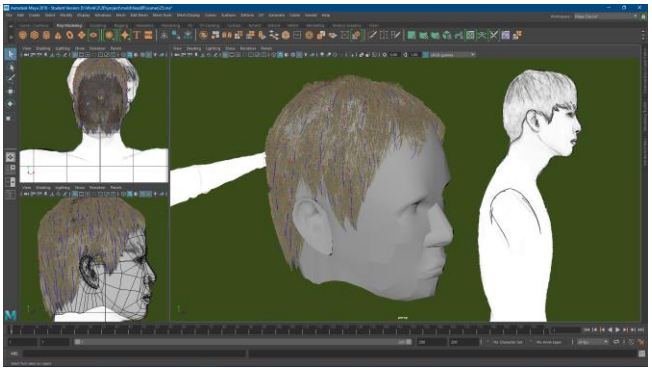

Fig.6. An example of the first hair system acting as the base hair. This system is attached on the character's head.

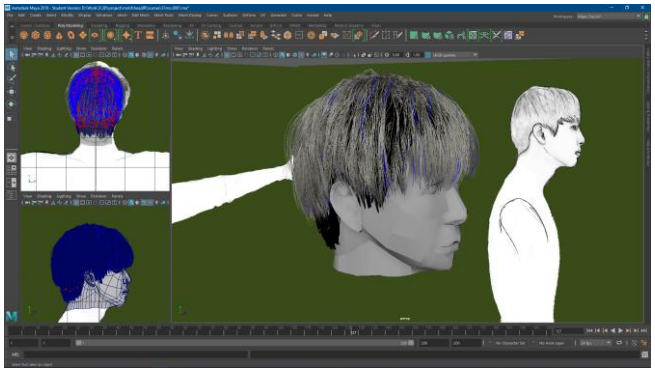

Fig.7. An example of the second hair system acting as the style of the hair. This system is placed on top of the first hair system.

After completing the hair systems, to make character looks as believable as possible, character's skin needs to be applied. As for a realistic character, a normal colour shader cannot give the level of detail required for this research. A realistic skin and a precise alignment is essential. This process is known as UV mapping. To do so, a UV map is needed to be created first. It can be created from a 2D painting application or from a photograph of a real person. This research uses the combination of the two. A real person photograph is taken first and used as the base skin. Then extra details are introduced through 2D painting application. The completed skin is wrapped around character body to acts as character's skin.

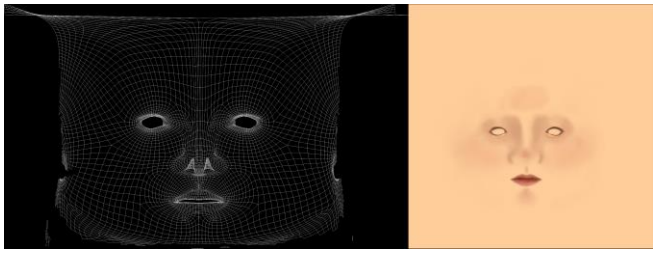

Fig.8. An Example of UV mapping of this character.

D. Deforming Process

The complete model is ready to set up a deformation. Deformation is a useful tool that can be interpreted in a number of useful way. The tool can be used to create facial, cloth, or any type of polygon movement. This research focuses on facial expression deformation. The best technique to achieve a realistic facial expression is facial rigging technique. Beneath human facial skin are facial muscles. Each time human face moved, it moves according to the facial muscles. Rigging technique can simulate as close to the muscular system of human. When facial components move, they affect their surrounding elements. This is known as a facial chain reaction. However, facial rigging is a time consuming process. In term of 3D modelling, only face part alone has more joints and the rest of the body. This research aims to keep the production time as minimum, so the facial deformation is introduced as an alternative approach.

This research takes facial deformation as a face animation approach. Deformation offers data collection in vertex movement. Each vertex has its own set of data carrying its position in 3D workspace. Deformation collects this data and how they change. The nature of deformation does not provide muscular system simulation. However, with a basic knowledge on muscular system and it chain reaction, artist can apply the knowledge to create a similar result using deformation tool. The advantage of this approach is it gives artist more time to set up on other parts of character. It is hugely less time consuming comparing to the facial rigging technique.

To create a workable facial deformation, artist needs to create a series of deferent facial expression of the character. Then uses deformation tool to remember the differences in each vertex position. Facial expression can be achieved through the transformation of those vertices. Another advantage of facial deformation is that they can be mixed together to create a new expression. With this quality, artist is not required to create all the expression but just the key expression. The mixture in key expression and create hundreds of expression at ease.

Fig.9. An example of a set of facial expression created with deformation tool.

E. Rigging Process

This is the most important process in term of character animation. 3D character is made from polygon surfaces which is static. Generally, polygon surface can be move by moving its components; vertex, edge, and face. Rigging technique groups these components together and move them simultaneously in any desire position. In order to do so, a skeleton is required. A skeleton consists of a series of joints joining together following the hierarchy relationship. Each character must have its own skeleton. The skeleton fits inside the character body. Each joint has a certain number of influence over one particular surface. The weighing system is used to define this influence. After finishing skeleton set up, the next step is to create controllers.

Controllers act as a driver for the driven joint to move. They give animator a more convenient way to control the

character. Without setting up controllers, animator has to rotate each joint manually which is extremely difficult. A proper set up of skeleton and controller is a basic requirement in animation industry. The weighting system is also crucial. In order to define weighting to the surface, one can use a paint weight tool. The tool offers a quick and easy way to reapply any weight in a particular area of character skin. It operates using brushing system. User uses the brush to actually paint the skin weight on the character.

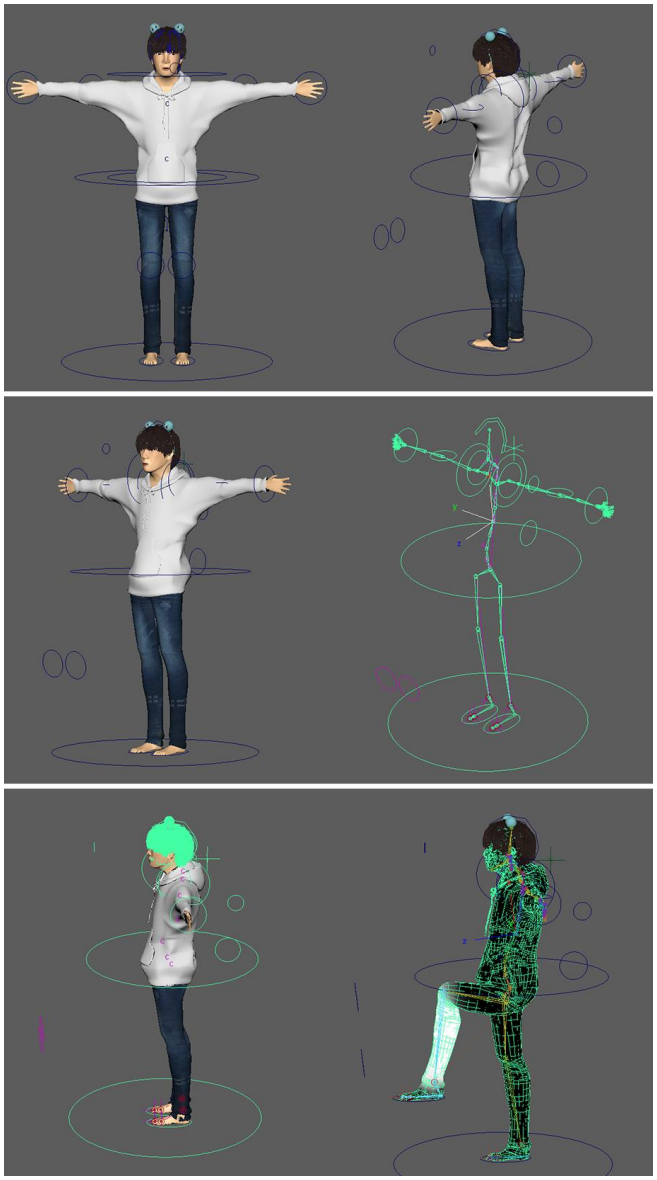

Fig.10. An example of character skeleton, controllers, and weighting influence.

F. Refining Process

This is the step to recheck all details and the setup of character. The model must carry the same quality as required. All the joints and skins must be animated properly. All the controllers are ready to be used. This is the final step in modelling process. After this process, character is ready to be animated. It is important to keep everything well-organised. The aim is to simplify any unexpected error that can be arise in animating process. In this research, additional controllers and head accessory are added to light up character personality and movement.

IV. Conclusion and Future Work

This research aims at analysing 3D character modelling for K-pop dances workflow. Different activities and characteristics require a different character modelling and setup. The number of segments is kept at the minimum level. However, dancing is an intensive movement activity. Some additional segments are required in some particular part of body especially around the character limb joints. The hair systems are also different from the normal setup. An introduction of double hair system achieves the satisfaction result. The combination of inverse kinetic and forward kinetic makes animating process much more convenient and less time consuming.

As for the future work, K-pop dancing has its unique dance pattern. It can be very effective to store key pose of this pattern as a set of data. The data can be recalled at any particular keyframe to reduce time consuming issue in animating process. Also, the data can be stored in term of a set of scripting language, so a dance cycle and be repeated and modified at any desire moment.

References

[1] M. Brindle, “The digital filmmaking handbook,” Quercus, Febuary 2013.

[2] J. Fitzgerald, “Filmmaking for change, 2nd edition: make films that transform the world,” Michael Wiese Productions, 2nd edition, November 2017.

[3] Pie International, “Beautiful scenes from a fantasy world: background illustrations and scenes from anime and manga work,” PIE: perception is everything, Bilingual edition, May 2018.

[4] D. Derakhshani, “Introducing Autodesk Maya 2015: Autodesk official press,” Sybex, June 2014.

[5] B. Clark, “Inspired 3D advanced rigging and deformations,” Course Technology, April 2005.

[6] T. O’Hailey, “Rig it right! Maya animation rigging concepts,” Routledge, 2nd edition, September 2018.

[7] R. Galanakis, “Practical Maya programming with Python,” Packt Publishing, June 2014.

[8] I. Stroud, and H. Nagy, “Solid modelling and CAD system: how to survive a CAD system,” Springer, 2011 edition, 2011.

[9] O. Villar, “Learning Blender: a hands-on guide to creating 3D animated characters,” Addison Wesley, 2nd edition, 2017.

[10] S. Corazza, and E. Gambaretto, “Real time concurrent design of shape, texture, and motion for 3D character animation,” US Patent 9,978,175, 2018.

[11] M. E. Biancolini, and P. P. Valentini, “Virtual human bone modelling by interactive sculpting, mesh morphing and force-feedback,” International Journal on Interactive Design and Manufacturing (IJIDeM), vol. 12, issue 4, pp. 1223-1234, November 2018.

[12] K. N. Iverson, P. J. Sweeney, W. Crow, D. Evseev, S. C. Sullivan, A. C. Romea, M. Chuang, Z. Wang, and E. Lalish, “eD printing using 3D video data,” US Patent, US20180046167A1.

Grammatical Design and 3D Character Development Reflecting Thai Identity for Children

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***Abstract*—This research aims at addressing a grammatical design development of a 3D character that reflexes Thai identity for children. There are many styles of character design. Eastern and Western styles are totally difference. The most influential style from the East is the Japanese style. Thai artists get huge impact by the Japanese style. This is reflexed from their study periods, in other words, their school time. Form the studies of students' character design style of second and third year students studying in various fields of animation and game design, the result shown more than half get influences from Japanese style in their works. Mastering a style from other countries is not always a bad thing as long as they keep their original style attached. The development and adaptation of one style to create their own is the way arts develop. This research does not aim at defining what Thai style character design should be but how to attach our Thai identity to the design. A case study of a design development of a character that reflexes Thai identity using grammatical design development is the aim of this research. The target group of this research are children age between eight and twelve. The design must hold elements that suitable to the target group and reflex Thai identity at the same time.**

Keywords—3D character modelling, character design, Thai identity, grammatical design

I. INTRODUCTION

The term character design refers to a process of defining and utilising appearance and personality of one character through design [1]. There are certain factors needed to be considered; body function, style and aesthetic, personality, and details and story context [2]. To be successful in term of designing a believable character, all the mention factors must be taken into account. The fact that one might appreciate a character from its aesthetic aspect. However, a beautifully designed character does not necessary always deliver a well-designed. There is a thin line separates between a good and a great character designs. There are no such rules to follow in order to be successful. Different purpose or difference use make different practice requirements [3]. However, the mention factors should be covered.

The first factor is character functions. It is the same as any design theories that form must follow functions. Character morphology must be defined according to its functionality [4]. There are certain questions needed to be answered, for example, where does that character live? how is that character able to see? how do they breathe? how to they grab or hold an object? etc. All these requirements create character function and functions create character morphology. A character that filled up with meaningless elements is not a believable character and one should avoid [5].

The second factor is character style and aesthetic. The style creates aesthetic. In the meantime, aesthetic also creates style [6]. By defining one style to follow, the design principles should be considered [7]. Each style has their own template and pattern. A different aspect of aesthetic can be achieved throughout a difference chosen style. In order to create a design template, some certain principles of design must be combined together harmoniously. A balance is character design is important. However, an overbalancing character brings to a boring and not appealing results [8]. The degree of emphasis and contrast must be carefully created to achieve aesthetic requirement [9]. Grammatical design plays an important part in character style and aesthetic development process [10].

The third factor is character personality. Character personality affects character design in term of aesthetic result. One character is a work of putting together of shapes and forms [11]. Each shape carries some specific meanings on its own [12]. In order to create a clear message, which is very important, to the audiences what the character personality really is, the wisely use of shapes and forms is crucial [13]. For example, a cute and adorable character personality goes well with more of round shapes rather than sharp corners. These are factors that designer must be considered carefully.

The fourth factor are character details and context of story. The harmonisation of grammatical design must not be violent [14]. This is the factor about character habitat. The habitat of character defines character function. To design character living under the sea or over the sky requires different set of function design. Each character must carry a look that go along with the whole set of characters and environments [15]. The four factors are relevant and important. In order to create a believable character design, all mentioned factors must be covered.

II. RELATED WORKS

A. Grammatical Design

Grammatical design is a design process using shape development to create a set of design [16]. The process divides into three steps; vocabulary, shape rules, and derivation. The concept mimics the way natural language works to create a design. The process starts with a vocabulary of shape. Some shape rules apply to manipulate the shape to create various derivation as a result. This process aims at assisting a design development.

B. Harmonised Shape Grammar

Harmonised shape grammar is a design framework that adopts a grammatical design to natural language processing

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to create a set of well-designed character [17]. The framework can be divided into four levels of analysis; lexicon, grammar, semantics, and pragmatics. The lexicon and grammar levels of analysis behave similar to vocabulary and shape rules in grammatical design. However, the semantics and pragmatics levels control character function, morphology, habitat, and harmonisation.

III. Three Dimensional Character Development

This research uses 3D character modelling of a Thai identity character as the case study. The aim is to develop a character using grammatical design and harmonised shape grammar to create a Thai identity looking character. The process covers the four requirements of character design; body function, style and aesthetic, personality, and details and story context developments. The target group of this design bases on children age between eight and twelve. The design development also follows grammatical design and harmonised shape grammar design in some points.

A. Body Function Development

The age of target group is between eight and twelve. That draws the design decision to create a look of a lovable and adorable character, so it can create more connection to the target group. The character is a female terrestrial humanoid character living in a semi-fantasy environment. The overall look of the environment is represented with semi-primitive shapes. The shapes are developed in a certain degree that still keeps the primitive appearance.

With all the mention aspects in mind, the character is required all proper humanoid body functions; head, body, and limbs. The character consists of four main sections; a head, a body, two upper limbs which are left and right arms, and two lower limbs which are left leg and right leg. Each section consists of their unique humanoid sub-elements. Each sub-element carries its own specific function. None of meaningless elements are created.

To begin with the top section, the head, head is the most important section in this design. It is where character expresses most of its feeling and communication to the audience. In order to capitalise the use of head section, the design aims at enlarge size of the head to capture the immediate attention from the audience. The head consists of five sub-elements; eyes, eyebrows, nose, mouth, and ears. Eyes have a multi-function. The major function is for character to be able to see. The minor function is to express character emotional state. Eyebrows hold the same minor functionality, to express the complete facial expression. Ears are for character to hear. They do not play any part in facial expression but to make character looks more believable. Nose holds the breathing function as the major function. It also plays a casual part in facial expression but not as important as eyes, eyebrows, and mouth. Mouth is the last section. It carries two major functions on itself. Character can talk and eat as the major functions when expresses their feeling as the minor function as well.

Following with the second section, the body. Body is the section that holds all other sections together. It connects head and limbs to create a complete body function. With the nature of target group in mind, this design aims at simplifying any details that is not necessary to the character function. The body section consists of two sub-elements; upper body, and lower body. Upper body includes character chest and torso. The lower body includes character hip. The main function of body in this research is to hold other sections together. It helps in term of character posing in term of body language as well. This is a simplified character as mentioned above, so the realistic look is not the first priority. This research creates a smaller than usual size of body to achieve a more adorable look to the character. However, the all the necessary functions are still there for audience to believe.

Fig.1 An example of character sketch drawing. The character holds a humanoid morphology which consists of head, body, and limbs sections. Each section consists of their sub-elements.

The final sections are upper and lower limbs. The upper limbs are the arms when the lower limbs are its legs. The arms function as a part for character to grab and hold things. Because, this is a terrestrial character, the legs are for carrying the whole character body. They also act as the function for character to move from one point to the other. If the aim is to create an aquatic character, the lower limbs should be replaced with fins and tail. That are the major functions of upper and lower limbs. The minor function is for the body language communication and emotional expression. The body plays a minor role in term of emotional expression comparing to the head section. However, without a well-designed body, one character cannot fully express its feeling and can be lacking in term of communication.

After getting all the sections required, it is time for the design. Design is a process of putting shapes and forms together in a scene of creating aesthetic. The shape of character bases on a semi-primitive shape. The placement of the main four section follows the humanoid morphology in order to capitalise the full functioning body structure. The proportions among head, body, and limbs are decided following the lovable and adorable theme. The placement of each sub-element is placed following the grammatical design rules. To capitalise the functioning character design, the semantics level of analysis of harmonised shape grammar is used as the core-concept to govern all sub-elements together.

B. Character Style and Aesthetic Development

This research aims at achieving character design that carrying a Thai identity in the style. The created style is a mixture between Eastern and Western styles. The Thai identity can be represented through shape and proportion of character sub-elements, the costume and hair style. Thai costume and hair style have developed through the time period. This research chooses an early Rattanakosin period as

the preferred period reference. This is to capitalise the earliest period before Western costume and hairstyle came to influence Thai culture.

Fig.2 An Example of character cray model. The model shows the spatial relationship of character figure and body proportion.

To be able to attract more attention from the target group, the original hairstyle is modified. This research keeps the top part of the hair as the way the traditional hairstyle should be but make it longer at the back part to create a more girly look for the character. The proportion of all facial sub-elements are enlarged to make it look adorable. Also, similar to the body function development, to achieve the aesthetic result, the use of grammatical design and harmonised shape grammar is required.

C. Character Personality Development

Character personality shows through their physical and mental states. The physical state is how character looks. This can be represented in two aspects; body shape, and character pose. In design principles, each shape carries its own specific meaning. The shape selection affects the personality of character. The round shape gives cuter and more adorable feelings than sharp corner shape that makes character looked strong and more aggressive. This research aims at creating a cute and adorable which east-to-connect to the audience character. Cornered shapes are avoided and replaced with round and soft edge shapes. The shape proportion also affects character personality. The designed female character has enlarged facial sub-elements to create a cartoony look. The proportion also affects character posing design. This research simplifies a realistic posing to a more cartoony posing. Children body movements are studied in order to use as character posing reference.

Physical state is how character looks when mental state is how character feels. The mood of character can be represented in term of an emotion such as a happy, aggressive, and grumpy characters. In order to create more depth in term of character personality, the mixed expression method is used. A conflict in character physical and mental states create a contrast and emphasis of character personality. The shape and look of character shows the friendly and adorable look when its mental state shows a grumpy feeling.

Grammatical design is used to decide character proportion. A simply primitive shape is manipulated spatially to create each of body part. This is used as a character guideline for body sections placement. Harmonised shape grammar assists in pragmatics level of analysis to create a harmonious personality. It defines the character attribute, characteristic (physical state), and behaviour (mental state).

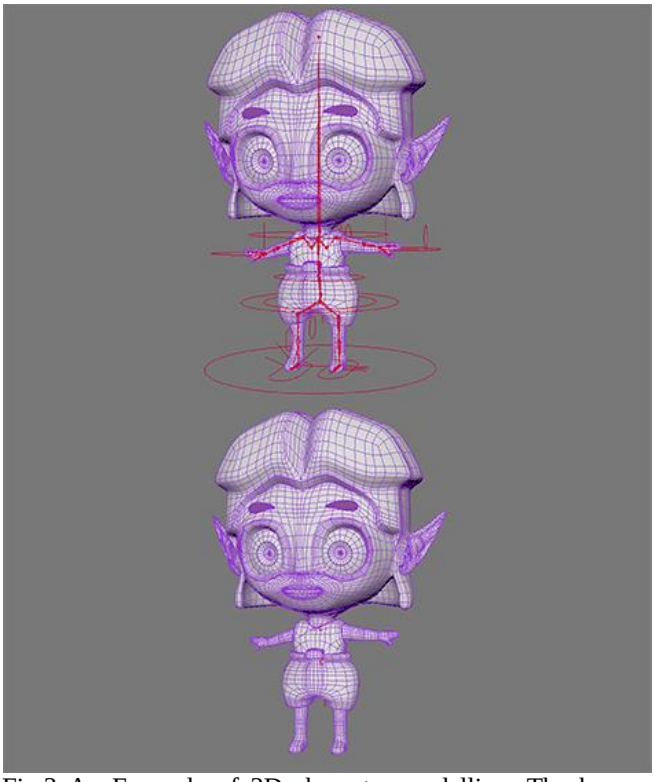

Fig.3 An Example of 3D character modelling. The human morphology is simplified to create a cartoony look.

D. Character Details and Story Context Development

Details are so important in order to make character look more believable. A realistic character contains a large number of small details putting together to make a whole character look real. This is a physical detail. However, a detail in context is never less important than the physical one. A well-designed character must cover both physical and context details.

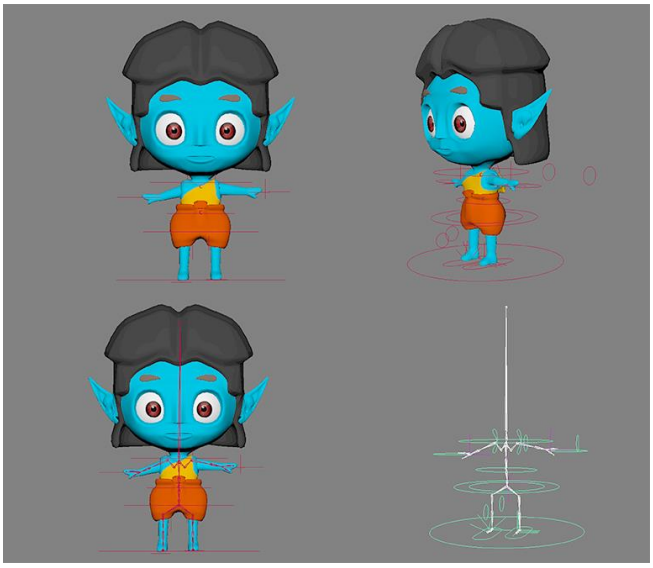

Fig.4 An example of 3D character texturing. The dark hair colour reflects traditional Thai hair colour. The costume is designed according to Rattanakosin period.

Character physical detail shows how character look physically. This is not about the surfaces of character skin but what are beneath them too. Under character skin, there are a set of muscle. When character moves, the muscles move and sending a chain-reaction to the skin. It is so important to understand all the muscle movements in order to mimic the skin movement. For example, when character open their mouth, the chain-reaction affects all surrounding facial sub-elements, the nose moves, the level of cheeks and ears are up a little. Mimicking all the facial movement relation makes character look believable and realistic.

Fig.5 An example of head sub-elements; eyes, eyebrows, nose, mouth, and ears combined to create character facial expression.

Character context detail show the overall context of the design, in other words, the meaning of design. This includes both character and environment designs. In order to make audience believe in the design, each character in the set must look harmonious to each other and to their environment. This is so-called the character universe. A wrong character context breaks the whole design context into pieces. It can be considered as a design error. It is similar to put a character from one story into a set of another story. To prevent this issue, harmonised shape grammar is used in semantics and pragmatics levels of analysis. The level of physical detail is also important. Mixing different levels of physical detail in one scene make that scene looks unappealing and cheap. This research considers all factors mentioned above to design a character that looks harmoniously in itself and in the scene.

Fig.6 An example of the designed character placing in the semi-fantasy environment. The level of physical detail and context play an important part in design harmonisation.

IV. Conclusion and Future Work

This research aims at applying grammatical design and harmonised shape grammar to design a 3D humanoid female character using Thai character design style. The target group are children age between right and twelve. This research divides the design process into four sections; a body function, a style and aesthetic, a personality, and details and story context. Grammatical design and harmonised shape grammar framework are used as the design approaches. The designed character lives in Rattanakosin period. Character costume and hairstyle are designed according to that period. Character bases on semi-primitive shapes, same as the whole environment to achieve the same level of physical detail. The design is used to create a cray model and a 3D character model to represent the design in term of height, width, and depth. The result is rendered using 3D rendering application.

As for the future work, it is challenging to extend the area of the design to other character design styles. Modern Japanese and Thai styles are referred to as the core reference in this research. However, as in Asia alone, there are more unique character design style to study such as Chinese traditional style and Thai traditional style. To adopt these character design styles and to apply the design principles are a challenging topic.

References

[1] K. Crossley, “Character design from the ground up: make your sketches come to life”, Ilex Press, 1st edition, October 2014.

[2] M. T. Holmes, “Designing creatures and characters: how to build an artist’s portfolio for video games, film, animation and more”, IMPACT Book, 1st edition, October 2016.

[3] B. Tillman, “Creative character design 2e”, CRC Press, 2nd edition, February 2019.

[4] K. Diaz, “Character design sketchbook”, CreateSpace Independent Publishing Platform, 1st edition, July 2017.

[5] C. Hart, “Cartooning: the ultimate character design book”, Chris Hart Book, 1st edition, May 2018.

[6] P. J. Graham, “Japanese Design: art, aesthetics and culture”, Tuttle Publishing, December 2014.

[7] W. Lidwell, and K. Holden, “Universal principles of design, revised and updated: 125 ways to enhance usability, influence, perception, increase appeal, make better design decisions, and teach through design”, Rockport Publishers, revised edition, February 2010.

[8] L. Ramirez, and L. R. Ramirez, “Design principles”, Luis Ramirez, April 2017.

[9] T. Whitlatch, “Principles of creature design: creating imaginary animals”, Design Studio Press, November 2015.

[10] G. Stiny, “Shape: talking about seeing and doing”, MIT Press, February 2008.

[11] A. Inma, “Character design by 100 illustrators: full of characters”, Promopress, April 2016.

[12] L. Carlson, “Contingency and the limits of history: how touch shapes experience and meaning”, Columbia University Press, July 2019.

[13] R. Shepherd, and R. Shepherd “1000 symbols: what shapes mean in art and myth”, Ivy Press, April 2019.

[14] B. Sharp, and A. Kunkhet “Harmonised and contextual based driven shape grammar”, SKIMA 2010.

[15] A. Kunkhet, B. Sharp, and L. Noriega, “Natural language processing based shape grammar”, NLPCS 2012, June 2012.

[16] G. Stiny, “Pictorial and formal aspects of shape and shape grammars”, Birkhäuser, January 1976.

[17] A. Kunkhet, “Harmonised shape grammar in design practice”, LAP LAMBERT Academic Publishing, March 2016.

Development of Character Design Frameworks using Game Engine: Unreal Engine

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Abstract --The purpose of this study is to show how to improve the character design frameworks by using game engine, Unreal Engine[1]. The contents emphasized on 3 dimensional production processing of the project "The creation of Science fiction Character inspired from Ramayana" which was created by 4th year student from Department of Animation and Game, College of Arts, Media and Technology, Chiang Mai University. This project decided to adapt the frameworks by integrating between digital animation and game technique to establish a new design process more capability. The source of development was based on the problem analysis while creating digital 3 dimensional character in the part of presentation or post-production which required a long term to progress such as rendering[2] and visual effect[3]. Moreover, the issue of a new digital software technology also affected the design pipeline which made the process to be changed more or less. This study will provide a valuable information of a new concept frameworks that is more efficient, expedient and useful for digital artist as an alternative way.

Keywords: Character Design frameworks, game engine, unreal engine, digital arts, 3 Dimensional Character

I. INTRODUCTION (*HEADING 1*)

In general, the processing of character design project components has been a common use of 2 dimensional and 3 dimensional system integrated together which depends on the initiative objective of any project. Some projects do not require 3 dimensional results, but mostly, nowadays, it has become a particular element of arts and design which especially must be contained in the design package. Because of the movement of the digital contents media which has been shifted and also cross each other numerously, e.g., 2 dimensional characters have been used in mobile game application mixed with 3 dimensional environments, has become the widespread of mixed media once everyone has an ability to create digital media and arts, especially, 3D information which has become a principle of digital arts and media. It has been counted into the art project requirements and the project's pipeline becomes more complex but also flexible. Nowadays, the visual quality has become one of the main points of attention. There is more and more demand for 3D content with higher accuracy (Xi- Dao. L, 2008, pp. 52) However, the framework in 3D art system is still in the stage of development. The problems in terms of technique (e.g.,

[1] Unreal engine (UE) is a software to create a game developed by Epic Game Company. The first released on 1998 and the latest version is version 4.20 on 2018. It is a complete suite of development tools made for working with real-time technology. From enterprise applications and cinematic experiences to high-quality games across PC, console, mobile, VR and AR technology. (Unrealengine.com, 2018).

[2] Rendering, in this case is a part of progressing digital 3 dimensional image which is in the post-production process.

[3] Visual effect, in the case is means digital animation elements such as fire, water, smoke or wind that are generated by using computer software.

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polygon[4] count, long time rendering images or texture quality control) have occurred to the artist. Somehow, it involves between software and hardware development which has to be relevant.

The working pipeline, the typical problems with 3D phase are modelling, rendering and texturing. Rendering is a final stage of the pipeline before moving to composite and sound editing process. Thus, rendering process is involved with modelling and texturing (e.g., the polygon count of the modelling should not go beyond 3 million faces and the texture quality should not below than 1k but not go beyond 4k size in the render scene, if not, the computer will takes more time to generate the render image than usual). However, this situation is also engaged with computer processor and specification of hardware which has to synchronize with software, e.g., the using of graphic card of the computer prefers Quadro type than Gtx series for 3D processing. Moreover, this process needs several software to work together, e.g., for modelling and texturing is using Maya, cinema4d or zbrush and adobe packs to create. Once the model is done, the rigging animating and rendering could do in Maya or other 3D software. In the end, composite editing and sound editing could work in adobe-aftereffect, lightroom or adobe-premier to finish a production. These pipelines need so many software to finish and take a long time, especially on the rendering process. In this study, we have found that one of the solutions of this situation is using game engine, Unreal engine could cut some frameworks out and be able to finish the final product in game engine in high quality level.

Game engine, unreal engine, is a popular game creating software which allows the artist using for free, was developed by Epic game company. The impact of using Unreal engine in 3D character design package is marvelous. It could be animating, rendering, compositing, applying visual effect, environment creating, and sound editing can use the character in other games and interactive media such as VR, AR or game development. The photometric system of this engine has a film quality with the adjustment effect, e.g., ambient cube maps, ambient occlusion, advanced bloom, color grading, depth of field, eye adaptation, lens flares, light shafts, temporal anti-aliasing and tone mapping and more. (Unrealengine.com, 2018: online). Furthermore, this software is using real time rendering mode[5], which could cut the time for rendering out from the framework.

In this study, it has been shown that the gaming software affected the animation arts frameworks and created a new processing by studying from the experimental project. This article also provides the comparison results between general and mix software pipeline, introduction of unreal engine capability and profit of use. The purpose of this article is also discussed that the game engine, unreal engine could solve the problems in 3D phase of the frameworks which is a primary concern.

II. General Character design Methodology

In general, the character design process comprises of 3 phases, pre-production, production and post-production. In this specific case of this project module, it is separated into 2 phases, pre-production[6]+ semi-production[7] and production + post-production[8]. This framework is classified by software and technique workflow. Because of the technique on the production process is overlapping between 2 phases, pre-production and post-production, so the frameworks have been designed more concisely. The more, phase one could be a finished artwork in 2D platform so that why the frameworks were cut into 2 phases. However, phase 1 begins with brains storming and ends up with concept arts but still is not a final product, (Figure 1).

Phase 2 is the converting from 2D illustration to 3D platform and ends up with animation and 3D concept art. This framework is significant to identify a final characteristic that should be. In other words, it is a final definition of the character which is a person who has a figurative and mined, the character personality which is constructed from the beginning stage will point out the message to the audience. (Joao Ramos da, S., 2016, pp. 551). So this phase is extremely important in terms of arts.

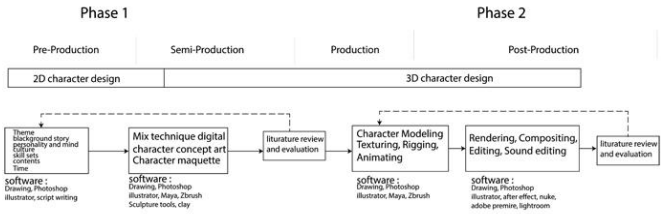

Fig. 1 the Diagram of the Character design frameworks module with 2 phases in animation software.

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[4] Polygon, in this case is a surface of the model in digital 3D model. It is formed with straight lines which are Triangles and quadrilaterals. In 3D workflows, polygon count and arrangement is the most important.

[5] Real time rending, in unreal engine is a command in UE4 to rendering a final image in real time unlike in animation software that needs long time for images rendering.

[6] Pre-production, in this case is the first step to create a character. The first step is brain storming and ends up with character concept art.

[7] Semi-production, in this case is a pre-production using production technique such as 3D or retouching to create a complete concept. Some of the project could finish in this point if that project does not require 3D character platform.

[8] Post-Production, in this case ends up with 3D figurative and animation of the character. However, it indicates a final design with a 2D and 3D platform.

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A. Digital 2D Character design and contents

The typical digital technique is applied on phase 1 is 2D. After making a decision of the theme, created a story background, character cultural design and personality design, and end up with concept art. The concept art is a key point of this phase. It could be created with a variety of techniques, e.g., digital painting technique. Some begin from the paper as traditional, then painting with a computer software. Therefore, the digital painting technique is flexible and the artist innovates a new technique as always. In this project case, it uses 3D modeling technique mixed with 2D digital painting. This does not require a polygon control in 3D part because the purpose of using 3D is to get the right form and shape including shade and shadow. This technique has saved time to get a final figure faster.

Fig. 2 Example result digital paint using 3D software to get a basic shape and shadow and paint over on 3D modeling (Nop K., 2016).

B. The Creation 3 dimensional character

In fact, the 3D phase has begun on the concept art process but it still needs a result from literature review and evaluation from the target group. This process also takes time to analyze but some project is approved by customer. In this case, to convert from 2D drawing to 3D drawing is using Maya and Zbrush as a main tool, thus it needs a polygon control. Because of the limitation of hardware and software in animation, in consequence, the problem on the render process has been on 2 steps which are 1) the step after animating the character, this is using Maya to render 2) Compositing step, this is using after effect and adobe premiere to render. Those 2 steps took a long time to finish and somehow got a computer file crashing and error because of the limitation of hardware. This project has made a new decision to using Unreal Engine to be a final step software that cover the requirement of the frameworks on phase 2, especially on post-production. The polygon use of 2 characters is about 1 million faces after Retopology[9] but not including environment. Once imported into the engine, it was able to animating in unreal engine and rendering simultaneously in high quality. The HDRI system was previewed on the screen in real time rendering. In game industry is used to create a movie promote call “cut-scene animation” This experiment has indicated that unreal engine could fix a problem of rendering time and could finished a post-production covered in one software.

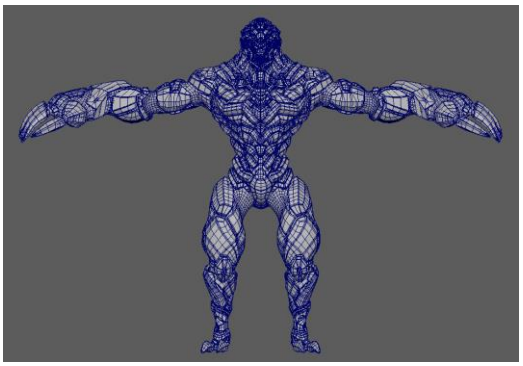

Fig. 3 Retopology of the 3D character before rigging. This is working in Maya (T. Oattarapon, 2018).

Fig. 4 Animating process in unreal engine with HDRI light generated. (T. Oattarapon, 2018).

III. UNREAL ENGINE CAPABILITIES

The software competencies are the core to build new frameworks at all the times. In this case, Unreal engine is a key to solve the problem in animation pipeline. Not only to solve the problem on rendering part, but it can also cut some pipeline out and finish in Unreal engine (UE), e.g., in the composite phase, it doesn’t have to shift from Maya or cinema 4D to adobe aftereffect (AE) to edit, the node call “blueprint” in UE is a key to comprise the scene and it works very well in current hardware (e.g. GPU, CPU processor and graphic card etc.). Unreal Engine (UE) have a varieties command to support a game industries but it can support in animation art very well and it is a profitable use.

A. Photoreal Rendering in real time in Unreal

Once the character modeling, texturing and rigging has been done, it has to do a Retopology first, then import to unreal. The photoreal rendering in unreal can render while animating or preview in high quality (Hollywood film quality

[9] Retopology, in 3D processing of rearranged a polygon from high polygon model to low polygon model. Mostly, this technique was used on before rigging and rendering.

as commercial from epic games). It could work as Playblast[10] command in Maya but totally different quality. So to apply this profit to the frameworks, the artist can do animating, setting up the light (SLR), rendering at the same time also using GPU or CPU rendering. (Fig. 5).

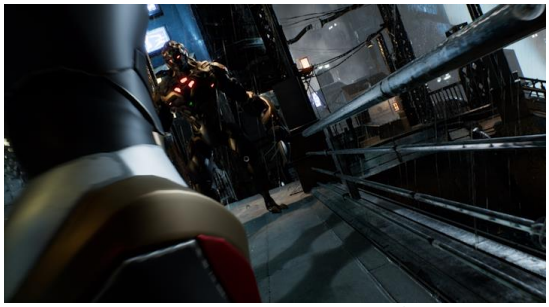

Fig. 5 Photoreal real time rendering on UE4 with full VFX and SLR set up. (T. Oattarapon, 2018).

B. Blueprint system without coding

As we know that, game engine needs to work with coding generally, it is the problem for the artist in somehow needs to study more about it. To create in advance for game, it needs specialist for C++ to develop the game. This code can be added into the blueprint node and it can keep the data and develop any time for using in other time, e.g., the artist can animate walk-cycle animation by using blueprint linked and adapted to children walk like, then keeping this data into a new separate blueprint node and using in other characters. Moreover, these 2 nodes can be linked together to become a new node continually It also supports a motion-capture[11] file type for alternative use. In this new feature, the developer adds an option for none coding user can use blueprint easier by using node system, as this profit, Unreal engine will be a widespread software in a short term. (Fig. 6)

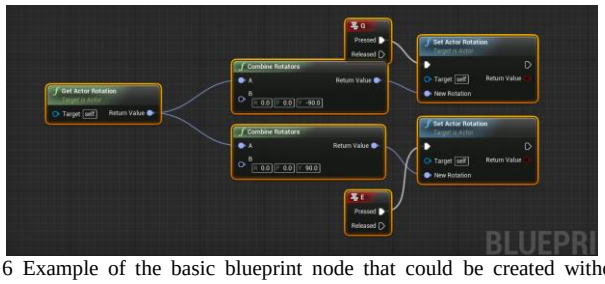

Fig. 6 Example of the basic blueprint node that could be created without adding code. (unrealengine.com, 2017).

C. VFX & Particle system and animation tool set

In animation process, visual effect such as water, explosion, smoke or even lighting effect need plugins or 3rd party software to build, e.g., realflow or nuke. In UE4, it can create a dynamic particle system on the scene with a high quality and yet render in real time in photometric mode at high quality level. This is phenomenal concept to added visual effect process at the same time with animating. The frameworks could be done faster as comparing with previous frameworks.

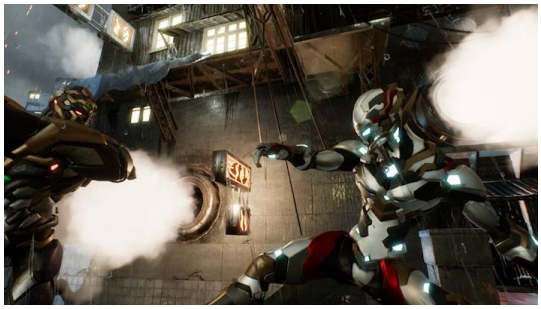

Fig. 7 Smoking effect in the scene is preset in the engine. It can edit a particle and render in real time as in the image. Also the effect on the texture of the character can glow by using visual effects (VFX) mode blueprint. (T. Oattarapon, 2018).

An extensive Animation tool set in animating process has been added in unreal feature, this command can customize the character gesture more unique. The power of this extensive tool such as state machines, blend spaces, inverse kinematics and animation driven physics have been added into animate blueprint. However, if an artist required more specific gesture and animating, this feature is the one option to edit in engine command.

D. Flexible Material Editor

The editing of the material in UE4 is more intuitive, once the plane material is added into the model, e.g., phong, phong E[12] in Maya, It can add the texture, fine tone, color and material into node system (blueprint) to create a new interactive material. Those material, also work well with SLR in the scene such as global illumination (GI) or high dynamic range imaging (HDRI). Of course, in Maya it could work too but the difference in UE is also to work in real time with a high quality texture preview.

[10] Playblast in Maya is a quick preview on screen mode, it provides an idea of the final render, timing and camera view. However, this could be only preview in draft quality.

[11] Motion-capture is an animation technology which is a process of recording the movement of object or people to get a data that using in computer animation. It help to cut a process of animating in animation pipeline easier.

[12] Phong and Phong E is a material shade in Maya. The specular highlights on Phong E surface are softer than those on Phong surfaces also render out faster. (knowledge.autodesk.com, 2018: online)

Fig. 8 Plane material of the character that apply in Maya but customized in Unreal engine (T. Oattarapon, 2018).

E. Film-quality Post-process effects

This is a post-production option that is added into UE4, this feature could work instead of compositing editing and sound in adobe aftereffect or premiere. The features have enabled a user to adjust the filmic effect including ambient cubemaps, ambient occlusion, advanced bloom, color grading, depth of field, eye adaptation, lens flares, light shafts, temporal anti-aliasing and tone mapping (www.unrealengine.com, 2018: online) This feature is a principal element of film editing, that is a particular point of the frameworks in 3D phases that is required to create a short film same as this project (Fig. 9).

Fig. 9 Screen capture while working on the final scene that rendering in real time, VFX added, SLR setup in to the scene. The frameworks could work these process at the same time and user can re-check and edit any time and flexible. (T. Oattarapon, 2018).

IV. ESTABLISH A NEW WORKFLOW

As the profit of using Unreal Engine (UE4), the project workflow has been modified in phase 2, production and Post-production part. However, the pipeline is still separated into 2 phases as general concept but final point has changed more concisely by ending up with UE4 (Figure 11), compared with the previous version, these frameworks have been tested and proceeded on the project as mentioned before, The creation of Science fiction Character inspired from Ramayana. It accelerated the timeline to be more compactable, because the artist has been able to animating, rendering, compositing and creating visual effect at the same time. This workflow was considered as an alternative for character artist which requires the character contents with more coverage for project presentation.

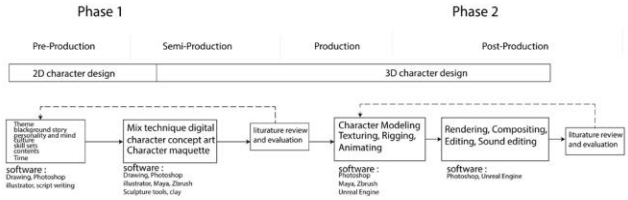

Fig. 10 the modifying frameworks arranged by software use that can end up with unreal engine in the post-production.

V. RESULTS

According to the results of new frameworks, it compared between general workflow (frameworks A: FWA) and mixed technique, using UE4 (frameworks B: FWB). It considered with time table, qualities of workflows and software synchronized. The results have shown on Phase 2. First, obviously time table on the FWB was reduced by post-production, e.g., rendering, compositing, editing and sound editing, had comprised production phases. It overlapped on rendering and compositing part, however, this will cut the timeline on the workflow also the timetable was decreased (Fig 11).

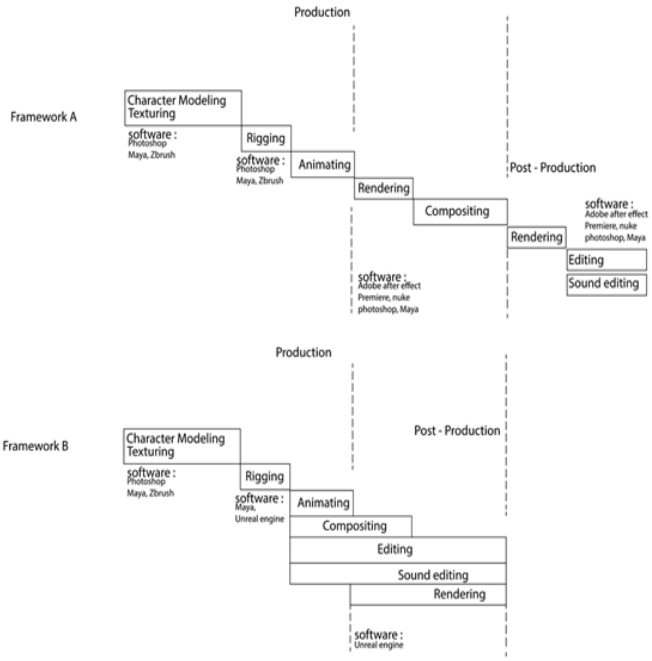

Fig. 11 Comparison of frameworks on Phase2, production to post-production, between frameworks A and frameworks B.

Second, the qualities of workflows were more flexible and accessible. Particularly, the editing between processes is easy to access and able to editing any time, e.g., on FWA workflows is a linear style, once the compositing stage has found some mistake on animating in the scene, it needs to re-render again to fix it, but on FWB workflows is more flexible, it can be shifted to animating stage in real-time and render out simultaneously. This is a big difference in work access between FWA and FWB, even sound editing that can work while animating on blueprint system. However, this module could be decided in several ways, depending on a specific purpose.

Third, once the Unreal (UE4) has been applied to the frameworks, it reduced the complexity of software linked. On FWA as can be seen on Figure 12, a linear workflow pattern, it required to shift a file type to sequence images before compositing and editing to the end. On the other hands, FWB could finish production in UE after rigging process. Therefore, on the rigging progress, also can do in UE on blueprint preset, then can animate in UE. It supports motion capture file and even Maya file if the animator prefers animating in 3D software. So the results in terms of software synchronize ability is adjustable, depending on the user.

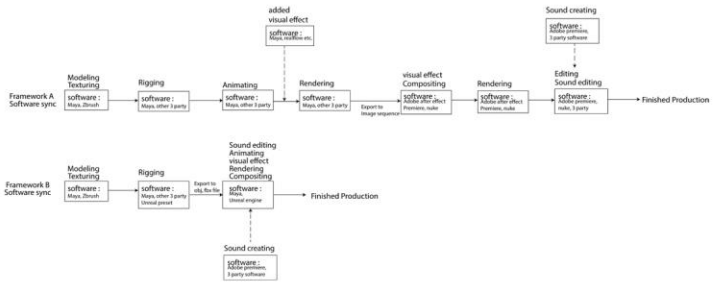

Fig. 12 Comparison of software used of frameworks A and B on phase 2, production to post production.

As a result from the project workflows, the software development is a key to complete artwork faster and with efficiency. In this case (FWB) which uses software integrate methodology between game and animation to create a new frameworks, it was found that this frameworks could be adjusted to more diversified method.

VI. CONCLUSIONS AND DISCUSSION

In terms of Art and Design in this digital age, computer knowledge and skills are a significant key to invent new things in this world. Digital Arts is the one that keeps going on along the technology in parallel. As follow this study frameworks, it has adapted following software and hardware technology to improve its efficiency. This could be one of a case study as a method to develop in different way. The impact results of this study which have been found are a new pattern of new workflows by changing software and illuminated some unnecessary process without decreasing a quality. Moreover, this pattern could conform to animation and film pipeline as an additional expect.

The crossing platform of software such as using Game engine: Unreal Engine, in digital arts is an alternative way to consider and could be possible. Somehow, any software in this digital society might cross each other unbounded which is very helpful to evolve a concept of frameworks more and more.

VII. REFERENCES

[1] Autodesk knowledge network.com. [Online]. Availablehttps://knowledge.autodesk.com/support/maya/learn-explore/caas/CloudHelp/cloudhelp/2015/ENU/Maya/files/Shading-Nodes-Phong-E-htm.html, August 2018.

[2] S. Brenden, “blueprints Visual Scripting for Unreal Engine: Build professional 3D games with Unreal Engine 4's Visual Scripting system,” United stage. Packt Publishing; 1 edition, July 2015.

[3] S. Joao Ramos da, M. Liandro Roger, Natal Anacleto Chicca. Jr., R. Artur de Oliveira da, M. Jose Gilvan Rodrigues, “Character design: a new process and its application in a trading card game,” SBC – Proceedings of SBGames 2016, ISSN: 2179-2259, September 8th - 10th, 2016.

[4] Unrealengine.com.]Online]. Available https://www.unrealengine.com/en-US/blog, August 2018.

[5] PV. Satheesh, “Unreal Engine 4 Game Development Essentials,” United stage. Packt Publishing; 1 edition, February 2016.

[6] L. Xi- Dao, X. Yu-Xing., Y. Long, W. Ling-Da., “Research and Development of 3D Modeling,” IJCSNS International Journal of Computer Science and Network Security, VOL.8 No.1, January 2008.

Nang Talung: Studying shadow play and the experience of Thai young people

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Abstract—This research studied the opinions and experiences of young people about shadow play ('Nang Talung') in Hatyai, Songkhla Province, in the southern region of Thailand. This project aimed to develop strategies for promoting shadow play amongst young people and to identify which media and shadow play genres are the best suited for adapting Nang Talung to their interests. At this research stage, 135 people between the ages of 18-22 were questioned. From those, half had less experience with shadow play. Contributions to the findings came from members of Prince of Songkla University and other educational institutions in Hatyai, as well as from the Vice President of the Shadow Play Society of Songkhla, who is a shadow player and advocate of shadow play in the community, seeking to preserve this tradition. The research tools employed include an online questionnaire, interviews, data analysis (percentage, average and standard deviation). The results of this research are as follows: 1) shadow play has become less popular, is hard to find, and has been replaced by new media; 2) local youth use the internet and smartphones in everyday life, and support the use of technology to promote shadow play; and 3) shadow players want to preserve the traditional shadow play artform, but acknowledge that digital technology would help to promote shadow play. The results of this research can lead to the new design and development of shadow play to be more contemporary to suit the lifestyle of the younger generation.

Keywords— folk media, Intangible Cultural Heritage, Nang Talung, shadow play, media, technology, Thai youth.

I. INTRODUCTION

The social elements in this study include beliefs, values, and norms. In light of this, culture can also be explained through folk media. Folk media is good at delivering and communicating cultural messages, and at making untold cultural stories even more valuable. Folk media has long been used to pass on stories from generation to generation and to encourage people in society to connect with knowledge, understanding, emotion, and passion [1].

From London to Bangkok, folk media is considered an effective way of preserving precious memories, national identities, beliefs, customs, and values. However, over time this media has become less popular. Akaradet's research argues that this exploitation of folk media is just a means to achieve particular goals, for instance, a commercial venture, without an actual interest in protecting and preserving the art form. This approach is commercially driven and shows no interest in modernising the medium so that it becomes more attractive to future generations [2].

With the surge of globalisation, the cultural environment of Thai youth is likely to be influenced by smartphones and internet usage. From an entertainment perspective, foreign cultures have a strong influence on Thai society through music and TV shows, which directly impact on Thai culture, social behaviours, and values [3], consequently becoming an integral part of youth culture in Thai society.

To protect its cultural heritage, the Thai government has launched policies that address this ongoing issue. Although people believe the issue is too sensitive and hard to control, most believe that the cultural heritage is important and needs to be taken care of and passed onto younger generations [4]. Furthermore, globalisation, communication technologies, and foreign media are having an impact on Thai youth which reduces interest in their own culture. The adoption of other media forms has subsequently replaced folk media, which is at the root of Thai cultural identity and is slowly being driven to extinction [5].

According to Asia-Pacific Cultural Centre for UNESCO (ACCU), there is a gradual disappearance of Thai culture and arts. Especially affected are traditional Thai performing arts such as folk drama, folk music, and folk dance. The concept of Intangible Cultural Heritage (ICH) explains that Nang Talung, or shadow play, is an essential cultural performance that represents the lifestyle of indigenous people in the south of Thailand. Similar art forms can also be found in neighbouring countries such as Cambodia, Malaysia, and Indonesia [6].

In 2009, Chaisuwan and Prajaknate found that social media was widely used amongst young Thai people [7]. The authors conducted a study to investigate their behaviour and usage of new social media. The findings of the study showed that Line and Facebook were the two most popular social media platforms and that young people accessed them via smartphone. The study also found that these two social media applications would usually engage the user for more than two hours per usage, non-stop. The on-line activities included watching cartoons or movies, listening to music, chatting with friends, playing games, and searching the web. The findings of the former study are consistent with those of Arpawet, Chewasart and Dejaswanong [8], which showed that young educated people used new media for fun, entertainment, and information. A recent study by Saisisod [9] also showed that university students connect with Facebook and YouTube mostly through their smartphone and notebook computers.

At this stage of the research, it is undeniable that several external factors are threatening Nang Talung, and that these factors might lead to its disappearance. Under such a drastic scenario, future Thai generations may no longer have access to their historical background since the social activities used

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to pass on these historical messages (e.g., Nang Talung) will have disappeared. If traditional practices are not adapted to current lifestyles and promoted via digital platforms, Thai culture and its identity may not be preserved or valued. Nang Talung plays a major role in conveying local messages, lifestyle, and the traditional culture of southern Thailand. It has been adapted to be more creative and appropriate to the changing context, establishing formal and informal dissemination networks, and being incorporated into the formal education system [10].

Only a few research studies on Thai shadow play have been conducted internationally; most studies are done at the national level. The studies addressing shadow play in Thailand reveal that Nang Talung has changed over time, in particular, its style and Puppet Theater [12] [13]. However, none of the existing research focuses on the opinions and experiences of young Thais or on the potential of using technology to support and promote Nang Talung.

With the aim of understanding the current aspects of Nang Talung among young Thais and of gaining insights into how they think about using technology, this research explored opinions and experiences in Songkhla Province in Southern Thailand. The findings of this pilot research will inform the designs and development of a contemporary shadow play.

II. Design of the Study

This study was cross-sectional and used a mix of methods to collect data. The duration was three months from April to June 2018. The objectives of this study are as follows: 1) To study current opinions and actual experiences about shadow play among youth in Southern of Thailand; and (2) To synthesize guidelines for promoting access to and interest in shadow play for Thai youth in southern Thailand.

The research location covers the area of Hatyai District, Songkhla Province, and was conduct in collaboration with the Prince of Songkla University, International College where a digital media course is provided.

Methodology

There are five methodological steps in this research:

1) Literature review on the history of southern folk media, especially the knowledge of shadow player, and other related studies.

2) Research tools comprise an online questionnaire and an in-depth interview guideline.

3) The researcher coordinated with key informants in the target area to make appointments with the target population and enlist support for the field study.

4) Field study for data collection.

5) Evaluation of the finding and reporting the results.

A. Sample Size and Sampling Method

The study populations are composed of 2,083 Thai youth who are between 18 and 22 years old and were located in Hatyai and Songkhla, as well as the experts, or the puppeteers who had long been expertise in folk media related to a shadow play who are called “Nai Nang”.

Purposive sampling was used to select Thai youth and puppeteers. The sample size calculation used in this research applied the Taro Yamane formula [14] at ± 10% for sampling errors. The Thai youth in this study are 135 students in the Digital Media Program of Prince of Songkhla University. A subsample of five youth participated a focus group discussion. One “Nai Nang” was selected for in-depth interview.

III. The Results of the Study

The results of this study are composed of three parts as follows:

Part A: Information about the use of media in daily life.

Part B: Information about opinions and experiences Thai youth have toward Nang Talung.

Part C: Content analysis of the focus group discussions and in-depth interviews.

A. Information about the use of media in daily life

The findings regarding daily use of media among the sample revealed that Thai music is the most popular type of media used (77%). The second most popular media was Thai drama (51.2%). Nearly all (97.8%) the respondents had a smartphone and used it for two to four hours daily. The second most used technology is a computer (81.5%) and the youth used it for one to two a day.

B. Information about opinions and experiences Thai youth have toward Nang Talung.

The findings from the online questionnaire show that 80.7% of all participants have seen a shadow play before. Among all participants, 49.6% reported seeing Nang Talung shows less than five times per year, and 72.6 % said that they liked the Nang Talung shows that they had seen.

The main reason for watching Nang Talung is entertainment followed by an interest in understanding Thai culture and gaining knowledge of history.

What makes Nang Talung most attractive is the use of funny jokes within the show followed by the storyline; only 1.5% reported liking the atmosphere of a live show.

The most liked storylines are humorous (62.2%) and historical (17.1%); the least enjoyed are love-based stories or cartoons (1.5%).

What people dislike the most about Nang Talung is the long performance (36.3%), the disturbances and noises from the surrounding area (35.6%), too much dialogue (25.9%), the abusive jokes (13.3%) and the unclear dialect (1.5%).

About half (48.9%) of Thai youth have watched Nang Talung online, one-fourth (25.2%) saw it at a festival in a temple and less than 1% saw a performance on TV. The most watched internet channel is YouTube (66.7%).

Over half (57.8%) of the respondents observed that there was less publicity of Nang Talung these days. They recognize that there is a need to preserve these art forms from one generation to the next. It is important to include

humerous content for the plays, and its charm is that it is shown at night. Most (78.5%) felt that technology should be used to keep Nang Talung current with the times. See detail in Table I.

TABLE I. INFORMATION ABOUT THE OPINION OF THE PARTICIPANTS ON NANG TALUNG. (n=135)

Issues	Number	Percentage
The prevalence of shadow play		
Less popular	58	42.9
Normal	43	31.9
Very popular	34	25.2
What is the charm of shadow play? (more than one answer)		
Perform in the night time	22	16.3
The technique of the performance	53	39.3
Fun story	68	50.4
Transfer from the old generation to new gen	78	57.8
Southern Language	1	0.7
Should we use technology to present Nang Talung or not?		
Yes	106	78.5
No	29	21.5

Reasons for not watching Nang Talung:

- It is boring and unentertaining.
- Not coeval.
- Modern movies and music are more attractive.

The participants suggested that the use of phone technology will help to promote Nang Talung as it will be easier and more accessible to Thai youth since they are always with their smartphone. That way, it is portable and easy-to-watch at anytime, anywhere. For the public sphere, the participants recommended the use of projectors in order to link the video from a smartphone so that more people can participate. Another interesting suggestion is to use the internet or online media to gain access to Nang Talung at any time and provide access to re-runs of popular performances.

C. Content analysis of Thai youth by focus group and in-depth interview of "Nai Nang".

These days, Nang Talung's popularity has massively declined compared to that in the past because it is so difficult for youth to access. A typical Nang Talung performance takes at least four hours to perform, and it is usually performed at night. This is inconsistent with today's lifestyle of Thai youth who are more accustomed to movies or animated cartoons.

The Nai Nang is concerned much about the current style of Nang Talung which is focused more on entertaining by jokes instead of moral or practical content. Apparently, today's youth prefer funny content to help them relax, and Nang Talung will lose its identity by catering to that.

Both groups of respondents felt that modern technology should be used to promote Nang Talung. Also, YouTube should be used more to show Nang Talung.

IV. Conclusions and discussion

This study confirms what is already known: Thai youth are on their smartphones and the internet every day. Almost all participants encouraged the use of modern technology in order to promote Nang Talung since it is much easier for the target audience to access. Also, by doing so, people are allowed to watch Nung Talung anywhere and at any time. These finding results are consistent with the study of the Office of Policy and Strategy of the Ministry of Public Health (2009) which found that Thai youth are increasingly influenced by global trends in media and performance, and this diminishes their interest in local art forms. [15]

Most respondents reported having had good experience with Nang Talung in the past and enjoy the comedy and fantasy aspects of it. However, they feel that Nang Talung is too long, noisy and sometimes hard to understand. Also, some jokes are too foolish and rude to the youth. However, they also acknowledge the importance of preserving and transmitting folk media from generation to generation. That provides some hope for sustainability of Nang Talung. These results indicate that folk media and Nang Talung should be preserved as well as modified while also maintaining the traditional values of Thai culture. According to Kaewtep K., (2005) [16], traditional media helps express social values, spirit and lifestyle of a social group to the audience. Rational media is also known as a social controller that maintains the cultural heritage and establishes social norms in society. The main features of traditional media include: 1) Being formed and practised among the social group; therefore, easily accessible and understandable by the group; 2) Having creative and primary appeal to the emotions rather than the intellect; 3) Flexibility in changing the form and content appropriate to the each certain context; 4) Use of local dialect, delightful, charming, appealing; 5) Cost-effectiveness; and 6) Embedded in one's own culture and tradition, and intimate with the group.

3) The Nai Nang, or shadow player, is concerned about the modern style of Nang Talung since it mainly focuses on providing jokes instead of any moral or useful content. The traditional playing styles are at risk of being lost if no one continues passing on the show. At the same time, the shadow player encouraged the use of new technology to promote Nang Talung. Kaewtep K., (2005) confirmed these findings, and various media have been developed to create new communication channels. Media that has been developed creatively is called 'New Media' [17] [18] which are forms of technological media utilised for current communication. DeFleur M. (1989) [19] reported that movie media is highly influencing.

4) Both Thai youth and the Nai Nang agreed that a better way to promote Nang Talung to the new generation is to apply the use of new technology such as using a projector to expand the image from a smartphone so that a group of friends can watch. Also, using the internet or any online media in order to gain better and easier access to Nang Talung will also make Nung Talung more popular among young people. This is supported by many pieces of research. P. Mistry, P. Maes, (2009) [20] studied *SixthSense a wearable gestural interface* to develop a portable digital projector, that can sensor natural hand gestures. The SixthSense allows natural hand gestures to interact with digital information such as finger drawing. Devices used are portable digital projectors, and they are wearable. Moreover,

H. Hyunwoo, K Kwanghee, (2015) [21] studied *A method for image-based shadow interaction with virtual objects.* The research presented a shadow gesture recognition method with an interactive projection system; method detected moving objects in real-time. Thus, smartphones and the internet are the best-suited media for adapting Nang Talung to the interests of the new generation.

V.Suggestions

This study is social phenomenon research of Nang Talung, revealing a declining popularity of Nang Talung. There are both internal and external factors contributing to the topic; some people think that Nang Talung itself is already out-of-date and sometimes too hard to understand, whereas other believe that the surge of technology, such as the use of smartphone and computer, are more attractive and divert Thai youth to global media. In order to facilitate and gain better access to Nang Talung, the researcher proposes the following issues for further research:

1) The future study should be focused on a range of age groups, including older people who might have a stronger attachment to Nang Talung. Their suggestions might be useful in developing and guiding an idea of how the new media can be adapted to Nang Talung.

2) Based on the findings, promoting Nang Talung through the use of new technology such as smartphones and online media will greatly help to make Nang Talung more accessible. Therefore, the future study should also focus more on the development of youth and Nai Nang who participate in designing the model in order to gain a better understanding of this issue. At the same time, the future research should also focus on Nang Talung's traditional style, otherwise the traditional art form could be lost.

3) The continuity, transmission and development are not just a function of one person. All Thais must help each other. If Thais do not protect and maintain their culture, it will gradually disappear. The fate of Nang Talung lies in the hands of all segments of society.

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REFERENCES

[1] K. Kaewtep, and T. Akaradet, "Folk Media for Health," Bangkok: The publisher of Thammasart University, 2006.

[2] T. Akaradet, "NORA: Culture of Community Health," International Museum, (Copy). 2002.

[3] D. Patcharaporn, "The International Cultural Hybridization on Television," Executive journal Bangkok university, 33(1), pp. 87, 2014.

[4] K. Chancharoen, et.al., "Strategies for Human Resources Development by using Folk Media: A Case study of Folk Media for Youth Health in the Northern Region." Kasetsart Journal. (Social Sciences), 33(1), pp. 27-42, 2012.

[5] S. Ubonrat, "Basic Communication: Media. Mass culture and society," (3rd edition), Bangkok: The publisher of Chulalongkorn University, 2007.

[6] L. Siyuan, "Routledge Handbook of Asian Theatre," Routledge., 553, 561. ISBN 978-1-317-27886-3., pp. 194, 2016.

[7] B. Chaisuwan, P. Prajaknate, "New media usage behavior of teenage 10-19 years old. Journal of communication and management," National institute of development administration, vol 1 (1), 2009.

[8] W. Arpawet, S. Chewasart, C. Dejaswanong, "Face book Usage: Communication Behavior of the Rajamangala University of Technology Phra Nakhon' Students." Mass Communication Technology, Rajamangala University of Technology Phra Nakhon. 2011.

[9] S. Saisisod, "The opening online newspaper behavior of the students in Udon Thani Municipality." Copyright © 2016 Udon Thani Rajabhat University. All Rights Reserved., 2016.

[10] O. Promtape, "Learning of shadow players for their existence of shadow plays in modern society," Princess of Naradhivas University Journal., pp. 41-56, 2010.

[11] O. Promtape, "Learning of shadow players for their existence of shadow plays in modern society," Princess of Naradhivas University Journal., pp. 41-56, 2010.

[12] K. Kaewtep, "Consider and Re-think: Applying folk media for development." Bangkok. The publisher of Thammasart University, 2005.

[13] J. You-Thong, "Adaptation of Nang Talung In Change Situation," Vol. 37, pp. 42-52, 2016

[14] Yamane, Taro. "Statistics: An Introductory Analysis." 3rd ed. New York: Harper and Row Publication, 1973.

[15] Office of Policy and Strategy Ministry of Public Health. The Report of Situation and Trends of Factors Affecting Thai children's health. Bangkok: The War Veterans Organization of Thailand Press., 2009.

[16] Kaewtep K. Consider and Re-think: Applying folk media for development. Bangkok. The publisher of Thammasart University, 2005

[17] Wertime, K. & Fenwick, I. DigiMarketing: The essential guide to new media & digital marketing. Singapore: John Wiley, 2008.

[18] Dewney A., Ride P. The Digital Media Handbook: Media Practice. Taylor & Francis. London & Newyork: Routledge. 2006

[19] DeFleur. M. & Ball-Rockeach. S. Theories of Mass Communication. 5th edited. Longman. 1969.

[20] P. Mistry, P. Maes, "SicthSense: A wearable Gestural Interface", SIGGRAPH Asia 2009, Yokohama, Japan, December 16–19, 2009.

[21] H. Hyunwoo, K Kwanghee, "A method for image-based shadow interaction with virtual objects", Journal of Computational Design and Engineering 2, pp.26–37, 2015.

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An Investigation of Monetisation Models in Digital Games

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Abstract—This paper presents a review and comparison of monetisation models in a free-to-play gaming. The monetisation is the essential element in a game production process because it helps clarify the design that should be compatible with the monetisation models and revenue generation methods of the game. The investigation is conducted by utilising a set of online questionaires. The results show that the in-game Ads are not bothering the majority of players and players does not pay to remove them. Fashion and uniqueness of player's avatar is more important than the in-game items that would help player in a game.

Index Terms—monetisation, revenue generation models,digital game, game marketing, game design analysis

I. Introduction

These days, a game has many revenue generation strategies in the global gaming market. Two of the well-known strategies are pay-to-play and free-to-play. Obviously, pay-to-play is the way to make money out of a game commonly known. However, the pay-to-play has one of the important drawback i.e., lack of the opportunity for game players to try before purchase. A free-to-play strategy tackles this drawback by offering a free gameplay and has some kind of models to generate revenue from the game i.e., monetisation models. This free-to-play kind of revenue generation strategy is widely available in today's digital gaming market. However, several monetisation models in a free-to-play game are available but a few information exists about which monetisation model is better than the others. This paper aims at investigating this information.

Monetisation model or revenue generation model is a mechanism in a free-to-play game that persuades players to pay to get extra characters, items, functionalities etc. of the game. These extra features of the game may or may not be the essential elements of the gameplay. However, it has been proven that some of the monetisation models is success in the revenue generation of a game.

Many monetisation models exist these days in the digital era including public Wi-fi advertising [3], monetisation incorporate in the software development process [1], cloud simulation platform [2], mobile advertising [6], and advertisement in mobile games [5].

This paper focuses on the monetisation models in digital gaming. To find out what is the effective monetisation model to persuade a player to pay in a free-to-play game. To find out the reason why a player intends to pay for a particular feature of a free-to-play game.

II. Related Works

Monetisation is very common in the digital world. It does involve in a number of digital content business such as in a software development process [1].

Monetisation of mobile free-to-play games has been applied to a software development to incorporate the revenue generation element in the early stage of the software development life cycle [1].

[10] reviews the influential factors that affect purchase intention in a virtual world. Four factors are identified i.e., enjoyment, social influent, customisation, and ease of use. Excitement, entertainment, and relaxing are the keys to those players who seek the enjoyment that can help them escape from the reality world. Social existence is also the important factor that affects purchase intention. A unique customisable character in a virtual world is another crucial factor. Ease of use is another key for the success of a smooth process to fulfil player intention to purchase in a virtual world.

[7] purchasing behaviour in free-to-play games [8], [9] why people buy virtual items in virtual worlds with real money

III. The Monetisation Models and Influential Factors

This section summarises the available monetisation models in a free-to-play game and the factors that could influence a decision to purchase in-game features. These models and factors are the basis for the design of a set of questionnaires.

A. Monetisation Models

Summarise of the monetisation models in free-to-play games are shown as follows.

1) Pay to unlock characters
This model has a mechanism that a player has the

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opportunity to unlock new characters by progressing the game or pay certain amount of money to unlock the characters.

2) Pay to remove Ads
A game contains in-game sponsorship Ads that appear during the gameplay e.g. during the scene transition, at the bottom of the game screen etc. A player has the option to remove the Ads by paying extra money to remove the Ads.
3) Pay for a special character
This model is very similar the the "Pay to unlock characters". However, a special character does exists in some games e.g. a special event character that can be purchased in a limited period of time.
4) Pay for an in-game item
An in-game item that is rarely to find would be purchased directly to unlock extra power or some kind of boosts in the game mechanic.
5) Pay for Gashapon
A "Gashapon" is the mechanic that allows players to buy a virtual box of item that can be opened and get a random chance to get an extremely rare to find item in the game.
6) Pay for an extension or downloadable content
A new story or map of the game could be purchased if a player satisfied with the current mechanic of the game.
7) Pay for continuous playing
Some of the games allow players to play by utilising energy that depleted over time. A player has to wait for certain amount of time for the energy to be recovered. A player that would want to play more without the waiting has the option to pay for this purpose.
8) Participate in sponsorships' programme for an in-game reward
Some games allow player to do an activity with the game's sponsorship programme to get some kind of rewards that can be used in the game.

B. Factors Affected the Decision to Pay

The factors that influence a decision to purchase in a free-to-play game are list as follows.

1) Want to win
A player wishes the win a game.
2) Want a good looking, unique, and different from other players
In a social or massive multiplayer online game that a player plays as a character avatar which is customisable for the look of the character.
3) Effortless, convenient ways, shortcut ways, don't have time to play
This is a shortcut way to win a game by paying extra money for the in-game mechanisms that can accelerate the time to reach the game's goal.
4) The Ads are annoying
The in-game Ads are annoying and a player pays to remove the Ads.
5) Wish to have a special / rare item
A special or rare to find item can be purchase or find via a Gashapon system.
6) Wish to get a special character
Some players want to get a special playable character that is different from the one they are used to have.
7) Wish to play continuously without waiting time to recover
A cool down mechanism in a game prevents player from progressing too rapidly. However, there is a way to accelerate this cool down mechanism by paying money so that the publisher of the game can generate revenue from this mechanism.
8) Wish to get an extension / downloadable content of the game
A player loves the game and wish to play with the extra contents of the game. A game publisher can generate revenue with an extension or downloadable content of the game.

IV. The Investigation Method

A quantitative approach is adopted to investigate the information in this research. A set of questions is produced via an online questionnaire platform to investigate the information from game players. The questionnaire is designed to investigate the tendency to pay to particular monetisation models and factors listed in the previous sections. The URL link of the online questionare is distributed towards a teenage group that regulary plays games.

V. Result

A total of 31 subjects participates in this investigation. 48.4% of the participants are male. Most of the participants ages between 18 to 24 years old while a few of them ages over 35.

Fig. 1 shows a number of players tends to pay to unlock a game's characters. Most of them has never paid for this purpose while the rest of the players occasionally pay to unlock character. Most of the players population has never paid for the purpose of Ads removal as shown in Fig. 2. An in-game special character is occassionally purchased by players as show in Fig. 3. Fig. 4 and Fig. 5 show the result in the similar way as Fig. 3 that players tends to pay for an in-game item and Gashapon, respectively, spatially distributed among the never to always pay. A few of player samples has paid for an extra feature or a downloadable content of a game as shown in Fig. 6. The graph distribution is rather similar in the "Pay for continuous playing" as shown in Fig. 7. A result of the sponsorships' participation reward programme is shown in Fig. 8. The distribution is considered equal among the scales.

Fig. 9 shows the result from the multiple choices formed from the factors in section III-B, numbered respectively.

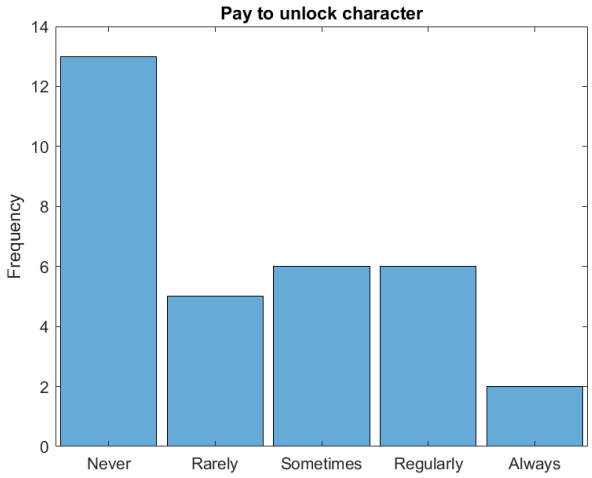

Fig. 1. Pay to unlock characters.

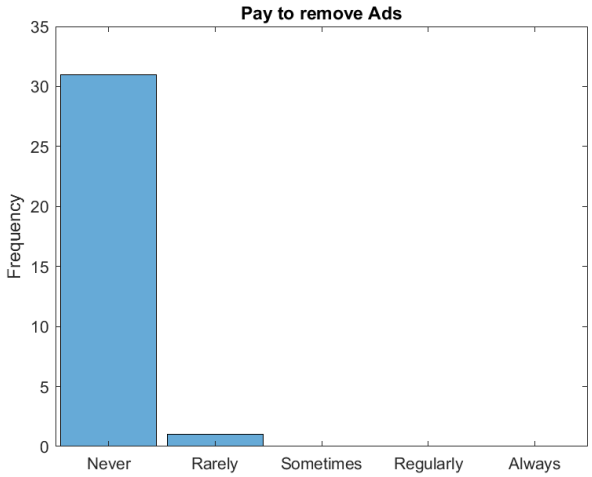

Fig. 2. Pay to remove Ads.

VI. Discussions

It is interesting that most of game players does not want to pay for Ads removal as shown in Fig.2. It might be implied that a game can have Ads without annoying much of most players. This is also agreed with the multiple choices investigation as shown in Fig. 9 and the bar graph numbered 4.

Fashion items, good looking character, uniqueness are keys for most of the game players who wish to spend money on their loved game. This is confirmed with one of the 4 factors of [10] and the result in this research as shown in Fig. 9 and the bar graph numbered 2.

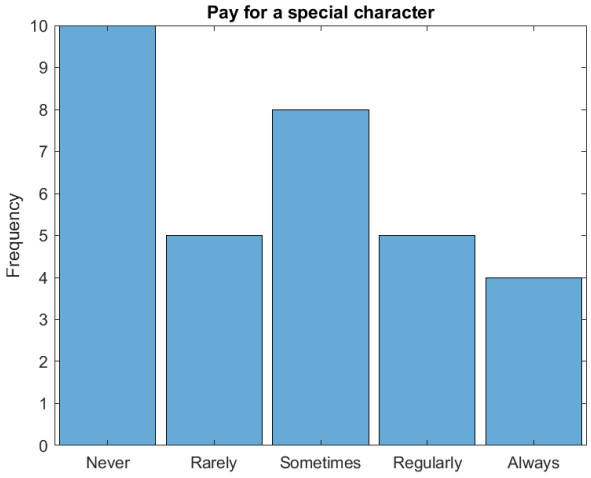

Fig. 3. Pay for a special character.

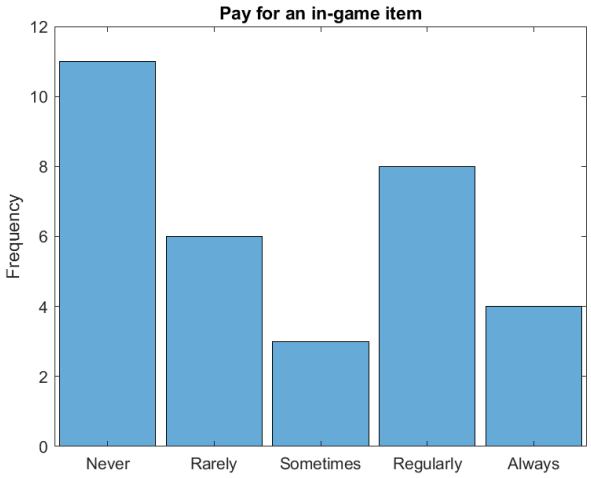

Fig. 4. Pay for an in-game item.

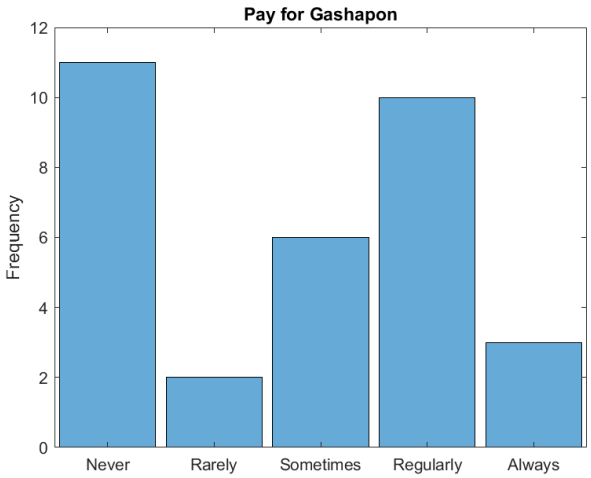

Fig. 5. Pay for Gashapon.

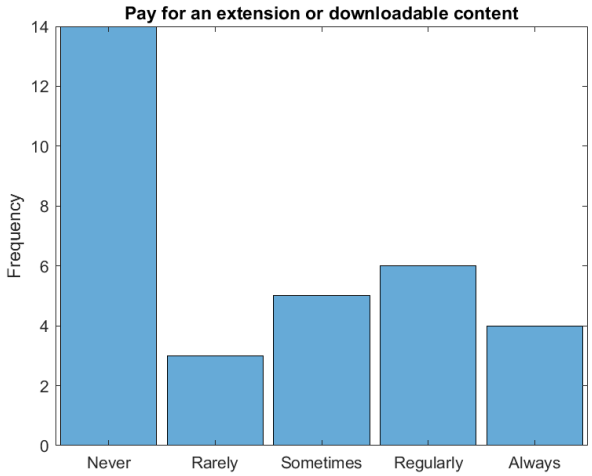

Fig. 6. Pay for an extension or downloadable content.

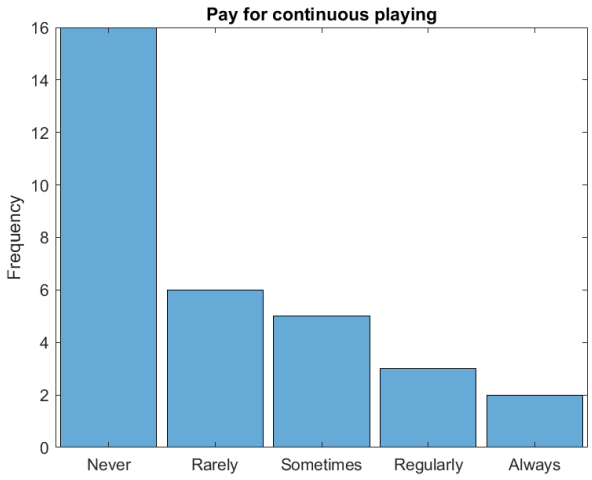

Fig. 7. Pay for continuous playing.

VII. Conclusions

This paper investigates the monetisation / revenue generation models in a free-to-play game. A number of monetisation models exists in these type of games. However, not all of the monitisation models does work in the real world gaming. The paper takes survey information from a number of potential game players and shows some of the intersting results. Players does not bother about the Ads that is annoyed in a game. Most players pay for fashion for a good looking avatar in a game.

References

[1] T. Ketola, "Quantifying software development: Applying mobile monetization techniques to your software development process," 2014 Computer Games: AI, Animation, Mobile, Multimedia, Educational and Serious Games (CGAMES), Louisville, KY, 2014, pp. 1-4.

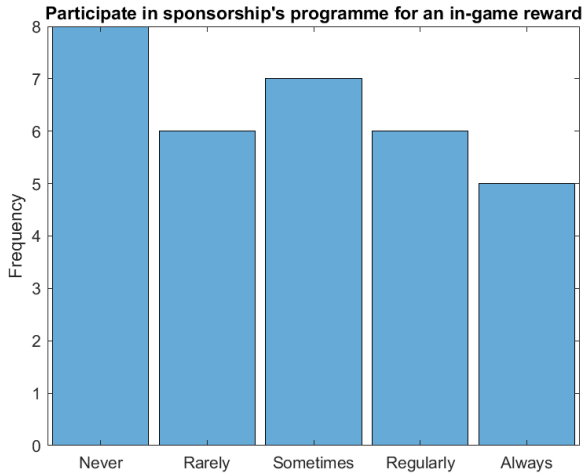

Fig. 8. Participate in sponsorships' programme for an in-game reward.

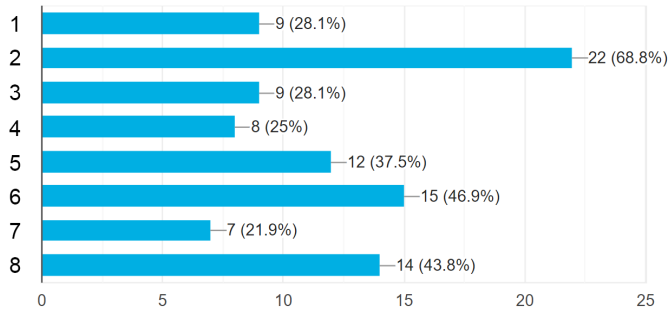

Fig. 9. Factors affected decision to pay.

[2] L. Yu and H. Zhang, "An effective monetization model with pricing and charging strategy on Cloud Simulation Platform," Proceedings of the 2012 IEEE 16th International Conference on Computer Supported Cooperative Work in Design (CSCWD), Wuhan, 2012, pp. 411-415.
[3] H. Yu, M. H. Cheung, L. Gao and J. Huang, "Public Wi-Fi Monetization via Advertising," in IEEE/ACM Transactions on Networking, vol. 25, no. 4, pp. 2110-2121, Aug. 2017.
[4] T. Yamakami, "Revenue-generation pattern analysis of mobile social games in Japan," 2012 14th International Conference on Advanced Communication Technology (ICACT), PyeongChang, 2012, pp. 1232-1236.
[5] I. Prochkova, V. Singh and J. K. Nurminen, "Energy Cost of Advertisements in Mobile Games on the Android Platform," 2012 Sixth International Conference on Next Generation Mobile Applications, Services and Technologies, Paris, 2012, pp. 147-152.
[6] G. Chen, S. Ji and J. A. Copeland, "Towards a Framework to Facilitate the Mobile Advertising Ecosystem," 2016 IEEE 22nd International Conference on Parallel and Distributed Systems (ICPADS), Wuhan, 2016, pp. 456-465.
[7] N. Hanner and R. Zarnekow, "Purchasing Behavior in Free to Play Games: Concepts and Empirical Validation," 2015 48th Hawaii International Conference on System Sciences, Kauai, HI, 2015, pp. 3326-3335.
[8] Yue Guo and Stuart Barnes. 2007. Why people buy virtual items in virtual worlds with real money. SIGMIS Database 38, 4 (October 2007), 69-76.
[9] Guo, Y. & Barnes, S. Electron Commer Res (2009) 9: 77. https://doi.org/10.1007/s10660-009-9032-6

[10] Daniëlle N. M. Bleize & Marjolijn L. Antheunis (2017) Factors influencing purchase intent in virtual worlds: a review of the literature, Journal of Marketing Communications, DOI: 10.1080/13527266.2016.1278028

Designing of Fractional Order PID Controller for 4-Pole Hard-To-Be-Control Plant

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***Abstract*—This paper proposes the fractional-order proportional-integral-derivative (FOPID or $PI^{\lambda}D^{\mu}$) controller design optimization for a 4-pole hard-to-be-control plant by using the flower pollination algorithm (FPA), one of the most efficient metaheuristic optimization search techniques. FPA is applied to design an optimal FOPID controller by searching for the 5 appropriate parameters to meet the response specification of the plant. Results obtained by this method will be compared with those obtained by the conventional controller or integer-order proportional-integral-derivative (IOPID or PID) controller. By comparison, the optimal FOPID controller yields very satisfactory responses superior than the IOPID controller with very small steady-state error of unit step response. MATLAB and FOMCON programs are used to conduct this research.**

Keywords—FOPID controller, IOPID controller, optimization, FPA, hard-to-be-control plant

I. INTRODUCTION

Controller is an important part of closed loop control system. There are proportional (P), proportional-derivative (PD), proportional-integral (PI) and proportional-integral-derivative (PID) controllers. The PID controller has been accepted and widely used in various automatic control systems since the first proposed by Minorsky [1]. The PID controller is widely accepted in industrial applications [2-5]. More than 95% of process control applications are controlled by PID controllers [6]. This controller uses integer-order (IO) as basis of designing. We name the controller as integer-order proportional-integral-derivative (IOPID) controller. We often called IOPID controller as PID controller. The controller has been played an important role as the heart of control engineering practice for over nine decade. The effects of IOPID parameters, i.e.; proportional constant, K_p; integral constant, K_i; and derivative constant, K_d; on system responses have already been well-known for theorists and practicing engineers.

The fractional-order PID (FOPID) controller (or $PI^{\lambda}D^{\mu}$ controller) was firstly proposed by Podlubny in 1994 [7]. In 1999, Podlubny reported this new controller to IEEE [8] and showed analysis in time domain. At the same time, Petras reported FOPID controller analysis in frequency domain [9]. The FOPID controller demonstrated the better response in comparison with the conventional IOPID controller. Once the FOPID controller is compared with the IOPID controller, there are two extra parameters λ (integration order) and μ (derivative order) making the FOPID controller more efficient, but more complicate than the IOPID controller in designing and implementation procedures. The FOPID controller has been successfully conducted in many applications, e.g., process control [10], and DC motor control [11]. Several design and tuning methods for FOPID controller have been consecutively launched, e.g., rule based methods [12-13] and analytical methods [14-15]. Review and tutorial articles of the FOPID controller providing the state-of-the-art and its background have been completely reported [16-17].

Recently, control system synthesis has been changed from the conventional paradigm to the new framework based on modern optimization using metaheuristics as an optimizer [18]. The flower pollination algorithm (FPA), firstly, proposed by Yang in 2012 [19]. Since then, there are wide range of diverse applications with more than 500 research papers published so far in the literature [20]. The FPA was proved for the global convergent property [20] and successfully applied to many real world engineering problems. In this paper, the FPA is applied to optimally design the FOPID controller for 4-pole hard-to-be-control plant. The rest of the paper is outlined as follows: fractional calculus and FOPID controller are briefly described in section II. Problem formulation of FPA-based FOPID controller design for 4-pole hard-to-be-control plant is performed in section III. Results and discussions are illustrated in section IV, while conclusions are summarized in section V.

II. FRACTIONAL CALCULUS AND FOPID CONTROLLER

A. Fractional Calculus

The idea of fractional calculus has been known since the development of the regular (integer-order) calculus. With the first reference probably being associated with Leibniz and L'Hopital in 1695 [16-17] where half-order derivative was mentioned. Fractional calculus is a generalization of integration and differentiation to non-integer order. Fundamental operator ${}_aD_t^{\alpha}$, where *a* and *t* are the limits of the operation. The continuous integro-differential operator is defined as in (1).

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where $\alpha \in R$ stands for the order of operation.

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The second definition is Riemann-Liouville (RL) as expressed in (5), for $n\text{-}1 < \alpha < n$. The third definition is Caputo definition as shown in (6), where n is an integer and $n\text{-}1 < \alpha < n$. Among those, the Caputo definition is most popular in engineering application [16].

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$$ \begin{aligned} \mathcal{L}\left\{ {}_aD_t^{\alpha} f(t) \right\} &= \int_0^{\infty} e^{-st} {}_0D_t^{\alpha} f(t) dt \\ &= s^{\alpha} F(s) - \sum_{k=0}^{n-1} s^k {}_0D_t^{\alpha-k-1} f(t)\Big|_{t=0} \end{aligned} \tag{7} $$

For solving engineering problems, the Laplace transform is routinely conducted. The formula of the Laplace transform of the RL fractional derivative in (5) is state in (7), for $n\text{-}1 < \alpha < n$, where $s = j\omega$ denotes the Laplace transform complex variable. Under zero initial condition for order α ($0 < \alpha < 1$), the Laplace transform of the RL fractional derivative in (5) can be expressed in (8)

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The FOPID or PI$^{\lambda}$D$^{\mu}$ controller is an extended version of the conventional integer order PID (IOPID) controller. The generalized transfer function of the FOPID controller is given by the differential equation as stated in (9), where u(t) is unit step input signal as the control signal, e(t) is the error signal and λ and μ are more than zero. The Laplace transform of the transfer function is expressed by (10).

$$ \mathrm{u}(t) = K_p \mathrm{e}(t) + K_i D_t^{-\lambda} \mathrm{e}(t) + K_d D_t^{\mu} \mathrm{e}(t) \tag{9} $$

$$ \mathrm{G}_c(s)\big|_{\mathrm{FOPID}} = K_p + \frac{K_i}{s^{\lambda}} + K_d s^{\mu} \tag{10} $$

Relationship between the IOPID and the FOPID controllers can be represented by a graphical way as visualized in Fig.1. In most research works, the ranges of λ and μ are varied from 0 to 1. If λ and μ are ones, it is the IOPID controller. Otherwise are FOPID controllers. If λ and μ are varied between one and two, the controller tends to be unstable.

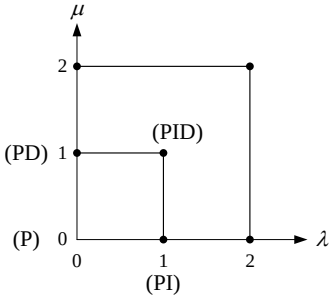

Fig. 1 Relationship between IOPID and FOPID controllers.

III. Problem Formulation

In this section, the FOPID control loop, the transfer function of 4-pole hard-to-be-control plant and the FPA-based FOPID controller design are consecutively presented as follows.

A. FOPID Control Loop

The FOPID control loop is represented by the block diagram as shown in Fig. 2, where $G_p(s)$ and $G_c(s)$ are the plant and the FOPID controller models, respectively. The FOPID controller receives the error signal E(s) and produces the control signal U(s) to control the output signal C(s) and regulate the disturbance signal D(s), referring to the reference input R(s).

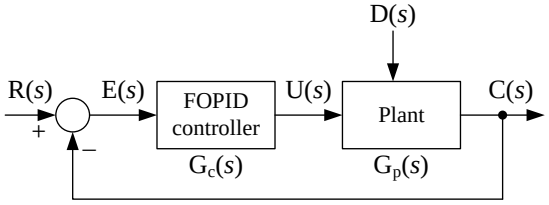

Fig. 2 FOPID control loop.

B. 4-pole Hard-to-be-control Plant

Because there are some standard systems those are well suited to parametric studies for research and for evaluation of commercial systems. These systems are benchmark systems [21]. Some of these benchmark systems are more specialized and illustrate with various hard-to-be-control. PID control is not well suited for all of them. Finding the new method to control these systems, we should try to use FOPID controller instead of IOPID controller. To illustrate FOPID control, first of all, we select a hard-to-be-control system which has transfer function shown in (11)

$$G_p(s) = \frac{(s+6)^2}{s(s+1)^2(s+36)} \quad (11)$$

This system is conditionally stable [21].

C. FPA-Based FOPID Controller Design

Designing methods of FOPID controller are as follows.

1) Analytical method [14-15].

2) Numerical method [10].

3) Rule-based tuning method [10, 12-13], e.g., Ziegler-Nichols type tuning rule method [12]. and

4) Optimization method [16-20], e.g., metaheuristic optimization method [18].

In this paper, FPA is used to design the FOPID controller instead of using Ziegler-Nichols type tuning rule method because the later method is difficult to or can not find s-shaped unit step response of the plant and/or critical gain of the plant [12]. Also, FPA is a promised metaheuristic algorithm for fast global convergence [19-20] and successfully applied to many real world engineering problems [20].

The FPA-based FOPID controller design framework can be represented by the block diagram shown in Fig. 3.

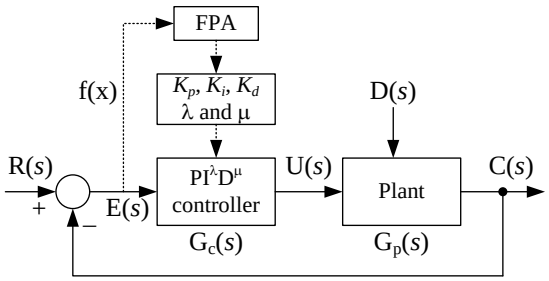

Fig. 3 FPA-based FOPID controller design framework.

Referring to Fig. 3, using pseudo code of FPA [19], the objective function, f(x) or f_{design}, and the error E(s) will be fed to the FPA to be minimized by searching for the appropriate values of the FOPID (or $PI^{\lambda}D^{\mu}$) controller parameters, i.e., K_p, K_i, K_d, λ and μ subject to inequality constraint parameters satisfying to the predefined response specifications.

The FPA's parameters:

f_{design} = objective function, f(x)
r_i = reference input signal = solution, x
c_i = controlled output signal = current best solution, g^*
N = number of sampling data in observed period
Γ(λ) = standard gamma function
L = Levy flight
n = number of generated flowers in the population
p = switch probability ∈ [0, 1]
ε = random draw ∈ [0, 1]

$$\textit{Minimize} \quad f_{design} = \sum_{i=1}^{N} (r_i - c_i)^2 \quad (12)$$

Subject to predefined constraint functions

IV. Results and Discussions

To design FPA-based FOPID controller for the 4-pole hard-to-be-control plant, FPA are coded by MATLAB version 2017b (License No. #40637337) run on Intel (R) Core (TM) i5-3470 CPU@3.60 GHz, 4.0 GB-RAM. The FOPID controller is implemented by MATLAB [22] with FOMCON toolbox [23-24]. The setting FPA's parameters are as follows: n = 25, p = 0.8, λ = 1.5, N = 2001 and Maxgen = 100, 20 trial runs. Minimize f_{design}

$$\text{Subject to} \quad \left.\begin{array}{lll} t_r \le 2.0\,\text{sec.}, & M_p \le 5\,\%, & t_s \le 7.5\,\text{sec.}, \\ e_{ss} \le 0.01\,\%, & 0 \le K_p \le 5, & 0 \le K_i \le 1, \\ 0 \le K_d \le 5, & 0.01 \le \lambda \le 1.5, & 0.01 \le \mu \le 1.5 \end{array}\right\} \quad (13)$$

Where t_r is rise time, M_p is percent maximum overshoot, t_s is settling time and e_{ss} is steady-state error. For comparison, the IOPID controller, λ and μ in (13) will be set as one (λ = μ = 1). The resulted transfer function of controllers are as follows.

$$G_c(s)\big|_{\text{IOPID}} = 1.851 + \frac{0.002923}{s} + 3s \quad (14)$$

$$G_c(s)\big|_{\text{FOPID}} = 1.8508 + \frac{0.002923}{s^{1.0128}} + 3s^{1.1024} \quad (15)$$

The unit step responses of the 4-pole hard-to-be-control plant without controller, with IOPID controller and with FOPID controller are shown in Fig. 4. The convergent rates of the objective function in (12) associated with inequality constraint functions in (13) proceeded by the FPA after 20 trial runs are depicted in Fig. 5.

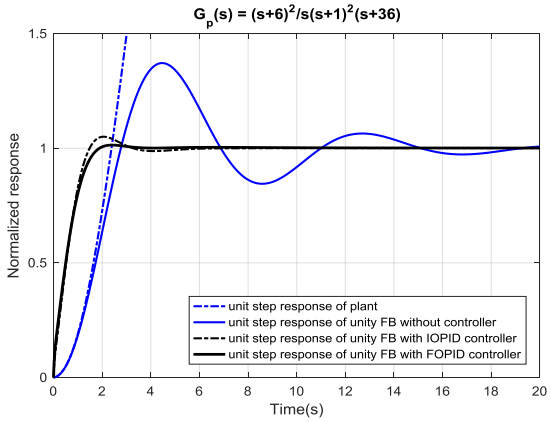

Fig. 4 Unit step responses of the 4-pole hard-to-be-control plant.

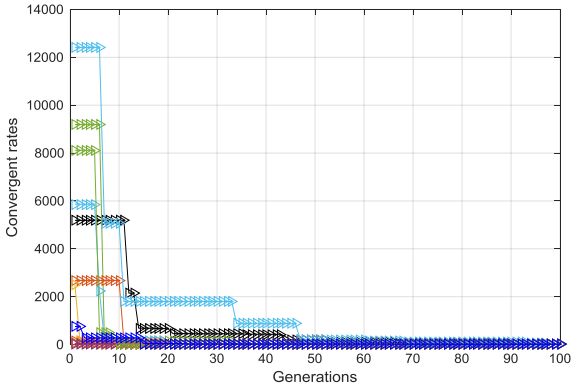

Fig. 5 Convergent rates after 20 trial runs.

Extract the performance indexes from the obtained unit step responses, we get data as shown in TABLE I.

TABLE I. PERFORMANCE INDEXES OF THE PLANT

Controller	Performance Index			
	t_r (s)	M_p (%)	t_s (s)	e_{ss} (%)
IOPID	1.48	5.05	2.81	0
FOPID	1.88	1.40	1.67	0

Extract the controller parameters form (14) and (15), we obtained data as shown in TABLE II.

TABLE II. CONTROLLER PARAMETERS

Controller	Controller Parameter				
	K_p	K_i	K_d	λ	μ
IOPID	1.851	0.002923	3	1	1
FOPID	1.8508	0.002923	3	1.0128	1.1024

This can be noticed that both controllers designed by FPA can provide very satisfactory both unit step response and parameter constraint functions, except M_p dues to IOPID controller which has small higher value than specific constraint value. The performance of FOPID control system is superior than the performance of IOPID control system, significantly.

V. CONCLUSIONS

The FOPID (or $PI^{\lambda}D^{\mu}$) controller design for 4-pole hard-to-be-control plant by using the flower pollination algorithm (FPA) has been proposed in this paper. Characterized by five parameters, the FOPID controller performs better responses compared with the IOPID (or PID) controller. In this paper, fractional calculus and FOPID controller have been briefly described. The FPA-based FOPID controller design framework has been formulated according to metaheuristic optimization context. By numerical simulation with MATLAB and FOMCON toolbox, five parameters of the FOPID controller have been successfully optimized by the FPA meeting the predefined response specification and inequality constraint functions. As simulation results, it was found that the FOPID controller designed by the FPA could yield satisfactory unit step response and superior than the response of IOPID controller.

ACKNOWLEDGMENT

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REFERENCES

[1] N. Minorsky, "Directional stability of automatically steered bodies," J. of the American Society of Naval Engineering, vol. 34, pp. 284–309, 1922.

[2] S. Bennett, "Development of the PID controller," IEEE Control System Magazine, pp. 58–65, 1994.

[3] F. Haugen, PID Control, Norway: Tapir Academic Press, 2004.

[4] M. A. Johnson and M. H. Moradi, Eds., PID Control, London, UK: Springer, 2005.

[5] A. O' Dwyer, Handbook of PI and PID Controller Tuning Rules, 2nd ed., London, UK:Imperial College Press, 2006.

[6] K. J. Astrom and T. Hagglund, Advanced PID Control, NC, USA: Instrumentation, Systems and Automation Society, 2006.

[7] I. Podlubny, Fractional-Order Systems and Fractional-Order Controllers, Slovak: Slovak Academy of Sciences, Institute of Experimental Physics, 1994.

[8] I. Podlubny, "Fractional-order systems and PID controller," IEEE Trans. Automatic Control, vol. 44, pp. 208–214, 1999.

[9] I. Petras, "The fractional-order controllers: methods for their synthesis and applications," J. of Electrial Engineering, vol. 50, pp. 284–288, 1999.

[10] C. A. Monje, B. M. Vinagre, V. Felie and Y. Chen, "Tuning and auto-tuning of fractional order controllers for industry applications," Control Engineering Practice, vol. 16, pp. 798–812, 2008.

[11] D. Xue, C. Zhao and Y. Q. Chen, "Fractional order PID control of a DC-motor with elastic shaft: a case study," Proc. 2006 American Control Conference, pp. 3182–3187, 2006.

[12] D. Valerio and J. Costa, "Tuning of fractional PID controllers with Ziegler-Nichols type rules," Signal Processing vol. 86, pp. 2771–2784, 2006.

[13] Y. Chen, T. Bhaskaran and D. Xue, "Fractional tuning rule development for fractional order proportional and integral controllers," J. of Computational and Nonlinear Dynamics, vol. 3, 2008.

[14] R. Caponetto, L. Fortuna and D. Porto, "A New tuning strategy for a noninteger order PID controller," Fractional Differentiation and Its Applications, Bordeaux, 2004.

[15] C. Zhao, D. Xue and Y. Chen, "A fractional order PID tuning algorithm for a class of fractional order plants," Inter. Conf. Mechatronics & Automation, Niagara Falls, 2005.

[16] Y. Q. Chen, I. Petras and D. Xue, "Fractional order control – a tutorial," American Control Conference, pp. 1399–1411, 2009.

[17] P. Shah and A. Agashe, "Review of fractional PID controller," Mechatronics, vol. 38, pp. 29–41, 2016.

[18] V. Zakian, Control Systems Design: A New Framework, Berlin, Germany: Springer-Verlag, 2005.

[19] Xin–She Yang, "Flower pollination algorithm for global optimization," in: Unconventional Computation and Natural Computation 2012, Lecture Notes in Computer Science, vol. 7445, pp. 240–249, 2012.

[20] X. S. He, X.–S. Yang, M. Karamanoglu and Y. X. Zhao, "Global convergence analysis of the flower pollination algorithm: A discrete-time Markov chain approach," Procedia Computer Science, vol. 108, pp. 1354–1364, 2017.

[21] K. J. Astrom and T. Hagglund, "Benchmark systems for PID control," IFAC Digital Control: Past, Present, and Future of PID Control, Terrassa, Spain, pp. 165–166, 2000.

[22] Math Works, System Identification Toolbox™, MATLAB-R2017b, 2017.

[23] A. Tepljakov, E. Petlenkov and J. Belikov, "FOMCON: fractional-order modeling and control toolbox for MATLAB," Proc. the 18th Inter. Conf. on Mixed Design of Integrated Circuits and Systems (MIXDES'11), pp. 684–689, 2011.

[24] A. Tepljakov, E. Petlenkov and J. Belikov, "FOMCON: a MATLAB toolbox for fractional-order system identtification and control," Inter. J. Microelectronics and Computer Science, vol. 2, pp. 51–62, 2011.

Designing of Fractional Order PID Controller for Hard-To-Be-Control Plant with Time Delay

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***Abstract*—The flower pollination algorithm (FPA), one of the most efficient metaheuristic optimization search techniques, is applied to design an optimal fractional-order proportional-integral-derivative (FOPID or $PI^{\lambda}D^{\mu}$) controller for a hard-to-be-control plant with time delay. FPA searches the 5 appropriate parameters of the controller to meet the response specifications of the plant. Results obtained by this procedure will be compared with those obtained by the conventional controller or integer-order proportional-integral-derivative (IOPID or PID) controller or the conventional controller. By comparison of unit step response, the optimal FOPID controller yields very satisfactory responses superior than the IOPID controller with faster response and very small steady-state error. MATLAB and FOMCON programs are used to conduct this research.**

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$$ \mathrm{u}(t) = K_p \mathrm{e}(t) + K_i D_t^{-\lambda} \mathrm{e}(t) + K_d D_t^{\mu} \mathrm{e}(t) \tag{9} $$

$$ \mathrm{G}_c(s)\big|_{\mathrm{FOPID}} = K_p + \frac{K_i}{s^{\lambda}} + K_d s^{\mu} \tag{10} $$

Relationship between the IOPID and the FOPID controllers can be represented by a graphical way as visualized in Fig.1. In most research works, the ranges of λ and μ are varied from 0 to 1. If λ and μ are ones, it is the IOPID controller. Otherwise are FOPID controllers. If λ and μ are varied between one and two, the controller tends to be unstable.

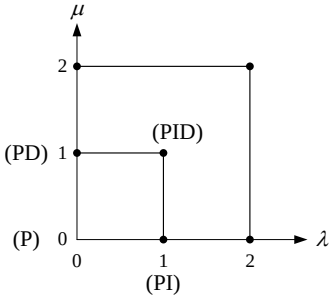

Fig. 1 Relationship between IOPID and FOPID controllers.

III. Problem Formulation

In this section, the FOPID control loop, the transfer function of hard-to-be-control plant with time delay and the FPA-based FOPID controller design are consecutively presented as follows.

A. FOPID Control Loop

The FOPID control loop is represented by the block diagram as shown in Fig. 2, where $G_p(s)$ and $G_c(s)$ are the plant and the FOPID controller models, respectively. The FOPID controller receives the error signal E(*s*) and produces the control signal U(*s*) to control the output signal C(*s*) and regulate the disturbance signal D(*s*), referring to the reference input R(*s*).

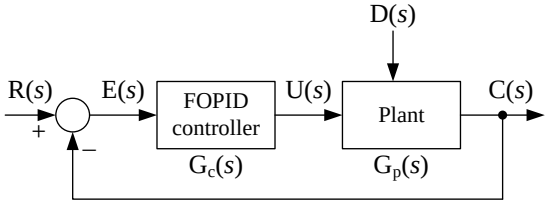

Fig. 2 FOPID control loop.

B. Hard-to-be-control Plant with Time Delay

There are some benchmark systems for PID control, used for research and for evaluation of commercial systems [21]. One of these systems is time delay and lag system shown in (11).

$$ \mathrm{G}_p(s) = \frac{1}{1 + s\tau} e^{-st_d} \tag{11} $$

Where t_d = delay time
τ = time constant of system

But the classical system which has been used in many investigations of PID control is shown in (12)

$$G_p(s) = \frac{1}{1+s\tau} e^{-s} \quad (12)$$

Where $\tau = 0, 0.1, 0.2, 0.5, 2, 5, 10$
When $\tau = 0$, the system has a pure time delay and represents lag dominated system for large τ. A drawback with the model is that it has slow roll-off at high frequencies. So noise problem occurs and needed cancelling high frequency noise. This paper selects $\tau = 0.5$ in (12).

To improve the performance of the system instead of using IOPID controller, the FOPID controller is investigated.

C. FPA-Based FOPID Controller Design

Designing methods of FOPID controller are as follows.

1) Analytical method [14-15].

2) Numerical method [10].

3) Rule-based tuning method [10, 12-13], e.g., Ziegler-Nichols type tuning rule method [12]. and

4) Optimization method [16-20], e.g., metaheuristic optimization method [18].

In this paper, FPA is used to design the FOPID controller instead of using Ziegler-Nichols type tuning rule method because the later method is difficult to or can not find s-shaped unit step response of the plant and/or critical gain of the plant [12]. Also, FPA is a promised metaheuristic algorithm for fast global convergence [19-20] and successfully applied to many real world engineering problems [20].

The FPA-based FOPID controller design framework can be represented by the block diagram shown in Fig. 3.

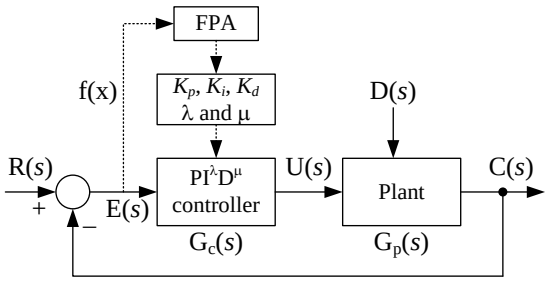

Fig. 3 FPA-based FOPID controller design framework.

Referring to Fig. 3, using pseudo code of FPA [19], the objective function, f(x) or f_{design}, and the error E(s) will be fed to the FPA to be minimized by searching for the appropriate values of the FOPID (or $PI^{\lambda}D^{\mu}$) controller parameters, i.e., K_p, K_i, K_d, λ and μ subject to inequality constraint parameters satisfying to the predefined response specifications.

The FPA's parameters:
f_{design} = objective function, f(x)
r_i = reference input signal = solution, x
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Γ(λ) = standard gamma function
L = Levy flight
n = number of generated flowers in the population
p = switch probability ∈ [0, 1]
ε = random draw ∈ [0, 1]

$$\textit{Minimize} \quad f_{design} = \sum_{i=1}^{N} (r_i - c_i)^2 \quad (13)$$

Subject to predefined constraint functions

IV. Results and Discussions

To design FPA-based FOPID controller for the hard-to-be-control plant with time delay, FPA are coded by MATLAB version 2017b (License No. #40637337) run on Intel (R) Core (TM) i5-3470 CPU@3.60 GHz, 4.0 GB-RAM. The FOPID controller is implemented by MATLAB [22] with FOMCON toolbox [23-24]. The setting FPA's parameters are as follows: n = 25, p = 0.8, λ = 1.5, N = 2001 and Maxgen = 100, 20 trial runs. Minimize f_{design}

$$\left.\begin{array}{l} \text{Subject to} \quad t_r \le 2.0\ \text{sec.}, \quad M_p \le 10\ \%, \quad t_s \le 10.0\ \text{sec.}, \\ \qquad e_{ss} \le 0.01\ \%, \quad 0 \le K_p \le 5, \quad 0 \le K_i \le 1, \\ \qquad 0 \le K_d \le 1, \quad 0.01 \le \lambda \le 1.5, \quad 0.01 \le \mu \le 1.5 \end{array}\right\} \quad (14)$$

Where t_r is rise time, M_p is percent maximum overshoot, t_s is settling time and e_{ss} is steady-state error. For comparison, the IOPID controller, λ and μ in (14) will be set as one (λ = μ = 1). The resulted transfer function of controllers are as follows.

$$G_c(s)\big|_{\text{IOPID}} = 0.68 + \frac{1.20}{s} + 0.25s \quad (15)$$

$$G_c(s)\big|_{\text{FOPID}} = 0.7842 + \frac{0.9753}{s^{0.9475}} + 0.3251s^{0.9851} \quad (16)$$

The unit step responses of the hard-to-be-control plant with time delay without controller, with IOPID controller and with FOPID controller are shown in Fig. 4. The convergent rates of the objective function in (13) associated with inequality constraint functions in (14) proceeded by the FPA after 20 trial runs are depicted in Fig. 5.

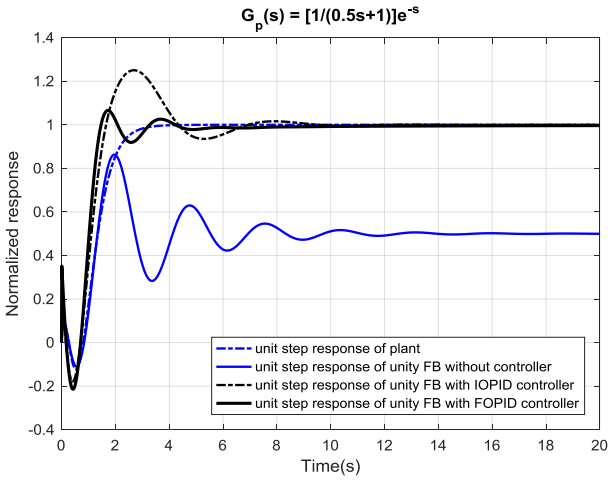

Fig. 4 Unit step responses of the hard-to-be-control plant with time delay.

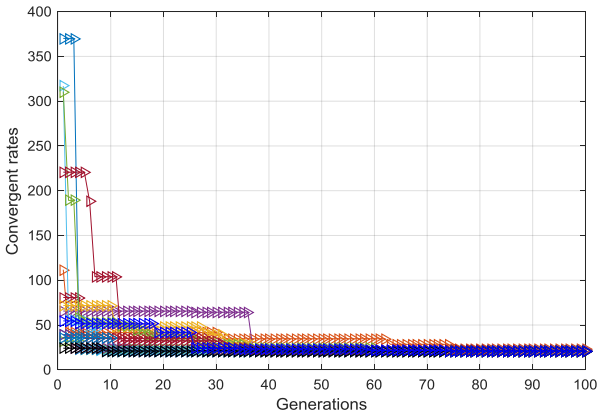

Fig. 5 Convergent rates after 20 trial runs.

Extract the performance indexes from the obtained unit step responses, we get data as shown in TABLE I.

TABLE I. PERFORMANCE INDEXES OF THE PLANT

Controller	Performance Index				
	t_r (s)	M_p (%)	t_s (s)	e_{ss} (%)	t_d(s)
without	2.84	0	2.93	0	0.8
IOPID	1.56	25.04	6.48	0	0.71
FOPID	1.46	6.59	5.11	0	0.70

Extract the controller parameters form (15) and (16), we obtained data as shown in TABLE II.

TABLE II. CONTROLLER PARAMETERS

Controller	Controller Parameter				
	K_p	K_i	K_d	λ	μ
IOPID	0.68	1.2	0.25	1	1
FOPID	0.7842	0.9753	0.3251	0.9475	0.9851

This can be noticed that FOPID controllers designed by FPA con provide very satisfactory both unit step response and parameter constraint functions. The M_p dues to IOPID controller has higher value than specific constraint value. Hence, the performance of FOPID control system is superior than the performance of IOPID control system, significantly.

V. CONCLUSIONS

The FOPID (or $PI^{\lambda}D^{\mu}$) controller design for hard-to-be-control plant with time delay by using the flower pollination algorithm (FPA) has been proposed in this paper. Characterized by five parameters, the FOPID controller performs better responses compared with the IOPID (or PID) controller. In this paper, fractional calculus and FOPID controller have been briefly described. The FPA-based FOPID controller design framework has been formulated according to metaheuristic optimization context. By numerical simulation with MATLAB and FOMCON toolbox, five parameters of the FOPID controller have been successfully optimized by the FPA meeting the predefined response specification and inequality constraint functions. As simulation results, it was found that the FOPID controller designed by the FPA could yield satisfactory unit step response and superior than the response of IOPID controller.

REFERENCES

[1] N. Minorsky, "Directional stability of automatically steered bodies," J. of the American Society of Naval Engineering, vol. 34, pp. 284–309, 1922.

[2] S. Bennett, "Development of the PID controller," IEEE Control System Magazine, pp. 58–65, 1994.

[3] F. Haugen, PID Control, Norway: Tapir Academic Press, 2004.

[4] M. A. Johnson and M. H. Moradi, Eds., PID Control, London, UK: Springer, 2005.

[5] A. O' Dwyer, Handbook of PI and PID Controller Tuning Rules, 2nd ed., London, UK:Imperial College Press, 2006.

[6] K. J. Astrom and T. Hagglund, Advanced PID Control, NC, USA: Instrumentation, Systems and Automation Society, 2006.

[7] I. Podlubny, Fractional-Order Systems and Fractional-Order Controllers, Slovak: Slovak Academy of Sciences, Institute of Experimental Physics, 1994.

[8] I. Podlubny, "Fractional-order systems and PID controller," IEEE Trans. Automatic Control, vol. 44, pp. 208–214, 1999.

[9] I. Petras, "The fractional-order controllers: methods for their synthesis and applications," J. of Electrial Engineering, vol. 50, pp. 284–288, 1999.

[10] C. A. Monje, B. M. Vinagre, V. Felie and Y. Chen, "Tuning and auto-tuning of fractional order controllers for industry applications," Control Engineering Practice, vol. 16, pp. 798–812, 2008.

[11] D. Xue, C. Zhao and Y. Q. Chen, "Fractional order PID control of a DC-motor with elastic shaft: a case study," Proc. 2006 American Control Conference, pp. 3182–3187, 2006.

[12] D. Valerio and J. Costa, "Tuning of fractional PID controllers with Ziegler-Nichols type rules," Signal Processing vol. 86, pp. 2771–2784, 2006.

[13] Y. Chen, T. Bhaskaran and D. Xue, "Fractional tuning rule development for fractional order proportional and integral controllers," J. of Computational and Nonlinear Dynamics, vol. 3, 2008.

[14] R. Caponetto, L. Fortuna and D. Porto, "A New tuning strategy for a noninteger order PID controller," Fractional Differentiation and Its Applications, Bordeaux, 2004.

[15] C. Zhao, D. Xue and Y. Chen, "A fractional order PID tuning algorithm for a class of fractional order plants," Inter. Conf. Mechatronics & Automation, Niagara Falls, 2005.

[16] Y. Q. Chen, I. Petras and D. Xue, "Fractional order control – a tutorial," American Control Conference, pp. 1399–1411, 2009.

[17] P. Shah and A. Agashe, "Review of fractional PID controller," Mechatronics, vol. 38, pp. 29–41, 2016.

[18] V. Zakian, Control Systems Design: A New Framework, Berlin, Germany: Springer-Verlag, 2005.

[19] Xin–She Yang, "Flower pollination algorithm for global optimization," in: Unconventional Computation and Natural Computation 2012, Lecture Notes in Computer Science, vol. 7445, pp. 240–249, 2012.

[20] X. S. He, X.–S. Yang, M. Karamanoglu and Y. X. Zhao, "Global convergence analysis of the flower pollination algorithm: A discrete-time Markov chain approach," Procedia Computer Science, vol. 108, pp. 1354–1364, 2017.

[21] K. J. Astrom and T. Hagglund, "Benchmark systems for PID control," IFAC Digital Control: Past, Present, and Future of PID Control, Terrassa, Spain, pp. 165–166, 2000.

[22] Math Works, System Identification Toolbox™, MATLAB-R2017b, 2017.

[23] A. Tepljakov, E. Petlenkov and J. Belikov, "FOMCON: fractional-order modeling and control toolbox for MATLAB," Proc. the 18th Inter. Conf. on Mixed Design of Integrated Circuits and Systems (MIXDES'11), pp. 684–689, 2011.

[24] A. Tepljakov, E. Petlenkov and J. Belikov, "FOMCON: a MATLAB toolbox for fractional-order system identtification and control," Inter. J. Microelectronics and Computer Science, vol. 2, pp. 51–62, 2011.

Designing of Fractional Order PID Controller for Stable Fractional Order System

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***Abstract*—This paper proposes the fractional-order proportional-integral-derivative (FOPID or $PI^{\lambda}D^{\mu}$) controller design optimization for a stable fractional order (FO) system by using the flower pollination algorithm (FPA), one of the most efficient metaheuristic optimization search techniques. FPA is applied to design an optimal FOPID controller by searching for the 5 appropriate parameters to meet the response specifications of the system. Results obtained by this method will be compared with those obtained by the conventional controller or integer-order proportional-integral-derivative (IOPID or PID) controller. By comparison, the optimal FOPID controller yields very satisfactory responses superior than the IOPID controller with faster and very small steady-state error of unit step response. MATLAB and FOMCON programs are used to conduct this research.**

Keywords—FOPID controller, IOPID controller, optimization, FPA, FO system, stable system

I. INTRODUCTION

Controller is an important part of closed loop control system. There are proportional (P), proportional-derivative (PD), proportional-integral (PI) and proportional-integral-derivative (PID) controllers. The PID controller has been accepted and widely used in various automatic control systems since the first proposed by Minorsky [1]. The PID controller is widely accepted in industrial applications [2-5]. More than 95% of process control applications are controlled by PID controllers [6]. This controller uses integer-order (IO) as basis of designing. We name the controller as integer-order proportional-integral-derivative (IOPID) controller. We often called IOPID controller as PID controller. The controller has been played an important role as the heart of control engineering practice for over nine decade. The effects of IOPID parameters, i.e.; proportional constant, K_p; integral constant, K_i; and derivative constant, K_d; on system responses have already been well-known for theorists and practicing engineers.

The fractional-order PID (FOPID) controller (or $PI^{\lambda}D^{\mu}$ controller) was firstly proposed by Podlubny in 1994 [7]. In 1999, Podlubny reported this new controller to IEEE [8] and showed analysis in time domain. At the same time, Petras reported FOPID controller analysis in frequency domain [9]. The FOPID controller demonstrated the better response in comparison with the conventional IOPID controller. Once the FOPID controller is compared with the IOPID controller, there are two extra parameters λ (integration order) and μ (derivative order) making the FOPID controller more efficient, but more complicate than the IOPID controller in designing and implementation procedures. The FOPID controller has been successfully conducted in many applications, e.g., process control [10], and DC motor control [11]. Several design and tuning methods for FOPID controller have been consecutively launched, e.g., rule based methods [12-13] and analytical methods [14-15]. Review and tutorial articles of the FOPID controller providing the state-of-the-art and its background have been completely reported [16-17].

Recently, control system synthesis has been changed from the conventional paradigm to the new framework based on modern optimization using metaheuristics as an optimizer [18]. The flower pollination algorithm (FPA), firstly, proposed by Yang in 2012 [19]. Since then, there are wide range of diverse applications with more than 500 research papers published so far in the literature [20]. The FPA was proved for the global convergent property [20] and successfully applied to many real world engineering problems. In this paper, the FPA is applied to optimally design the FOPID controller for stable fractional order system. The rest of the paper is outlined as follows: fractional calculus and FOPID controller are briefly described in section II. Problem formulation of FPA-based FOPID controller design for stable fractional order system is performed in section III. Results and discussions are illustrated in section IV, while conclusions are summarized in section V.

II. FRACTIONAL CALCULUS AND FOPID CONTROLLER

A. Fractional Calculus

The idea of fractional calculus has been known since the development of the regular (integer-order) calculus. With the first reference probably being associated with Leibniz and L'Hopital in 1695 [16-17] where half-order derivative was mentioned. Fractional calculus is a generalization of integration and differentiation to non-integer order. Fundamental operator ${}_aD_t^{\alpha}$, where *a* and *t* are the limits of the operation. The continuous integro-differential operator is defined as in (1).

$$ {}_aD_t^{\alpha} \triangleq \begin{cases} \dfrac{d^{\alpha}}{dt^{\alpha}} & R(\alpha) > 0, \\ 1 & R(\alpha) = 1, \quad \lambda = \text{real number} \\ \displaystyle\int_a^t (d\tau)^{-\alpha} & R(\alpha) < 0, \end{cases} \tag{1} $$

where $\alpha \in R$ stands for the order of operation.

There are three definitions used for the generally fractional differintegral. The first definition is Grunwald-Letnikov (GL) as stated in (2), where $[\cdot]$ is integer part and n is an integer satisfying the condition $n\text{-}1 < \alpha < n$. The binomial coefficient is stated in (3), while the Euler's gamma function $\Gamma(\cdot)$ is defined by (4).

$$ {}_aD_t^{\alpha} f(t) = \lim_{h \to 0} h^{-\alpha} \sum_{r=0}^{\left[\frac{t-a}{h}\right]} (-1)^r \begin{bmatrix} n \\ r \end{bmatrix} f(t - rh) \tag{2} $$

$$ \begin{bmatrix} n \\ r \end{bmatrix} = \frac{\Gamma(n+1)}{\Gamma(r+1)\Gamma(n-r+1)} \tag{3} $$

$$ \Gamma(x) = \int_0^{\infty} t^{x-1} e^{-t} dt \tag{4} $$

The second definition is Riemann-Liouville (RL) as expressed in (5), for $n\text{-}1 < \alpha < n$. The third definition is Caputo definition as shown in (6), where n is an integer and $n\text{-}1 < \alpha < n$. Among those, the Caputo definition is most popular in engineering application [16].

$$ {}_aD_t^{\alpha} f(t) = \frac{1}{\Gamma(n-\alpha)} \left(\frac{d}{dt}\right)^n \int_a^t \frac{f(\tau)}{(t-\tau)^{\alpha-n+1}} d\tau \tag{5} $$

$$ {}_aD_t^{\alpha} f(t) = \frac{1}{\Gamma(n-\alpha)} \int_a^t \frac{f^n(\tau)}{(t-\tau)^{\alpha-n+1}} d\tau \tag{6} $$

$$ \begin{aligned} \mathcal{L}\left\{ {}_aD_t^{\alpha} f(t) \right\} &= \int_0^{\infty} e^{-st} {}_0D_t^{\alpha} f(t) dt \\ &= s^{\alpha} F(s) - \sum_{k=0}^{n-1} s^k \, {}_0D_t^{\alpha-k-1} f(t) \Big|_{t=0} \end{aligned} \tag{7} $$

For solving engineering problems, the Laplace transform is routinely conducted. The formula of the Laplace transform of the RL fractional derivative in (5) is state in (7), for $n\text{-}1 < \alpha < n$, where $s = j\omega$ denotes the Laplace transform complex variable. Under zero initial condition for order α ($0 < \alpha < 1$), the Laplace transform of the RL fractional derivative in (5) can be expressed in (8)

$$ \mathcal{L}\left\{ {}_aD_t^{\pm\alpha} f(t) \right\} = s^{\pm\alpha} F(s) \tag{8} $$

B. FOPID Controller

The FOPID or PI$^{\lambda}$D$^{\mu}$ controller is an extended version of the conventional integer order PID (IOPID) controller. The generalized transfer function of the FOPID controller is given by the differential equation as stated in (9), where u(t) is unit step input signal as the control signal, e(t) is the error signal and λ and μ are more than zero. The Laplace transform of the transfer function is expressed by (10).

$$ \mathrm{u}(t) = K_p \mathrm{e}(t) + K_i D_t^{-\lambda} \mathrm{e}(t) + K_d D_t^{\mu} \mathrm{e}(t) \tag{9} $$

$$ \mathrm{G}_c(s)\big|_{\mathrm{FOPID}} = K_p + \frac{K_i}{s^{\lambda}} + K_d s^{\mu} \tag{10} $$

Relationship between the IOPID and the FOPID controllers can be represented by a graphical way as visualized in Fig.1. In most research works, the ranges of λ and μ are varied from 0 to 1. If λ and μ are ones, it is the IOPID controller. Otherwise are FOPID controllers. If λ and μ are varied between one and two, the controller tends to be unstable.

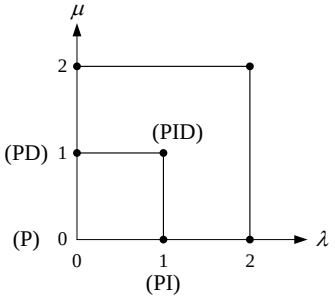

Fig. 1 Relationship between IOPID and FOPID controllers.

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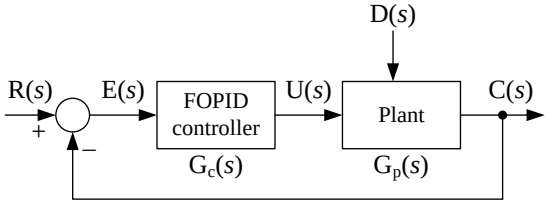

Fig. 2 FOPID control loop.

B. Stable Fractional Order System

Since 90 era, many researchers have studied fractional order system of both stable and unstable plants. The problem is that how to control the plant to work properly or optimum of its performance. Either IOPID controller or FOPID controller can be used and which is better. This paper will study how to control a stable fractional order system as model below.

$$ \mathrm{G}_p(s) = \frac{1}{s^{3/2} - 2s^{1/2} + 1/3} = \frac{1}{s^{1.5} - 2s^{0.5} + 0.333} \tag{11} $$

This system (or plant) has very high percent maximum overshoot, long rise time and very long settling time of unit step response.

C. FPA-Based FOPID Controller Design

Designing methods of FOPID controller are as follows.

1) Analytical method [14-15].

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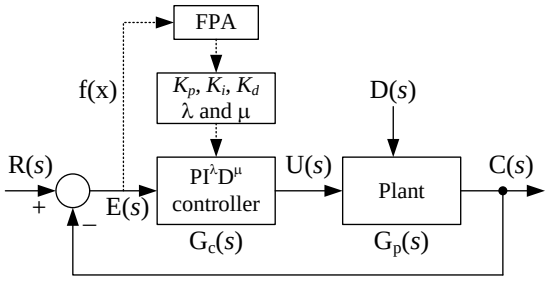

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N = number of sampling data in observed period
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L = Levy flight
n = number of generated flowers in the population
p = switch probability ∈ [0, 1]
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$$Minimize \quad f_{design} = \sum_{i=1}^{N} (r_i - c_i)^2 \tag{12}$$

Subject to predefined constraint functions

IV. Results and Discussions

To design FPA-based FOPID controller for the stable fractional order system, FPA are coded by MATLAB version 2017b (License No. #40637337) run on Intel (R) Core (TM) i5-3470 CPU@3.60 GHz, 4.0 GB-RAM. The FOPID controller is implemented by MATLAB [21] with FOMCON toolbox [22-23]. The setting FPA's parameters are as follows: n = 25, p = 0.8, λ = 1.5, N = 2001 and Maxgen = 100, 20 trial runs. Minimize f_{design}

$$\left.\begin{aligned} \text{Subject to} \quad & t_r \le 0.25\,\text{sec.}, \quad M_p \le 10\,\%, \quad t_s \le 2.5\,\text{sec.}, \\ & e_{ss} \le 0.01\,\%, \quad 0 \le K_p \le 80, \quad 0 \le K_i \le 50, \\ & 0 \le K_d \le 20, \quad 0.01 \le \lambda \le 1.5, \quad 0.01 \le \mu \le 1.5 \end{aligned}\right\} \tag{13}$$

Where t_r is rise time, M_p is percent maximum overshoot, t_s is settling time and e_{ss} is steady-state error. For comparison, the IOPID controller, λ and μ in (13) will be set as one (λ = μ = 1). The resulted transfer function of controllers are as follows.

$$G_c(s)\big|_{IOPID} = 22.651 + \frac{32.916}{s} + 4.525s \tag{14}$$

$$G_c(s)\big|_{FOPID} = 68.687 + \frac{32.922}{s^{0.681}} + 14.953s^{1.1021} \tag{15}$$

The unit step responses of the stable fractional order system without controller, with IOPID controller and with FOPID controller are shown in Fig. 4. The convergent rates of the objective function in (12) associated with inequality constraint functions in (13) proceeded by the FPA after 20 trial runs are depicted in Fig. 5.

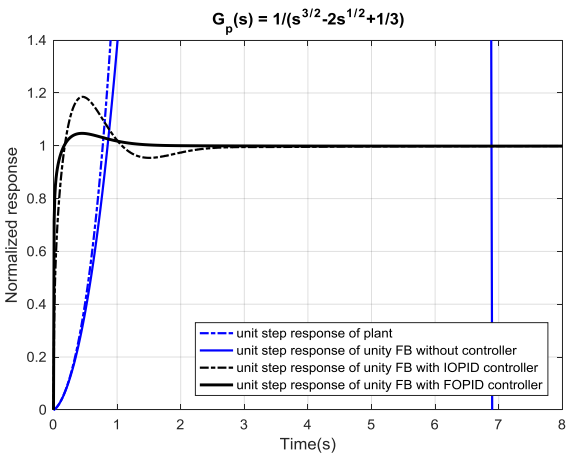

Fig. 4 Unit step responses of the stable fractional order system.

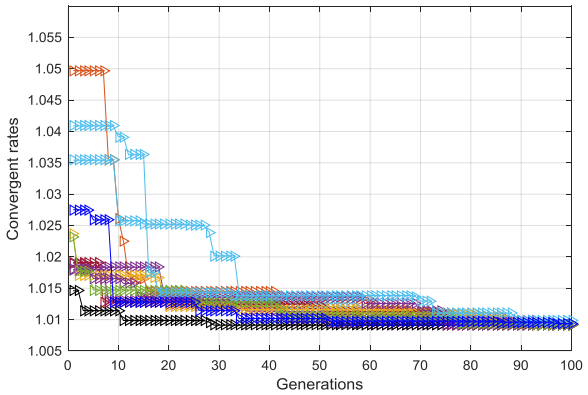

Fig. 5 Convergent rates after 20 trial runs.

Extract the performance indexes from the obtained unit step responses, we get data as shown in TABLE I.

TABLE I. PERFORMANCE INDEXES OF THE PLANT

Controller	Performance Index			
	t_r (s)	M_p (%)	t_s (s)	e_{ss} (%)
IOPID	0.17	18.54	2.12	0
FOPID	0.16	4.71	0.95	0

Extract the controller parameters form (14) and (15), we obtained data as shown in TABLE II.

TABLE II. CONTROLLER PARAMETERS

Controller	Controller Parameter				
	K_p	K_i	K_d	λ	μ
IOPID	22.651	32.916	4.525	1	1
FOPID	68.687	32.922	14.953	0.681	1.1021

This can be noticed that FOPID controller designed by FPA can provide very satisfactory both unit step response and parameter constraint functions. The M_p dues to IOPID controller has higher value than specific constraint value. The performance of FOPID control system is superior than the performance of IOPID control system, significantly.

V. CONCLUSIONS

The FOPID (or $PI^{\lambda}D^{\mu}$) controller design for stable fractional order system by using the flower pollination algorithm (FPA) has been proposed in this paper. Characterized by five parameters, the FOPID controller performs better responses compared with the IOPID (or PID) controller. In this paper, fractional calculus and FOPID controller have been briefly described. The FPA-based FOPID controller design framework has been formulated according to metaheuristic optimization context. By numerical simulation with MATLAB and FOMCON toolbox, five parameters of the FOPID controller have been successfully optimized by the FPA meeting the predefined response specification and inequality constraint functions. As simulation results, it was found that the FOPID controller designed by the FPA could yield satisfactory unit step response and superior than the response of IOPID controller.

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The authors thank Rangsit university for financial support according to audio engineering program establishment. B. Chipipop thanks Associate Professor Kosol Petchsuwan, the former president of King Mongkut's Institute of Technology, Ladkrabang, and Professor Kenzo Watanabe, the former director of Research Institute of Electronics, Shizuoka university, Japan for giving him JSPS (Japan Society for the Promotion of Sciences) scholarship in 1986-1987 and 1987 Ph.D. candidate of Monbusho (Japanese Government) scholarship. Also, B. Chipipop thanks Prof. Pairash Thajchayapong, the former president of King Monkut's Institute of Technology, Ladkrabang, for academic support.

REFERENCES

[1] N. Minorsky, "Directional stability of automatically steered bodies," J. of the American Society of Naval Engineering, vol. 34, pp. 284–309, 1922.

[2] S. Bennett, "Development of the PID controller," IEEE Control System Magazine, pp. 58–65, 1994.

[3] F. Haugen, PID Control, Norway: Tapir Academic Press, 2004.

[4] M. A. Johnson and M. H. Moradi, Eds., PID Control, London, UK: Springer, 2005.

[5] A. O' Dwyer, Handbook of PI and PID Controller Tuning Rules, 2nd ed., London, UK:Imperial College Press, 2006.

[6] K. J. Astrom and T. Hagglund, Advanced PID Control, NC, USA: Instrumentation, Systems and Automation Society, 2006.

[7] I. Podlubny, Fractional-Order Systems and Fractional-Order Controllers, Slovak: Slovak Academy of Sciences, Institute of Experimental Physics, 1994.

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[10] C. A. Monje, B. M. Vinagre, V. Felie and Y. Chen, "Tuning and auto-tuning of fractional order controllers for industry applications," Control Engineering Practice, vol. 16, pp. 798–812, 2008.

[11] D. Xue, C. Zhao and Y. Q. Chen, "Fractional order PID control of a DC-motor with elastic shaft: a case study," Proc. 2006 American Control Conference, pp. 3182–3187, 2006.

[12] D. Valerio and J. Costa, "Tuning of fractional PID controllers with Ziegler-Nichols type rules," Signal Processing vol. 86, pp. 2771–2784, 2006.

[13] Y. Chen, T. Bhaskaran and D. Xue, "Fractional tuning rule development for fractional order proportional and integral controllers," J. of Computational and Nonlinear Dynamics, vol. 3, 2008.

[14] R. Caponetto, L. Fortuna and D. Porto, "A New tuning strategy for a noninteger order PID controller," Fractional Differentiation and Its Applications, Bordeaux, 2004.

[15] C. Zhao, D. Xue and Y. Chen, "A fractional order PID tuning algorithm for a class of fractional order plants," Inter. Conf. Mechatronics & Automation, Niagara Falls, 2005.

[16] Y. Q. Chen, I. Petras and D. Xue, "Fractional order control – a tutorial," American Control Conference, pp. 1399–1411, 2009.

[17] P. Shah and A. Agashe, "Review of fractional PID controller," Mechatronics, vol. 38, pp. 29–41, 2016.

[18] V. Zakian, Control Systems Design: A New Framework, Berlin, Germany: Springer-Verlag, 2005.

[19] Xin–She Yang, "Flower pollination algorithm for global optimization," in: Unconventional Computation and Natural Computation 2012, Lecture Notes in Computer Science, vol. 7445, pp. 240–249, 2012.

[20] X. S. He, X.–S. Yang, M. Karamanoglu and Y. X. Zhao, "Global convergence analysis of the flower pollination algorithm: A discrete-time Markov chain approach," Procedia Computer Science, vol. 108, pp. 1354–1364, 2017.

[21] Math Works, System Identification Toolbox™, MATLAB-R2017b, 2017.

[22] A. Tepljakov, E. Petlenkov and J. Belikov, "FOMCON: fractional-order modeling and control toolbox for MATLAB," Proc. the 18th Inter. Conf. on Mixed Design of Integrated Circuits and Systems (MIXDES'11), pp. 684–689, 2011.

[23] A. Tepljakov, E. Petlenkov and J. Belikov, "FOMCON: a MATLAB toolbox for fractional-order system identtification and control," Inter. J. Microelectronics and Computer Science, vol. 2, pp. 51–62, 2011.

Designing of Fractional Order PID Controller for Unstable Fractional Order System

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***Abstract*—The flower pollination algorithm (FPA), one of the most efficient metaheuristic optimization search techniques, is applied to design an optimal fractional-order proportional-integral-derivative (FOPID or PI$^{\lambda}$D$^{\mu}$) controller for an unstable fractional order (FO) system. FPA searches the 5 appropriate parameters of the controller to meet the response specifications of the system. Results obtained by this procedure will be compared with those obtained by the integer-order proportional-integral-derivative (IOPID or PID) controller or the conventional controller. By comparison of unit step response, the optimal FOPID controller yields very satisfactory responses superior than the IOPID controller with faster response and very small steady-state error. MATLAB and FOMCON programs are used to conduct this research.**

Keywords—FOPID controller, IOPID controller, optimization, FPA, FO system, unstable system

I. INTRODUCTION

Controller is an important part of closed loop control system. There are proportional (P), proportional-derivative (PD), proportional-integral (PI) and proportional-integral-derivative (PID) controllers. The PID controller has been accepted and widely used in various automatic control systems since the first proposed by Minorsky [1]. The PID controller is widely accepted in industrial applications [2-5]. More than 95% of process control applications are controlled by PID controllers [6]. This controller uses integer-order (IO) as basis of designing. We name the controller as integer-order proportional-integral-derivative (IOPID) controller. We often called IOPID controller as PID controller. The controller has been played an important role as the heart of control engineering practice for over nine decade. The effects of IOPID parameters, i.e.; proportional constant, K_p; integral constant, K_i; and derivative constant, K_d; on system responses have already been well-known for theorists and practicing engineers.

The fractional-order PID (FOPID) controller (or PI$^{\lambda}$D$^{\mu}$ controller) was firstly proposed by Podlubny in 1994 [7]. In 1999, Podlubny reported this new controller to IEEE [8] and showed analysis in time domain. At the same time, Petras reported FOPID controller analysis in frequency domain [9]. The FOPID controller demonstrated the better response in comparison with the conventional IOPID controller. Once the FOPID controller is compared with the IOPID controller, there are two extra parameters λ (integration order) and μ (derivative order) making the FOPID controller more efficient, but more complicate than the IOPID controller in designing and implementation procedures. The FOPID controller has been successfully conducted in many applications, e.g., process control [10], and DC motor control [11]. Several design and tuning methods for FOPID controller have been consecutively launched, e.g., rule based methods [12-13] and analytical methods [14-15]. Review and tutorial articles of the FOPID controller providing the state-of-the-art and its background have been completely reported [16-17].

Recently, control system synthesis has been changed from the conventional paradigm to the new framework based on modern optimization using metaheuristics as an optimizer [18]. The flower pollination algorithm (FPA), firstly, proposed by Yang in 2012 [19]. Since then, there are wide range of diverse applications with more than 500 research papers published so far in the literature [20]. The FPA was proved for the global convergent property [20] and successfully applied to many real world engineering problems. In this paper, the FPA is applied to optimally design the FOPID controller for unstable fractional order system. The rest of the paper is outlined as follows: fractional calculus and FOPID controller are briefly described in section II. Problem formulation of FPA-based FOPID controller design for unstable fractional order system is performed in section III. Results and discussions are illustrated in section IV, while conclusions are summarized in section V.

II. FRACTIONAL CALCULUS AND FOPID CONTROLLER

A. Fractional Calculus

The idea of fractional calculus has been known since the development of the regular (integer-order) calculus. With the first reference probably being associated with Leibniz and L'Hopital in 1695 [16-17] where half-order derivative was mentioned. Fractional calculus is a generalization of integration and differentiation to non-integer order. Fundamental operator ${}_aD_t^{\alpha}$, where *a* and *t* are the limits of the operation. The continuous integro-differential operator is defined as in (1).

$$ {}_aD_t^{\alpha} \triangleq \begin{cases} \dfrac{d^{\alpha}}{dt^{\alpha}} & R(\alpha) > 0, \\ 1 & R(\alpha) = 1, \quad \lambda = \text{real number} \\ \displaystyle\int_a^t (d\tau)^{-\alpha} & R(\alpha) < 0, \end{cases} \tag{1} $$

where $\alpha \in R$ stands for the order of operation.

There are three definitions used for the generally fractional differintegral. The first definition is Grunwald-Letnikov (GL) as stated in (2), where $[\cdot]$ is integer part and n is an integer satisfying the condition $n\text{-}1 < \alpha < n$. The binomial coefficient is stated in (3), while the Euler's gamma function $\Gamma(\cdot)$ is defined by (4).

$$ {}_aD_t^{\alpha} f(t) = \lim_{h \to 0} h^{-\alpha} \sum_{r=0}^{\left[\frac{t-a}{h}\right]} (-1)^r \begin{bmatrix} n \\ r \end{bmatrix} f(t - rh) \tag{2} $$

$$ \begin{bmatrix} n \\ r \end{bmatrix} = \frac{\Gamma(n+1)}{\Gamma(r+1)\Gamma(n-r+1)} \tag{3} $$

$$ \Gamma(x) = \int_0^{\infty} t^{x-1} e^{-t} dt \tag{4} $$

The second definition is Riemann-Liouville (RL) as expressed in (5), for $n\text{-}1 < \alpha < n$. The third definition is Caputo definition as shown in (6), where n is an integer and $n\text{-}1 < \alpha < n$. Among those, the Caputo definition is most popular in engineering application [16].

$$ {}_aD_t^{\alpha} f(t) = \frac{1}{\Gamma(n-\alpha)} \left(\frac{d}{dt}\right)^n \int_a^t \frac{f(\tau)}{(t-\tau)^{\alpha-n+1}} d\tau \tag{5} $$

$$ {}_aD_t^{\alpha} f(t) = \frac{1}{\Gamma(n-\alpha)} \int_a^t \frac{f^n(\tau)}{(t-\tau)^{\alpha-n+1}} d\tau \tag{6} $$

$$ \begin{aligned} \mathcal{L}\left\{ {}_aD_t^{\alpha} f(t) \right\} &= \int_0^{\infty} e^{-st} {}_0D_t^{\alpha} f(t) dt \\ &= s^{\alpha} F(s) - \sum_{k=0}^{n-1} s^k \, {}_0D_t^{\alpha-k-1} f(t) \Big|_{t=0} \end{aligned} \tag{7} $$

For solving engineering problems, the Laplace transform is routinely conducted. The formula of the Laplace transform of the RL fractional derivative in (5) is state in (7), for $n\text{-}1 < \alpha < n$, where $s = j\omega$ denotes the Laplace transform complex variable. Under zero initial condition for order α ($0 < \alpha < 1$), the Laplace transform of the RL fractional derivative in (5) can be expressed in (8)

$$ \mathcal{L}\left\{ {}_aD_t^{\pm\alpha} f(t) \right\} = s^{\pm\alpha} F(s) \tag{8} $$

B. FOPID Controller

The FOPID or PI$^{\lambda}$D$^{\mu}$ controller is an extended version of the conventional integer order PID (IOPID) controller. The generalized transfer function of the FOPID controller is given by the differential equation as stated in (9), where u(t) is unit step input signal as the control signal, e(t) is the error signal and λ and μ are more than zero. The Laplace transform of the transfer function is expressed by (10).

$$ \mathrm{u}(t) = K_p \mathrm{e}(t) + K_i D_t^{-\lambda} \mathrm{e}(t) + K_d D_t^{\mu} \mathrm{e}(t) \tag{9} $$

$$ \mathrm{G}_c(s)\big|_{\mathrm{FOPID}} = K_p + \frac{K_i}{s^{\lambda}} + K_d s^{\mu} \tag{10} $$

Relationship between the IOPID and the FOPID controllers can be represented by a graphical way as visualized in Fig.1. In most research works, the ranges of λ and μ are varied from 0 to 1. If λ and μ are ones, it is the IOPID controller. Otherwise are FOPID controllers. If λ and μ are varied between one and two, the controller tends to be unstable.

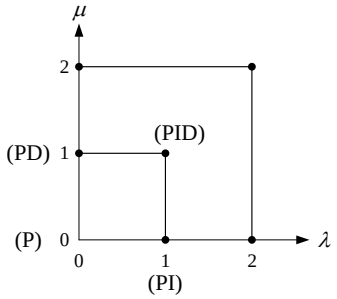

Fig. 1 Relationship between IOPID and FOPID controllers.

III. Problem Formulation

In this section, the FOPID control loop, the transfer function of unstable fractional order system and the FPA-based FOPID controller design are consecutively presented as follows.

A. FOPID Control Loop

The FOPID control loop is represented by the block diagram as shown in Fig. 2, where $G_p(s)$ and $G_c(s)$ are the plant and the FOPID controller models, respectively. The FOPID controller receives the error signal E(s) and produces the control signal U(s) to control the output signal C(s) and regulate the disturbance signal D(s), referring to the reference input R(s).

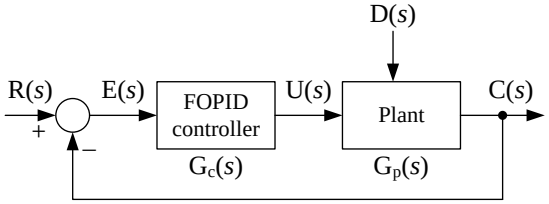

Fig. 2 FOPID control loop.

B. Unstable Fractional Order System

Since 90 era, many researchers have studied fractional order system of both stable and unstable plants. The problem is that how to control the plant to work properly or optimum of its performance. Either IOPID controller or FOPID controller can be used and which is better. This paper will study how to control an unstable fractional order system as model below.

$$ \begin{aligned} \mathrm{G}_p(s) &= \frac{s^{2/3} - 2}{s^{4/3} + 2s^{2/3} - 3s^{1/2} + 3/4} \\ &= \frac{s^{0.66667} - 2}{s^{1.3333} + 2s^{0.66667} - 3s^{0.5} + 0.75} \end{aligned} \tag{11} $$

This system (or plant) is oscillating system. For control system viewpoint, this system is unstable.

C. FPA-Based FOPID Controller Design

Designing methods of FOPID controller are as follows.

1) Analytical method [14-15].

2) Numerical method [10].

3) Rule-based tuning method [10, 12-13], e.g., Ziegler-Nichols type tuning rule method [12]. and

4) Optimization method [16-20], e.g., metaheuristic optimization method [18].

In this paper, FPA is used to design the FOPID controller instead of using Ziegler-Nichols type tuning rule method because the later method is difficult to or can not find s-shaped unit step response of the plant and/or critical gain of the plant [12]. Also, FPA is a promised metaheuristic algorithm for fast global convergence [19-20] and successfully applied to many real world engineering problems [20].

The FPA-based FOPID controller design framework can be represented by the block diagram shown in Fig. 3.

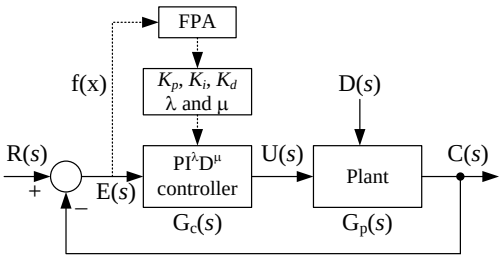

Fig. 3 FPA-based FOPID controller design framework.

Referring to Fig. 3, using pseudo code of FPA [19], the objective function, f(x) or f_{design}, and the error E(s) will be fed to the FPA to be minimized by searching for the appropriate values of the FOPID (or $PI^{\lambda}D^{\mu}$) controller parameters, i.e., K_p, K_i, K_d, λ and μ subject to inequality constraint parameters satisfying to the predefined response specifications.

The FPA's parameters:

f_{design} = objective function, f(x)
r_i = reference input signal = solution, x
c_i = controlled output signal = current best solution, g*
N = number of sampling data in observed period
Γ(λ) = standard gamma function
L = Levy flight
n = number of generated flowers in the population
p = switch probability ∈ [0, 1]
ε = random draw ∈ [0, 1]

$$Minimize \quad f_{design} = \sum_{i=1}^{N} (r_i - c_i)^2 \tag{12}$$

Subject to predefined constraint functions

IV. Results and Discussions

To design FPA-based FOPID controller for the unstable fractional order system, FPA are coded by MATLAB version 2017b (License No. #40637337) run on Intel (R) Core (TM) i5-3470 CPU@3.60 GHz, 4.0 GB-RAM. The FOPID controller is implemented by MATLAB [21] with FOMCON toolbox [22-23]. The setting FPA's parameters are as follows: n = 25, p = 0.8, λ = 1.5, N = 2001 and Maxgen = 100, 20 trial runs. Minimize f_{design}

$$\left.\begin{aligned} \text{Subject to} \quad & t_r \le 2.0\,\text{sec.}, \quad M_p \le 100\,\%, \quad t_s \le 20\,\text{sec.}, \\ & e_{ss} \le 0.10\,\%, \quad -5 \le K_p \le 0, \quad -1 \le K_i \le 0, \\ & -1 \le K_d \le 0, \quad 0.01 \le \lambda \le 2.0, \quad 0.01 \le \mu \le 1.5 \end{aligned}\right\} \tag{13}$$

Where t_r is rise time, M_p is percent maximum overshoot, t_s is setting time and e_{ss} is steady-state error. For comparison, the IOPID controller, λ and μ in (13) will be set as one (λ = μ = 1). The resulted transfer function of controllers are as follows.

$$G_c(s)\big|_{IOPID} = -1.0429 - \frac{0.1482}{s} - 0.1758s \tag{14}$$

$$G_c(s)\big|_{FOPID} = -0.8924 - \frac{0.1044}{s^{1.6481}} - 0.1976s^{0.7858} \tag{15}$$

The unit step responses of the unstable fractional order system without controller, with IOPID controller and with FOPID controller are shown in Fig. 4. The convergent rates of the objective function in (12) associated with inequality constraint functions in (13) proceeded by the FPA after 20 trial runs are depicted in Fig. 5.

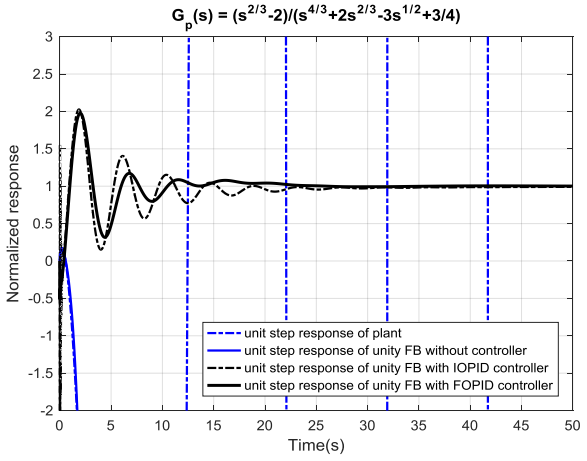

Fig. 4 Unit step responses of the unstable fractional order system.

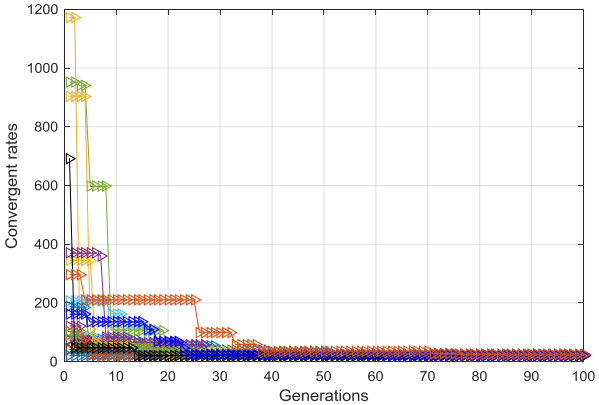

Fig. 5 Convergent rates after 20 trial runs.

Extract the performance indexes from the obtained unit step responses, we get data as shown in TABLE I.

TABLE I. PERFORMANCE INDEXES OF THE PLANT

Controller	Performance Index			
	t_r (s)	M_p (%)	t_s (s)	e_{ss} (%)
IOPID	0.91	102.64	30.81	0.01
FOPID	0.98	97.69	22.32	0

Extract the controller parameters form (14) and (15), we obtained data as shown in TABLE II.

TABLE II. CONTROLLER PARAMETERS

Controller	Controller Parameter				
	K_p	K_i	K_d	λ	μ
IOPID	-1.0429	-0.1482	-0.1758	1	1
FOPID	-0.8924	-0.1044	-0.1976	1.6481	0.7858

This can be noticed that FOPID controller designed by FPA can provide fair satisfactory both unit step response and parameter constraint functions even higher t_s than the constraint value. The M_p an t_s due to IOPID controller have higher values than specific constraint values. The performance of FOPID control system is superior than the performance of IOPID control system, significantly.

V. CONCLUSIONS

The FOPID (or $PI^{\lambda}D^{\mu}$) controller design for unstable fractional order system by using the flower pollination algorithm (FPA) has been proposed in this paper. Characterized by five parameters, the FOPID controller performs better responses compared with the IOPID (or PID) controller. In this paper, fractional calculus and FOPID controller have been briefly described. The FPA-based FOPID controller design framework has been formulated according to metaheuristic optimization context. By numerical simulation with MATLAB and FOMCON toolbox, five parameters of the FOPID controller have been successfully optimized by the FPA meeting the predefined response specification and inequality constraint functions. As simulation results, it was found that the FOPID controller designed by the FPA could yield satisfactory unit step response and superior than the response of IOPID controller.

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REFERENCES

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[2] S. Bennett, "Development of the PID controller," IEEE Control System Magazine, pp. 58–65, 1994.

[3] F. Haugen, PID Control, Norway: Tapir Academic Press, 2004.

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[5] A. O' Dwyer, Handbook of PI and PID Controller Tuning Rules, 2nd ed., London, UK:Imperial College Press, 2006.

[6] K. J. Astrom and T. Hagglund, Advanced PID Control, NC, USA: Instrumentation, Systems and Automation Society, 2006.

[7] I. Podlubny, Fractional-Order Systems and Fractional-Order Controllers, Slovak: Slovak Academy of Sciences, Institute of Experimental Physics, 1994.

[8] I. Podlubny, "Fractional-order systems and PID controller," IEEE Trans. Automatic Control, vol. 44, pp. 208–214, 1999.

[9] I. Petras, "The fractional-order controllers: methods for their synthesis and applications," J. of Electrial Engineering, vol. 50, pp. 284–288, 1999.

[10] C. A. Monje, B. M. Vinagre, V. Felie and Y. Chen, "Tuning and auto-tuning of fractional order controllers for industry applications," Control Engineering Practice, vol. 16, pp. 798–812, 2008.

[11] D. Xue, C. Zhao and Y. Q. Chen, "Fractional order PID control of a DC-motor with elastic shaft: a case study," Proc. 2006 American Control Conference, pp. 3182–3187, 2006.

[12] D. Valerio and J. Costa, "Tuning of fractional PID controllers with Ziegler-Nichols type rules," Signal Processing vol. 86, pp. 2771–2784, 2006.

[13] Y. Chen, T. Bhaskaran and D. Xue, "Fractional tuning rule development for fractional order proportional and integral controllers," J. of Computational and Nonlinear Dynamics, vol. 3, 2008.

[14] R. Caponetto, L. Fortuna and D. Porto, "A New tuning strategy for a noninteger order PID controller," Fractional Differentiation and Its Applications, Bordeaux, 2004.

[15] C. Zhao, D. Xue and Y. Chen, "A fractional order PID tuning algorithm for a class of fractional order plants," Inter. Conf. Mechatronics & Automation, Niagara Falls, 2005.

[16] Y. Q. Chen, I. Petras and D. Xue, "Fractional order control – a tutorial," American Control Conference, pp. 1399–1411, 2009.

[17] P. Shah and A. Agashe, "Review of fractional PID controller," Mechatronics, vol. 38, pp. 29–41, 2016.

[18] V. Zakian, Control Systems Design: A New Framework, Berlin, Germany: Springer-Verlag, 2005.

[19] Xin–She Yang, "Flower pollination algorithm for global optimization," in: Unconventional Computation and Natural Computation 2012, Lecture Notes in Computer Science, vol. 7445, pp. 240–249, 2012.

[20] X. S. He, X.–S. Yang, M. Karamanoglu and Y. X. Zhao, "Global convergence analysis of the flower pollination algorithm: A discrete-time Markov chain approach," Procedia Computer Science, vol. 108, pp. 1354–1364, 2017.

[21] Math Works, System Identification Toolbox™, MATLAB-R2017b, 2017.

[22] A. Tepljakov, E. Petlenkov and J. Belikov, "FOMCON: fractional-order modeling and control toolbox for MATLAB," Proc. the 18th Inter. Conf. on Mixed Design of Integrated Circuits and Systems (MIXDES'11), pp. 684–689, 2011.

[23] A. Tepljakov, E. Petlenkov and J. Belikov, "FOMCON: a MATLAB toolbox for fractional-order system identtification and control," Inter. J. Microelectronics and Computer Science, vol. 2, pp. 51–62, 2011.

Straw Mushroom Co_2&Co Condition Control

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***Abstract*— The Straw Mushroom Monitoring and Air Condition Control System has developed because of news which showed that family's farmers which consist of parent and their children when lack of respiration within the mushroom greenhouse. The cause of group dead may come from Carbon Dioxide (Co_2) or Carbon Monoxide (Co) gases.**

This project has developed by using a Node MCU board with Carbon Monoxide (MQ-9) and Carbon Dioxide (MH-Z14A) sensors to measure the level of Co_2 and Co gases and using a Raspberry pi boards to be a field server and an airflow controller.

The network communication inside greenhouse has been using Wi-Fi router to be an access point for communication between the field server and sensor boxes through Message Queuing Telemetry Transport (MQTT). The network communication between the mushroom greenhouse and the main server has used a 3/4G router to connect the internet for sending Co_2 and Co values to the database server.

Warning and airflow control depend on the level of Co_2 and Co values which has conditions to alert and turn on the red light signal to protect farmers when lack of respiration within the mushroom greenhouse and turn on exhaust fans for controlling the airflow condition until the normal level of air condition.

Keywords— straw mushroom, micro-climate, weather station, MQTT, Co_2, Co

I. INTRODUCTION

Problems about air quality in a straw mushroom farms as news which farmers died from working in a Mushroom Cultivation House, Ubolratchathani Province because of unconsciousness when the owner came into the farm while others try to help until all death together. Doctors identified death because of asphyxia as in [3]. At that time, it was not clear about what caused of the problem.

The cultivation room is defined as in [3,4] to be a confined space identification because it has restricted means of entry and exit, is not intended or designed primarily as a place of work and is at atmospheric pressure or high temperature while persons are in it and it has an atmosphere with potentially harmful contaminants.

The dangerous atmosphere in the mushroom cultivation house is caused by biogas in the fermentation process which materials use clear plastic to cover all sides of the nursery and then flow hot steam which temperature of the steam for nursery materials uses a constant temperature of 65 degrees Celsius as in [1] to kill the fungus and the mushroom enemies so that the materials were fermented to be a biogas which consists of methane (CH4), Co_2, Jane (H2), hydrogen sulfide (H2S), nitrogen (N2) and water vapor. Those gases and Co are called asphyxiants which are a group of gases that cause asphyxia as in [3]. After flowed hot stream, farmer prepares straw mushroom fungus and sprinkles it on the fermented material for every layers. Then, the cultivation house will be taken care of the temperature and the weather within the house until the mushroom grows and the harvesting. Some mushroom cultivations implement by using application with the internet of things technology to control in smart farms mushroom for temperature and humidity by using microcontroller such as Node.JS with NETPIE REST API over mobile phone [5,7].

Co gas is a colorless, odorless, tasteless and toxic gas which produced as a by-product of combustion. Any fuel-burning appliance, vehicle, tool or other device has the potential to produce dangerous levels of Co gas. The levels of Co gas are explained in table I as in [6].

TABLE I. SYMPTOMS ASSOCIATED WITH A GIVEN CONCENTRATION OF CO OVER TIME

PPM	Symptoms
35	Maximum exposure allowed by OSHA in the workplace over an eight hour period.
200	Mild headache, fatigue, nausea and dizziness.
400	Serious headache-other symptoms intensify. Life threatening after 3 hours.
800	Dizziness, nausea and convulsions. Unconscious within 2 hours. Death within 2-3 hours.
1600	Headache, dizziness and nausea. Death within 1 hour.
3200	Headache, dizziness and nausea. Death within 1 hour.
6400	Headache, dizziness and nausea. Death within 25-30 minutes.
12,800	Death

Co_2 gas is a colorless, odorless, faintly acidic-tasting, non-flammable gas. Co_2 gas is a byproduct of normal cell function and is removed from the body via the lungs in the exhaled air. Co_2 gas is also produced when fossil fuels are burned. The levels of Co_2 gas are explained in table II as in [2].

This research interesting in considering the levels of Co_2 and Co values from table I and II which are stored by using real-time sensor boxs over embedding system. The system environment inside the mushroom house consists of five micro-climate clients and the field server which connect to the Internet via 3/4G network to store information on the virtual cloud system of the University.

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II. Materials and Methods

A. Co_2&Co Data Mornitoring

The proposed smart farm model to protect a farmer from the environment which can adjust automatically by itself according to the hazardous level of gases. It is a smart farm that automatically adjusts the environment of gasses which consist of Co_2 and Co inside of the cultivation room. When it is a hazardous level of time, the system can remove gases from the cultivation room and notify farmers to protect when they want to enter the cultivation room. The smart farm system can help to balance gases environment in the cultivation room which is essential for the safety of farmers. With the smart farm system, a farmer can easily monitor gases level and warning messages through a mobile phone.

TABLE II. Symptoms Associated With a Given Concentration of Co_2 Over Time

PPM	Symptoms
250-350	background (normal) outdoor air level
350-1,000	typical level found in occupied spaces with good air exchange
1,000-2,000	level associated with complaints of drowsiness and poor air
2,000-5,000	level associated with headaches, sleepiness, and stagnant, stale, stuffy air; poor concentration, loss of attention, increased heart rate and slight nausea may also be present.
>5,000	This indicates unusual air conditions where high levels of other gases also could be present. Toxicity or oxygen deprivation could occur. This is the permissible exposure limit for daily workplace exposures.
>40,000	This level is immediately harmful due to oxygen deprivation.

The network design starts with sensors that are required to monitor the parameters which connect to the microcontroller by using program and automate control inside of the cultivate room using mobile phone from anywhere. So that the system has designed network for the microcontroller to send the data from sensors and status of the actuator to the field server by using MQTT protocol which is designed on Wi-Fi network inside the cultivate room and for the field server to send all data by using HTTP protocol into the database on the main server which is designed on 3G/4G Wi-Fi network.

Data collection of gases in cultivation room has installed on five layers which system has started to collect data since the 1st to the 5th days of cultivation process. The hardware is designed by using NodeMCU boards v.3 with ESP8266 on board for connecting with the MQ9 sensor and the MH-Z14a sensor which are powered with 5V. The sensors and the pin configurations are explained in Fig. 1.

The most importance component that is the controller to handle monitoring. The smart farm system monitor parameters and control the devices in order to utilize for farmer as protect as possible from gases. The sensors parameters consist of Co_2 and Co values. The parameters are read by sensor boxes which will send wirelessly by using ESP8266 on boards and MQTT technology to communicate between main server to field server to control devices.

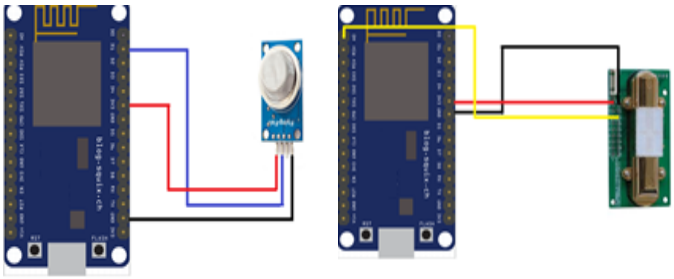

Fig. 1. NodeMCU with with the MQ9 sensor and the MH-Z14a sensor

The control devices consist of eight exhaust fans which four exhaust fans are setup on the back side of the cultivation room to remove exceed Co_2 and Co inside to outside and the other exhaust fans which are setup on the front side of the cultivation room to flow airs from outside to inside of cultivation room. The factors of the airs quality are controlled automatically based on Co_2 and Co values which are tracked in real time.

III. Results and Analysis

A. Co Air quality Analysis

The formation of Co gas is caused by the fermentation process of materials which are used for straw mushroom cultivation. The system will start collecting data within the house by collecting from the 1st day. The level of Co gas will increase significantly in the 1st day, which will begin to decrease until in the 5th day in Table III because of the hot stream process which is caused to increase the amount of smoke and it will be high in the 1st to 2rd day which the system had turned on the warning light and exhaust fans when detected Co gas over condition.

- In the 1st day while heating to sterilize using a constant temperature of 65 degrees Celsius, the level of Co was analyzed by using (Average of Co ~ Floors) and found that the floors of the house have the Pr (> F) value less than 0.05, which indicates that each floor of the house is different. Analysis of differences in layers of straw mushroom houses in the 1st day found that the average values of the 5th and 3rd floors was not different. Therefore, the installation of sensors for data storage can be installed with only 4 units, i.e. layers (1, 2, 3 and 4) or (1, 2, 4 and 5).
- In the 2nd day, level of Co was analyzed by using (Average of Co ~ Floors) and found that the floors of the house have the Pr (> F) values less than 0.05, which indicates that each floor of the house is different. Analysis of differences in layers of straw mushroom houses in the 2nd day found that the average values of the 5th and 3rd floors was not different. Therefore, the installation of sensors for data storage can be installed with only 4 units, i.e. layers (1, 2, 3 and 4) or (1, 2, 4 and 5).

TABLE III. MONTHLY AVERAGE PRICE OF 2018

Cs	Fs	Average of Co on time 9.00, 12.00 and 16.00				
		Day I	*Day II*	*Day III*	*Day IV*	*Day V*
C1	F1	264.3	265	161.3	153.3	151.3
C1	F2	274.3	257.3	178.6	176	171.3
C1	F3	223.3	210.3	134.3	125.3	116
C1	F4	213.6	206	195	191.3	187.3
C1	F5	223.6	212	146	143.6	141.3
C2	F1	264.6	263.6	162	155	152.6
C2	F2	275.3	258	176.3	174.3	173
C2	F3	222.6	211.3	135.3	123.6	116
C2	F4	215	205.3	193.3	192.6	187
C2	F5	224.3	211.6	145.6	143.3	140.3
C3	F1	264.6	262.6	163	155.3	152.3
C3	F2	273	257.3	173.3	175.3	173.6
C3	F3	222.6	213.3	137	125	115.3
C3	F4	215.3	205.3	197.6	193	186.3
C3	F5	224.6	215	146.6	145.6	143.3
C4	F1	265.3	264	161.3	153.3	151.3
C4	F2	276.3	255.6	174	173.3	172.3
C4	F3	222.6	212	135	126.3	117.6
C4	F4	213	206.6	193.6	191	187.6
C4	F5	222.6	210.6	146.3	145	141.6
C5	F1	264	264	161.6	154.3	152.3
C5	F2	274.3	256	175.3	175.3	172.3
C5	F3	223.3	212.3	133.6	126	115.6
C5	F4	213.6	204.6	194.3	192.6	187.3
C5	F5	222.6	213	145.6	145.3	143

- In the 3rd to 5th day, level of Co was analyzed by using (Average of Co ~ Floors) and found that the floors of the house have the Pr (> F) value less than 0.05, which indicates that each floor of the house is different. Analysis of differences in layers of straw mushroom houses in the third day found that the average values of every floors was different. Therefore, the installation of sensors for data storage need to be installed all layers.
- In the 1st to 5th days, level of Co was analyzed by using (Average of Co ~ Date+Floors) and found that the floors of the house have the Pr (> F) value less than 0.05, which indicates that each floor of the house is different. Analysis of differences in layers of straw mushroom houses in the 1st to 5th day found that the average value of the (2 and 1), (4 and 1) , (4 and 2) and (5 and 3) floors was not different. Therefore, the installation of sensors for data storage can be installed with only 3-4 units, i.e. layers (1 and 5), (1 and 3), (2 and 3) , (4 and 3) and (4 and 5).
- In the 1st to 5th days, level of Co was analyzed by using (Average of Co ~ Date+Floors) and found that the dates have the Pr (> F) value less than 0.05, which indicates that dates from the 1st to 5th day are different. Analysis of differences in dates of straw mushroom houses in the 1st to 5th day found that the average value of the (2nd and 1st), (4th and 3rd) , (5th and 3rd) and (5th and 4th) dates was not different. Therefore, the installation of sensors for data storage can be installed with only 2-3 units, i.e. dates (1st, 3rd and 5th), (1st and 3rd), (2nd, 3rd and 5th) or (2nd and 3rd)

B. Co_2 Air quality Analysis

The formation of Co_2 gas is caused by the fermentation process of materials which are used for straw mushroom cultivation. The system will start collecting data within the house which start from the 1st day. The level of Co_2 gas will increase from the 1st day, which will be added until dangerous in the 4th and 5th day in Table IV. The system will turn on the warning light and exhaust fans when detected Co_2 gas over condition.

- In the 1st day while heating to sterilize using a constant temperature of 65 degrees Celsius, the level of Co_2 gas was analyzed by using (Average of Co_2 ~ Floors) and found that the floors of the house have the Pr (> F) value more than 0.05, which indicates that each floor of the house is not different.
- In the 2nd day, level of Co_2 gas was analyzed by using (Average of Co_2 ~ Floors) and found that the floors of the house have the Pr (> F) value less than 0.05, which indicates that each floor of the house is different. Analysis of differences in layers of straw mushroom houses in the 2nd day found that the average values of the (3rd and 1st) and (4th and 1st) floors was not different. Therefore, the installation of sensors for data storage can be installed with only 3-4 units, i.e. layers (1, 2 and 5) or (2, 3, 4 and 5).
- In the 3rd day, level of Co_2 gas was analyzed by using (Average of Co_2 ~ Floors) and found that the floors of the house have the Pr (> F) value less than 0.05, which indicates that each floor of the house is different. Analysis of differences in layers of straw mushroom houses in the 3rd day found that the average values of the 4th and 3rd floors was not different. Therefore, the installation of sensors for data storage can be installed with only 4 units, i.e. layers (1, 2, 4 and 5) or (1, 2, 3 and 5).
- In the 4rd day, level of Co_2 gas was analyzed by using (Average of Co_2 ~ Floors) and found that the floors of the house have the Pr (> F) value less than 0.05, which indicates that each floor of the house is different. Analysis of differences in layers of straw mushroom houses in the day 4th found that the average values of the (3rd and 1st), (4th and 1st) and (4th and 2rd) floors was not different. Therefore, the installation of sensors for data storage can be installed with only 2-3 units, i.e. layers (1, 2 and 5), (3, 4 and 5) or (2 and 5).
- In the 5st day, level of Co_2 gas was analyzed by using (Average of Co_2 ~ Floors) and found that the floors of the house have the Pr (> F) value less than 0.05, which indicates that each floor of the house is different.

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TABLE IV. MONTHLY AVERAGE PRICE OF 2018

Cs	Fs	Average of Co_2 on time 9.00, 12.00 and 16.00				
		Day I	*Day II*	*Day III*	*Day IV*	*Day V*
C1	F1	153	253	297	335.3	384.3
C1	F2	153	154	272.3	326.6	368.3
C1	F3	154.6	257.6	277	348	378.3
C1	F4	156.3	251	275.6	325.6	377.6
C1	F5	155	246.3	287.6	297.6	375.3
C2	F1	155.3	253.3	296.3	335.6	382.3
C2	F2	153.6	157	272.3	325.3	367.3
C2	F3	153.3	253.3	276	346	376.6
C2	F4	154.6	251	274.6	326.6	377.6
C2	F5	156	248.6	286.6	295	372.3
C3	F1	155.6	253.6	298.6	337	384
C3	F2	153	154.6	261	326.3	367.6
C3	F3	153.3	259	277.3	345.3	378
C3	F4	156.3	251	275.3	325.3	375.6
C3	F5	156.6	248.6	287.3	294.6	373
C4	F1	156	254	297.3	336.6	381.6
C4	F2	157.6	155.3	273.6	325.6	348.3
C4	F3	155.6	256.6	276.3	345.6	382
C4	F4	155.6	258	276	349	375.3
C4	F5	168.3	247.6	286.6	296.3	377.6
C5	F1	154	255	297	336	386.3
C5	F2	152.3	153.3	271.6	323.6	369
C5	F3	153.3	255.6	276	346.3	370.6
C5	F4	154	251	277.6	346.3	375.6
C5	F5	156.3	247	287.3	297	361

Analysis of differences in layers of straw mushroom houses in the 5th day found that the average values of the (3rd and 1st), (4th and 1st) , (5th and 2rd) , (4th and 3st) , (5th and 3st) and (5th and 4rd) floors was not different. Therefore, the installation of sensors for data storage can be installed with only 2-3 units, i.e. layers (1 and 2), (1 and 3), (1 and 5) or (2, 3 and 4).

- In the 1st to 5th days, level of Co_2 was analyzed by using (Average of Co_2 ~ Date+Floors) and found that the floors of the house have the Pr (> F) value less than 0.05, which indicates that each floor of the house is different. Analysis of differences in layers of straw mushroom houses in the 1st to 5th day found that the average value of the (3 and 1), (4 and 1), (5 and 1), (4 and 3), (5 and 3) and (5 and 4) floors was not different. Therefore, the installation of sensors for data storage can be installed with only 3-4 units, i.e. layers (1, 2 and 3), (1, 2, 3 and 4) and (1, 2, 3 and 5).
- In the 1st to 5th days, level of Co_2 was analyzed by using (Average of Co_2 ~ Date+Floors) and found that the dates have the Pr (> F) value more than 0.05, which indicates that dates from the 1st to 5th days is different.

IV. CONCLUSION AND DISCUSION

The results of the research found that Co_2 gas generation will increase from the first day until it is dangerous on the 4th to 5th day but the occurrence of Co gas is dangerous on the 1st to 2nd day and will decrease after the 2nd until open house. The system will turn on the warning light and exhaust fans when detected Co_2 and Co gases over condition. The results from the statistical analysis found that

1) The 1st to 2nd days can install sensors for Co gas for storage only 4 layers but the 3rd to 5th days is necessary to install all 5 layers.

2) The 1st to 5th days can install sensors for Co gas for storage only only 3 days and 4 layers.

3) The 1st day can install sensors for Co_2 gas for storage only 1 layer.

4) The 2nd and 3th days can install sensors for Co_2 gas for storage only 4 layers.

5) The 4rd and 5th days can install sensors for Co_2 gas for storage only 3 layers.

6) The 1st to 5th days can install sensors for Co_2 gas for storage only 4 layers and is necessary to install all 5 days.

7) The 1st to 2nd days, farmers will have severe nausea, vomiting, dizziness and may even faint because of Co gas but the 4th to 5th days, farmers will have dizziness, faster breathing, headaches because of Co_2 gas.

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REFERENCES

[1] C. Panutat, N. Somboonsarn, and N. Tangsup."Straw mushroom cultivation in greenhouses". Department of Agricultural Extension., in press.

[2] OHS, "Carbon Dioxide Detection and Indoor Air Quality Control".[Online] https://ohsonline.com/articles/2016/04/01/carbon-dioxide-detection-and-indoor-air-quality-control.aspx

[3] S. Aoopara, " Investigation of the Cases of Farmers Died from Working in a Mushroom Cultivation House, Ubolratchathani Province," J. Health Science, Vol. 23, No. 2, March - April 2014.

[4] S.PhongKao,"Safety in operation in confined spaces, licensors, supervisors, helpers and workers in confined spaces".[online] http://www.shawpat.or.th/images/PDF/2017/961.pdf

[5] S. Phaka,S. Wongyai and A. Thomya, "Developing suitable system of temperature and humidity control for mushroom's growth at Baan Tung Bor Paan's mushroom farm, Pongyangkok, Hangchat, Lampang", J. Industrial Technology Lampang Rajabhat University, Lampang Rajabhat University, Vol 7, No. 1, January - June 2014.

[6] Wikipedia, "Carbon monoxide poisoning". [Online] https://en.wikipedia.org/wiki/Carbon_monoxide_poisoning

[7] W. Foongyen, S. Petcharn and R. Yajira, "Application with the Internet of Things Technology Control in Smart Farms Mushroom", J. Information Technology Management and Innovation, Department of nformation technology, Rajabhat Maha Sarakham University, Vol 5, No.1, January-June 2018.

A Modify Rule-Based System from Greedy Method

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***Abstract*—There are numerous numbers of orchids in Thailand's forest. Searching for orchids by some characteristics is extremely difficult. This research aims to develop the search engine via web application which can search for orchids in Thailand efficiently. In the proposed search engine, the characteristic of each orchid will be given by experts and all information will be collected in the knowledge base of the engine. Each characteristic of orchid will be collected in each vector. The related vectors will be combined to be the representative of each orchid chromosome by the greedy method and stored in the chromosome database. Users can use the proposed search engine by keyword or from characteristics of the orchid which is/are automatically produced by the system. This search engine is tested on 20 orchids by 50 users. It found that the proposed search engine works effectively.**

Keywords—orchid, knowledge base, chromosome, greedy method

I. INTRODUCTION

Today, the naturally occurring orchids have more than 25,000 species and more than 30,000 species created by human. Such that, it is difficult to search for the information of orchids especially searching through WWW page(s). One important thing to retrieve useful information from the search engine is the keyword. Using the wrong keyword might find the results for thousand useless pages. It claims that the relevant set of keywords data can help to optimize the retrieval function from the search engine. Curtis and Scherer [1], we proposed the new method for the search engine called indexing method which included a record file, an index file, a duplicate segment file and access to a network of computers. The first part of the data object is indexed according to the indexing method of this invention whereas the second part of the data object is indexed by other known database technology, such as B-tree. Rubenczyk et al. [2], presented the search engine method and apparatus. They use the classifications of the retrieved data items to formulate prompts for the users and use responses in conjunction with classification values to exclude some of the results for the retrieved data items as a query result. Kraft and Tewari [3], presented the system and method for dynamically associating keywords with domain-specific search engine queries. They marked an update the abstract that corresponding to the URL in the search engine store, and marked and inserted a domain-specific query for all occurrences of the keyword. Brady et al. [4] presented provides a taxonomy search method using example documents related to the subject taxonomy retrieval priority list.

This paper proposes a greedy method and transforms keyword to vector platform to generate rule-based automatically. After that, the boolean data type is applied in order to control rule-based and values in the vector for search engine tools. The concept of researching processes is shown in Fig. 1.

Following this introduction, section 2 describes the expert system. Section 3 presents a proposed algorithm with a description of each step. The experimental methodology and the results are explained in section 4. Finally, the conclusion is given in section 5.

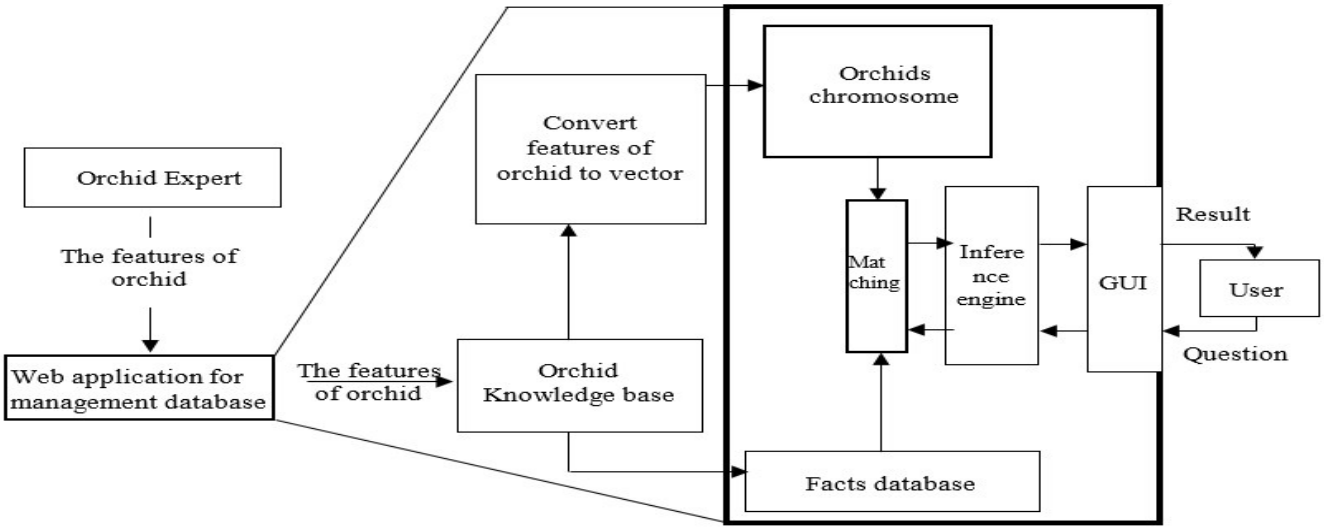

Fig. 1. The concept of research.

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II. EXPERT SYSTEM

Expert systems (ES) are a branch of applied artificial intelligence (AI) and were developed by the AI community in the mid-1960s. The basic idea behind ES is simply that expertise, which is the task-specific knowledge and transmission from human to computer. A rule-based ES is defined as one that contains information obtained from human experts and represents that information in the form of rules, such as IF-THEN. The rule can be used to process data for inference to obtain the appropriate conclusion. These inference engine is essentially a computer program that acting on facts and rule-based for investigation and present the results from the search engine. Applications of rule-based systems on ESs including state transition analysis [5], production planning [6], knowledgebase maintenance [7], knowledge verification/ validation [8], and others. The components of ES consist of knowledgebase, inference engine, and user interface, as shown in figure 2.

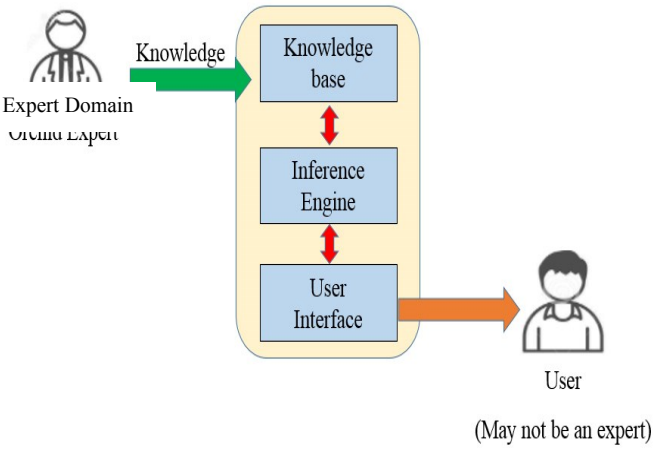

Fig. 2. Components of Expert Systems.

Knowledgebase: It contains the specific and high-quality domain. The exhibit intelligence is required of expert knowledge. The success of any ES majorly depends upon the collection of highly accurate and precise knowledge.

Inference engine: use of efficient procedures and rules by the inference engine is essential in deducting a correct and perfect solution. In case of rule-based ES, include: first, applies rules repeatedly to the facts, which are obtained from earlier rule application, second, adds new knowledge into the knowledge base if required, and the last resolves rules conflict when multiple rules are applicable to a particular case.

In this study, the proposed targets to improve rule-based for the knowledgebase and modify the inference engine method. The detail of the proposed described in the next section.

III. PROPOSED ALGORITHM

In this paper, the greedy method is used to generate rule-based automatically. The procedure of the proposed model including the following steps:

Step 1: from the characteristics of orchids obtained by experts, they converted to be the binary (0,1) attributes of the features in vector formats.

Step 2: after that, the greedy method is applied to generate the rule-based. The following figure (Fig. 3) is an example of the generated rule-based of the orchid color and type of orchid characteristics.

ID	Flower color	Type	Orchid number
1	white	1	1
2	pink	1	2

ID	Type of Orchid	Type	Orchid number
3	En:Epiphyte	2	1
4	Terrestrial	2	2

Transform to rule-based vectors

Type	1	1	2	2	Orchid
id	1	2	3	4	number
Rule1 :	1	0	0	0	1
Rule2 :	1	1	0	0	1,2
Rule3 :	1	0	1	0	1
Rule4 :	1	0	0	1	1,2
Rule5 :	1	1	1	0	1,2
Rule6 :	1	1	0	1	1,2
Rule7 :	1	1	1	1	1,2
Rule8 :	0	1	0	0	2
Rule9 :	0	1	1	0	1,2
Rule10 :	0	1	0	1	2
Rule11 :	0	1	1	1	1,2
Rule12 :	0	0	1	0	1
Rule13 :	0	0	1	1	1,2
Rule14 :	0	0	0	1	2

Fig. 3. Generated rule-based from the flower color characteristics.

Step3: added new features of orchid. The rule-based will be adjusted automatically. For example, the purple color is added to be the new feature the new rule-based will be generated as shown in Fig. 4.

ID	Flower color	Type	Orchid number
1	white	1	1
2	pink	1	2
5	purple	1	3

ID	Type of Orchid	Type	Orchid number
3	En:Epiphyte	2	1
4	Terrestrial	2	2

Transform to rule-based vectors

Type	1	1	2	2	1	Orchid
id	1	2	3	4	5	number
Rule1 :	1	0	0	0	0	1
Rule2 :	1	1	0	0	0	1,2
Rule3 :	1	0	1	0	0	1
Rule4 :	1	0	0	1	0	1,2
Rule5 :	1	1	1	0	0	1,2
Rule6 :	1	1	0	1	0	1,2
Rule7 :	1	1	1	1	0	1,2
Rule8 :	0	1	0	0	0	2
Rule9 :	0	1	1	0	0	1,2
Rule10 :	0	1	0	1	0	2
Rule11 :	0	1	1	1	0	1,2
Rule12 :	0	0	1	0	0	1
Rule13 :	0	0	1	1	0	1,2
Rule14 :	0	0	0	1	0	2
Rule15 :	1	0	0	0	1	1,3
Rule15 :	1	1	0	0	1	1,2,3
Rule17 :	1	0	1	0	1	1,3
Rule18 :	1	0	0	1	1	1,2,3
Rule19 :	1	1	1	0	1	1,2,3
Rule20 :	1	1	0	1	1	1,2,3
Rule21 :	1	1	1	1	1	1,2,3
Rule22 :	0	1	0	0	1	2,3
Rule23 :	0	1	1	0	1	1,2,3
Rule24 :	0	1	0	1	1	2,3
Rule25 :	0	1	1	1	1	1,2,3
Rule26 :	0	0	1	0	1	1,3
Rule27 :	0	0	1	1	1	1,2,3
Rule28 :	0	0	0	1	1	2,3

Fig. 4. Generate new rule-based, in case add the new feature of orchid.

Step4: Boolean data type is applied in order to control the rule-based and values of search engine the vector as the following equation (1). The control rule-based tool demonstrated in Fig. 5.

$$value = \begin{cases} \text{T}, & \textit{the feature is used} \\ \text{F or D}, & \textit{not used} \end{cases} \quad (1)$$

ID	Flower color	Type	Orchid number
1	white	1	1
2	pink	1	2
5	purple	1	3

ID	Type of Orchid	Type	Orchid number
3	En:Epiphyte	2	1
4	Terrestrial	2	2

Transform to rule-based vectors

Control value	T	T	T	T	F	Orchid number
Type	1	1	2	2	1	
id	1	2	3	4	5	
Rule1 :	1	0	0	0	0	1
Rule2 :	1	1	0	0	0	1,2
Rule3 :	1	0	1	0	0	1
Rule4 :	1	0	0	1	0	1,2
Rule5 :	1	1	1	0	0	1,2
Rule6 :	1	1	0	1	0	1,2
Rule7 :	1	1	1	1	0	1,2
Rule8 :	0	1	0	0	0	2
Rule9 :	0	1	1	0	0	1,2
Rule10 :	0	1	0	1	0	2
Rule11 :	0	1	1	1	0	1,2
Rule12 :	0	0	1	0	0	1
Rule13 :	0	0	1	1	0	1,2
Rule14 :	0	0	0	1	0	2
Rule15 :	1	0	0	0	1	1,3
Rule15 :	1	1	0	0	1	1,2,3
Rule17 :	1	0	1	0	1	1,3
Rule18 :	1	0	0	1	1	1,2,3
Rule19 :	1	1	1	0	1	1,2,3
Rule20 :	1	1	0	1	1	1,2,3
Rule21 :	1	1	1	1	1	1,2,3
Rule22 :	0	1	0	0	1	2,3
Rule23 :	0	1	1	0	1	1,2,3
Rule24 :	0	1	0	1	1	2,3
Rule25 :	0	1	1	1	1	1,2,3
Rule26 :	0	0	1	0	1	1,3
Rule27 :	0	0	1	1	1	1,2,3
Rule28 :	0	0	0	1	1	2,3

Fig. 5. The control rule-based tool.

Step5: after the rule-based is created, the Euclidean distance (see Equation (2)) method is applied to the inference engine step.

$$Orchid_{win} = \min\left(dist_i\right) \tag{2}$$

where

$i = 1, 2, 3, \ldots$ Nr is the maximum order of vector rule-based.

$$dist_i = \sqrt{\sum_{i=1}^{Nr} \sqrt{\left(p_i - q_i\right)^2}} \tag{3}$$

Step6: The orchid search engine is created based on the characteristics of the orchid by the orchid expert. The screen of the search engine tool and the vector is shown in Fig. 6.

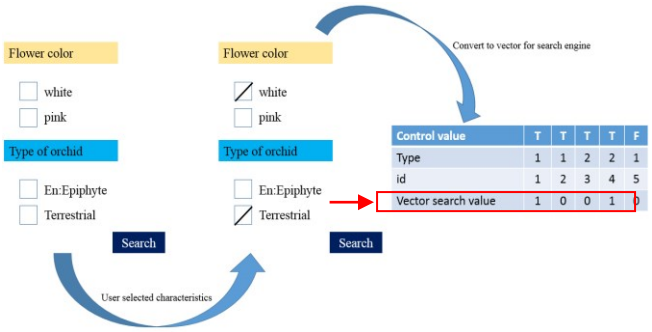

Fig. 6. The user interface of the search engine tool.

IV. Experimental Results

The proposed algorithm was tested by 50 users, the search engine can find the information they need most effectively. The experiment for the search engine was divided into 2 forms: first, used specific of features for search data and second, used all of the features for search data. It found that the results return 100 percent of accuracy for both of cases. The GUI of search engine and the result of it show in figure 7-10.

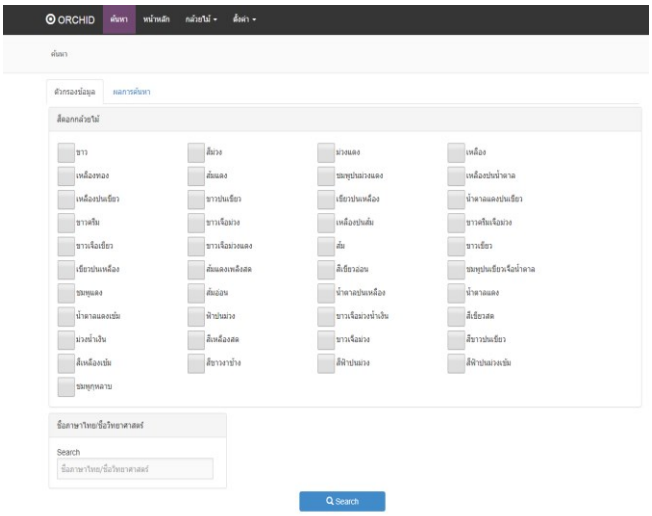

Fig. 7. GUI of orchids search engine.

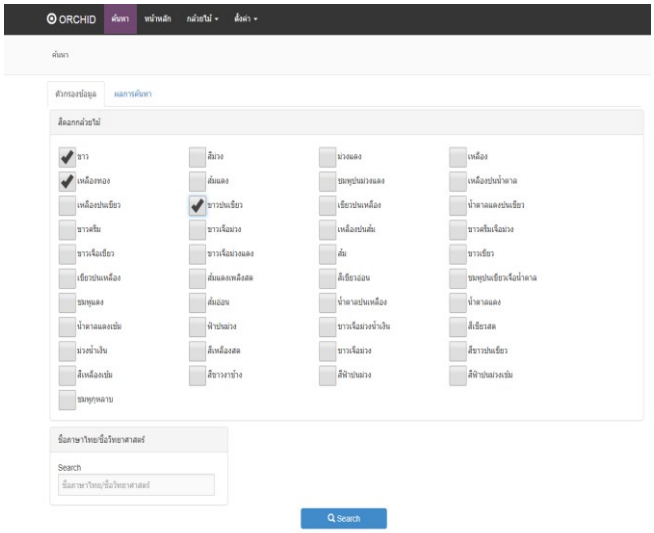

Fig. 8. The user chooses the characteristics of orchid.

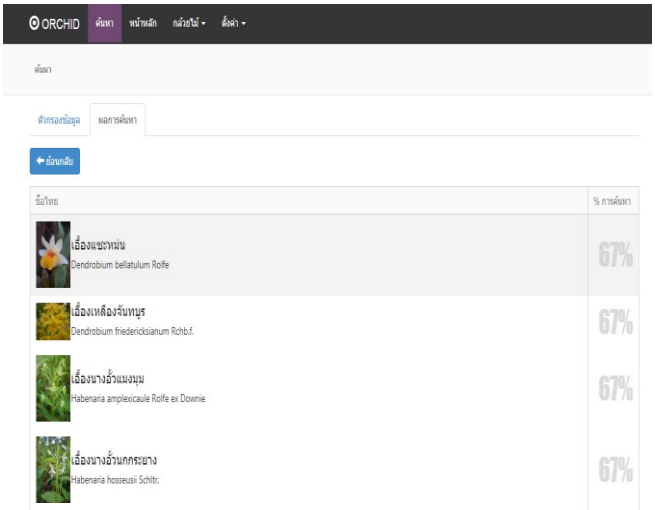

Fig. 9. The results of searching.

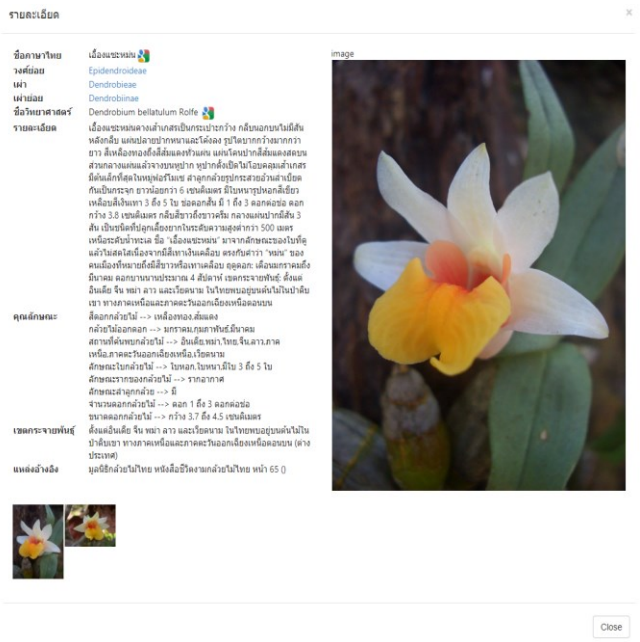

Fig. 10. The detail of orchid.

V. CONCLUSION

This paper proposes a new methodology to develop the search engine via the web application. The main idea is to modify rule-based and the inference engine for the expert system. The original if-then rule-based is replaced by a vector of binary value. The boolean data type is applied to control rule-based and values of the vector in the search engine in the GUI form while the Euclidean distance is applied for inference engine step. In this research, the developed search engine returns 100 percent of results in terms of accuracy.

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REFERENCES

[1] G. Eason, B. Noble, and I. N. Sneddon, “On certain integrals of Lipschitz-Hankel type involving products of Bessel functions,” Phil. Trans. Roy. Soc. London, vol. A247, pp. 529–551, April 1955. *(references)*

[2] J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.

[3] I. S. Jacobs and C. P. Bean, “Fine particles, thin films and exchange anisotropy,” in Magnetism, vol. III, G. T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271–350.

[4] Brady, S., Harris, C., Dammeier, J., & Samat, S. (2003). *U.S. Patent Application No. 10/267,952*.

[5] K. Elissa, “Title of paper if known,” unpublished.

[6] R. Nicole, “Title of paper with only first word capitalized,” J. Name Stand. Abbrev., in press.

[7] Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, “Electron spectroscopy studies on magneto-optical media and plastic substrate interface,” IEEE Transl. J. Magn. Japan, vol. 2, pp. 740–741, August 1987 [Digests 9th Annual Conf. Magnetics Japan, p. 301, 1982].

[8] M. Young, The Technical Writer’s Handbook. Mill Valley, CA: University Science, 1989.

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Prediction heating and cooling loads of building using evolutionary grey wolf algorithms

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***Abstract*—This paper proposes using evolutionary grey wolf algorithm to predict the heating load (HL) and the cooling load (CL) of buildings. The proposed algorithm was constructed using 768 various residential buildings with eight input variables (relative compactness, surface area, wall area, roof area, overall height, orientation, glazing area, glazing area distribution) and two output variables. The experimental results are evaluated by comparative to previous work, geometric semantic genetic programming (GSGP), artificial neural network (ANN), support vector regression (SVR), evolutionary multivariate adaptive regression splines (EMARS), random forests (RF) and multilayer perceptron (MLP). The results prove that the proposed algorithm is competitive compared to the other machine learning algorithms.**

Keywords—heating load, cooling load, energy performance, machine learning, grey wolf algorithm

I. INTRODUCTION

Global warming is an increasing average temperature of the Earth's climate system, and it has been challenging and widely recognized issue recently. The main reason for this effect comes from human activities. For example, while the temperature rises, we use cooling equipment to reduce the heat in our building. On the other hand, we use heating equipment in the building when the temperature cools down. These equipment emit the Carbon Dioxide (CO2) to the environment and cause of the Greenhouse effect. To help reduce Global Warming issue, the energy-saving buildings have been proposed and developed. In Thailand, there have been several contests to find the best energy-saving buildings, for example, MEA Energy Saving Building [1]. This contest has conducted for five years consecutive. However, to design energy efficient buildings, it should think of Heating Load (HL) and Cooling Load (CL) of the buildings. The HL is the amount of heat energy that would need to be added to a space to maintain the temperature in an acceptable range, and the CL is the amount of heat energy that would need to be removed from an area (cooling) to maintain the temperature in an acceptable range. Therefore, it requires in-depth knowledge and experiences of architects, engineers, and designers.

Recently, several computational approaches have been proposed to assist architects in designing energy-efficient buildings. One of these techniques is Machine Learning (ML). The ML technique learns the past evidence and builds a model to estimate the new value. Tsanas and Xifara [2] proposed the pioneering work which applied ML technique to predict HL and CL of several types of building. In that work, they investigated the association between input variables and output variables and employed regression technique. Later Duartea et al. [3], compared three single classifiers (Decision Tree, Multi-layer Perceptron and Support Vector Regressor) and one ensemble classifier (Random Forest). They concluded that Multi-layer Perceptron shown the best performance for both HL and CL. Moreover, Castelli et al. [4] proposed Genetic Programming approach to predict HL and CL of residential buildings and they found that their method performed better than previous works.

In this paper, we applied evolutionary grey wolf algorithm to predict HL and CL of the buildings. Grey wolf algorithm has high performance in unknown and challenging search space. The model uses data associated to eight input variables (relative compactness, surface area, wall area, roof area, overall height, orientation, glazing area, and glazing area distribution) to define the output variables. The proposed approach is to compare the performance of various machine learning tools including geometric semantic genetic programming (GSGP), artificial neural network (ANN), support vector regression (SVR), evolutionary multivariate adaptive regression splines (EMARS), random forests (RF) and multilayer perceptron (MLP).

The paper is organized as follows: Section II introduces grey wolf algorithm used in this work and evaluation criteria. Section III describes the dataset that has been used. Section IV describes the experimental settings and compares model performance. Finally, the conclusions will be discussed in Section V.

II. METHODOLOGY

A. Grey Wolf Algorithm

Grey wolf algorithm is an evolutionary computation-based technique inspired by the hunting behavior and leadership hierarchy of grey wolves in nature was proposed in [5] has ability to solving problems with unknown search spaces. Examples include economic load dispatch problems [6], wide-area power system stabilizer design [7], and optimum spectrum mask based medical image fusion [8].

The grey wolves in general lives in a social group called pack. These wolves hunt the prey efficiently, since they follow very serious social dominant hierarchy. The social rank of the wolves pack is divided into four levels. From top level to bottom grade are alpha wolves, beta wolves, delta wolves and omega wolves.

The leader of wolves is called alpha. The alpha is responsible for making decisions in agreement with hunting, sleeping time and place, and so on [9]. The second level is the subordinate wolves is called beta. Beta wolves are also

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the best candidate when alpha getting old or passing away. The operation of beta is to help the alpha in decision making or other activities. The third level is the subordinate wolves is called delta, which must submit to alpha and beta, but they dominate the omega. Delta wolves should scout to protect and ensure the safety of the wolves pack. The members in this category consist of scouts, sentinels, elders, hunters and caretakers. The lowest ranking wolves are called omega. Omega wolves have to comply with all the other dominant wolves.

Grey wolves have an ability to recognize the positions of prey and hence whole pack will move to encircle them. The hunting behavior of wolves is divided into three steps: 1) Finding and reaching prey, 2) Encircling the prey, and 3) Attacking the prey. The hunting (optimization) is guided by alpha, beta and delta wolves. The omega wolves are iteratively improved by following the alpha, beta and delta wolves. The mathematical model is developed as follow.

$$\vec{D} = \left| \vec{C} \cdot \vec{X}_p(t) - \vec{X}(t) \right| \quad (1)$$

$$\vec{X}(t+1) = \vec{X}_p(t) - \vec{A} \cdot \vec{D} \quad (2)$$

where t is the iteration number, $\vec{X}$ is the grey wolf position and $\vec{X}_p$ is the prey position. The vectors $\vec{A}$ and $\vec{C}$ that are coefficients are calculated as follows

$$\vec{A} = 2a \cdot \vec{r}_1 - a \quad (3)$$

$$\vec{C} = 2\vec{r}_2 \quad (4)$$

The value of a is decreased linearly from 2 to 0 over the course of iterations in order to impress exploration and exploitation and $\vec{r}_1, \vec{r}_2$ are random vectors in the range [0, 1]. The vector $\vec{C}$ is used to provide a random weight to mention attractiveness of prey is a random value in the range [0, 2].

Hunting strategy of the grey wolves can be mathematically modeled by approximating the prey position with the help of alpha, beta and delta solutions. The first three best solutions get so far and force the other search agents (including the omegas) to update their positions according to the position of the three best search agents. Each wolf are updated their positions by following equations.

$$\vec{D}_\alpha = \left| \vec{C}_1 \cdot \vec{X}_\alpha - \vec{X} \right| \quad (5)$$

$$\vec{D}_\beta = \left| \vec{C}_2 \cdot \vec{X}_\beta - \vec{X} \right| \quad (6)$$

$$\vec{D}_\delta = \left| \vec{C}_3 \cdot \vec{X}_\delta - \vec{X} \right| \quad (7)$$

where $\vec{C}_1, \vec{C}_2, \vec{C}_3$ are determined as in (4), and $\vec{X}_\alpha, \vec{X}_\beta, \vec{X}_\delta$ are determined as in (8)-(10), respectively.

$$\vec{X}_1 = \left| \vec{X}_\alpha - \vec{A}_1 \cdot \vec{D}_\alpha \right| \quad (8)$$

$$\vec{X}_2 = \left| \vec{X}_\beta - \vec{A}_2 \cdot \vec{D}_\beta \right| \quad (9)$$

$$\vec{X}_3 = \left| \vec{X}_\delta - \vec{A}_3 \cdot \vec{D}_\delta \right| \quad (10)$$

$$\vec{X}(t+1) = \frac{\vec{X}_1 + \vec{X}_2 + \vec{X}_3}{3} \quad (11)$$

where $\vec{X}_\alpha, \vec{X}_\beta, \vec{X}_\delta$ are the first three best solutions at a given iteration t, $\vec{A}_1, \vec{A}_2, \vec{A}_3$ are determined as in (3).

The parameter a that controls the tradeoff between exploration and exploitation is updated in the final step. The fluctuation range of $\vec{A}$ is also decreased by a, i.e., $\vec{A}$ is a random value in [-a, a] where a is decreased from 2 to 0 over the course of iterations in (12).

$$a = 2 - t\frac{2}{MaxIter} \quad (12)$$

where t is the iteration number and *MaxIter* is the total number of iteration.

B. Evaluation Criteria

Multiple evaluating criteria are utilized to compare the performance of prediction models. The mean absolute error (MAE), root mean squared error (RMSE) and mean relative error (MRE) are used to compare the performance of proposed algorithm against other models. Low MAE, RMSE, MRE values indicate high confidence in model-predicted values.

The mean absolute error (MAE) is a quantity used to measure magnitude of the errors in a set of predictions, without considering their direction. MAE is the average over the test sample of the absolute differences between prediction and actual observation where all individual differences have equal weight.

$$MAE = \frac{1}{n} \times \sum_{i=1}^{n} \left| y_i - \hat{y}_i \right| \quad (13)$$

The root mean square error (RMSE) is a quadratic scoring rule that also measures the average magnitude of the error. RMSE is the square root of the average of squared differences between prediction and actual observation.

$$RMSE = \sqrt{\frac{1}{n} \times \sum_{i=1}^{n} \left(y_i - \hat{y}_i \right)^2} \quad (14)$$

And the mean relative error (MRE) is obtained using the following equation.

$$MRE = 100 \cdot \frac{1}{n} \times \sum_{i=1}^{n} \left(\frac{\left| y_1 - \hat{y}_i \right|}{y_i} \right) \quad (15)$$

where y_i is the predicted output variable, $\hat{y}_i$ is the actual output variable for the ith entry in the training or testing subset and n is the number of samples in the training or testing subset.

III. Data Despcription

The data used in this study was simulated using Ecotect [2] simulation software. Each of the 12 building forms investigated comprised 18 elementary blocks (3.5×3.5×3.5) (see Fig. 1). All buildings had the same volume (771.75 m^3) and used the same materials for each block but have different surface areas and dimensions. The simulation data assumed that activities of the buildings were sedentary.

The simulation used materials with lowest U-values, as follows: walls (1.780), floors (0.860), roofs (0.500), windows (2.260). The internal conditions of buildings were designed as follows: clothing (0.6 clo), humidity (60%), air speed (0.30 m/s), lighting level (300 Lux). The internal gains were set to sensible (5) and latent (2 W/m2). Infiltration-of-air change rate and wind sensitivity were set to 0.5 and 0.25, respectively. The simulation used a mixed mode with 95% efficiency and thermostat range [19, 24] ◦C. The operational time was defined as 15-20 h on weekdays and 10-20 h on weekends.

The dataset consists of eight independent variables (or features) and two output variables. Each instance is related to a residential buildings, i.e., relative compactness, surface area, wall area, roof area, overall height, orientation, glazing area, glazing area distribution, and heating load/cooling load.

Surface area is calculated as the total of wall area, roof area and floor area. Three percentages of glazing area to floor area were 10%, 25% and 40%. Furthermore, five different distribution scenarios for each glazing area were simulated: 1) uniform: with 25% glazing for each face, 2) north: 55% for the north face and 15% for each of the other faces, 3) east: 55% for the east face and 15% for each of the other faces, 4) south: 55% for the south face and 15% for each of the other faces, and 5) west: 55% for the west face and 15% for each of the other faces. In addition, no glazing areas are simulated in the experiment. Finally, all shapes were rotated to face the four cardinal points. Table 1 provides the detailed input and output parameters in this study.

TABLE I. Input and Output Variables

Mathematical representation	Input or output variable	Number of possible value
X_1	Relative compactness	12
X_2	Surface area	12
X_3	Wall area	7
X_4	Roof area	4
X_5	Overall height	2
X_6	Orientation	4
X_7	Glazing area	4
X_8	Glazing area distribution	6
Y_1	Heating load (HL)	586
Y_2	Cooling load (CL)	636

IV. Experimental Study

A. Experimental Settings

In data processing, rescaling data is a method used to standardize the range of independent variables or features of data. The training data and testing data should both be normalized independently using the linear rescaling parameters of training dataset.

This paper using the min-max scaling of the entire dataset for input variables. Min-max scaling or min-max normalization is the simplest method and consists in rescaling the range of features to scale the range in [0, 1] or [−1, 1]. Original data are normalized to avoid attributes in greater numeric ranges dominating those in smaller numeric ranges as well as avoid numerical difficulties. However, the nature of the data is factor to select the target range. The general formula is given as:

$$x_i^{nor} = \frac{x_i - x_{min}}{x_{max} - x_{min}} \tag{16}$$

where x_i is any input value, x_{min} is the minimum value of the entire dataset, x_{max} is the maximum value of the entire dataset, and x_i^{nor} is the normalized value of the data.

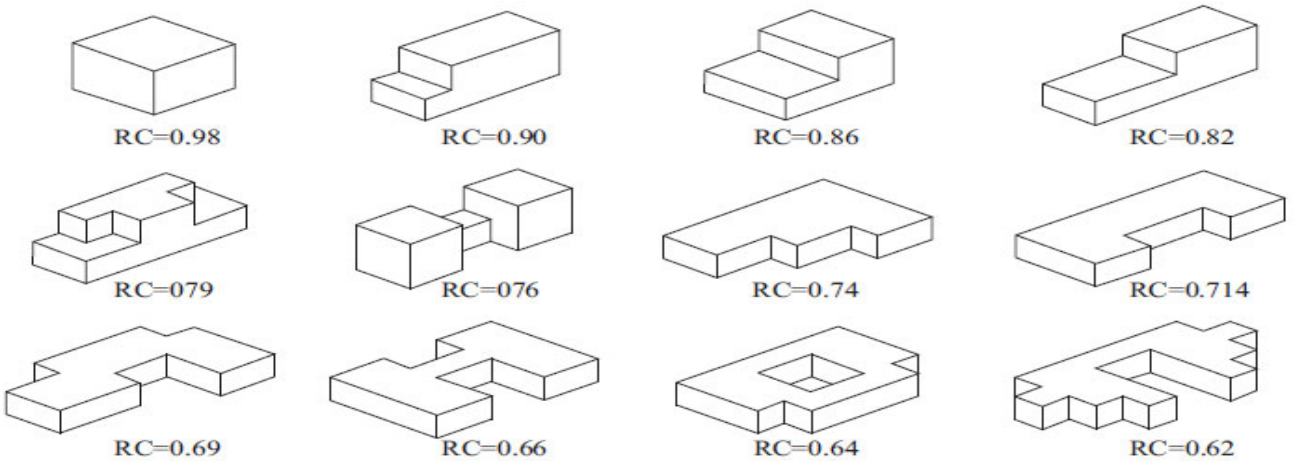

Fig. 1. Building shapes

Model performance was evaluated by a stratified k-fold cross-validation approach. Cross-validation is fundamentally used in applied machine learning to estimate the skill of a machine learning model on unseen data. The procedure has a single parameter called k that refers to the number of groups that a given data sample is to be split into. When a specific value for k is chosen, it may be used in place of k in the reference to the model, such as k=10 becoming 10-fold cross-validation. For this paper, we appraise the HL and CL values using a 10-fold cross validation with 100 repetitions because 10 folds were optimal in terms of bias and variance associated with the validation process and in terms of time [10].

B. Experimental Results

The performances of the proposed algorithm have been evaluated with geometric semantic genetic programming (GSGP), artificial neural network (ANN), support vector regression (SVR), evolutionary multivariate adaptive regression splines (EMARS), random forests (RF) and multilayer perceptron (MLP).

The comparison results for heating load are shown in Table II and in Table III for cooling load. The results of GSGP were taken from the results reported in [4]. The results of ANN and SVR were taken from the results reported in [11]. The results of EMARS were taken from the results reported in [12]. The results of RE were taken from the results reported in [2] while the results of MLP were taken from the results reported in [13]. The italic figures indicate the best results among the seven algorithms.

Tables II and III present the best values produced in this work for each performance metric. These values are compared to the results obtained in other comparable algorithms. For the prediction of HL, SVR delivered very small estimation values in terms of MAE and RMSE while GSGP produces results that are statistically better than other machine learning tools using MRE as error measures. Regarding the EMARS technique, the performance is comparable better than the other algorithms for the prediction of CL using RMSE as error measure. The proposed algorithm produced the best values for 2 of the 3 metrics applied for the prediction of CL. What can be concluded is that proposed algorithm for prediction of heating load/cooling load is a viable and competitive alternative.

TABLE II. RESULT COMPARISON FOR HEATING LOAD

Model	Heating load		
	MAE (kW)	***RMSE (kW)***	***MRE (%)***
GSGP	1.120	-	***0.960***
ANN	0.432	0.610	-
SVR	***0.236***	***0.346***	-
EMARS	0.340	0.460	-
RF	0.510	-	2.180
MLP	0.246	1.094	1.197
Proposed	0.317	1.193	1.275

TABLE III. RESULT COMPARISON FOR COOLING LOAD

Model	Cooling load		
	MAE (kW)	***RMSE (kW)***	***MRE (%)***
GSGP	1.290	-	4.860
ANN	1.158	1.678	-
SVR	0.890	1.647	-
EMARS	0.680	***0.970***	-
RF	1.420	-	4.620
MLP	0.390	1.284	1.649
Proposed	***0.323***	1.394	***1.546***

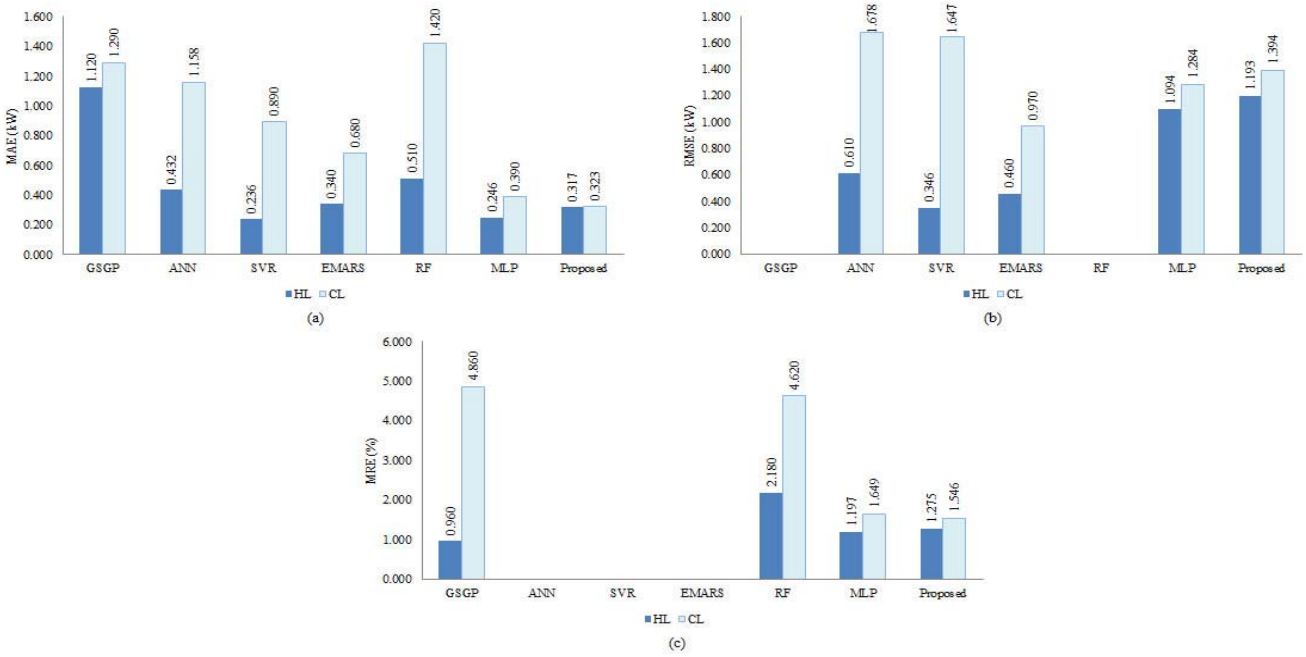

Fig. 2. Criteria for evaluating comparative models

V. CONCLUSTIONS

This paper proposes using evolutionary grey wolf algorithm to predict the heating load (HL) and the cooling load (CL) of buildings. The process of traditional grey wolf algorithm has only one pack and has opportunity to trap in local optimum. The proposed algorithm presents grey wolf algorithm has more than one pack to reduce local optimum ratio and distribute value to expand the search space.

This work evaluated by comparative to six machine learning algorithms, geometric semantic genetic programming (GSGP), artificial neural network (ANN), support vector regression (SVR), evolutionary multivariate adaptive regression splines (EMARS), random forests (RF) and multilayer perceptron (MLP) based on a data set of 768 simulated buildings.

After measuring the accuracy of the proposed algorithm with three statistical metrics (MAE, RMSE and MRE) one can decide that is possible to predict with reasonably quality the heating load and cooling load of residential buildings with the proposed methods. As future work, with the expectation to improve the results presented here, others evolutionary algorithm will be discussed.

REFERENCES

[1] MEA Energy Saving Building [http://meaenergysavingbuilding.net].

[2] A. Tsanas and A. Xifara, "Accurate quantitative estimation of energy performance of residential buildings using statistical machine learning tools," Energy and Buildings, vol. 49, pp. 560-567, 2012.

[3] G. R. Duarte, L. G. da Fonseca, P. Vanessa Z.C. Goliatt, A.C. de Castro Lemonge, "Comparison of machine learning techniques for predicting energy loads in buildings," Ambiente Construído, vol.7, no.3, pp. 103-115, 2017.

[4] M. Castelli, L. Trujillo, L. Vanneschi, A. Popovic, "Prediction of energy performance of residential buildings: A genetic programming approach," Energy and Buildings, vol. 102, pp. 67-74, 2015.

[5] S. Mirjalili, S. M. Mirjalili and A. Lewis, "Grey Wolf Optimizer," Advances in Engineering Software, vol. 69, pp. 46-61, 2014.

[6] M. Pradhan, P.K. Roy and T. Pal, "Grey wolf optimization applied to economic load dispatch problems," International Journal of Electrical Power & Energy Systems, vol. 83, pp. 325-334, 2016.

[7] M. R. Shakarami and I. F. Davoudkhani, "Wide-area power system stabilizer design," Electric Power Systems Research, vol. 133, pp. 149-159, 2016.

[8] E. Daniel, J. Anitha, K. K. Kamaleshwaran and I. Rani, "Optimum spectrum mask based medical image fusion using Gray Wolf Optimization," Biomedical Signal Processing and Control, vol. 34, pp. 36-43, 2017.

[9] C. M. Matthew and J. A. Vucetich, "Effect of sociality and season on grey wolf foraging behavior," Plos One, vol. 6, issue 3, pp. 1-10, 2011.

[10] R. Kohavi, "A study of cross-validation and bootstrap for accuracy estimation andmodel selection," in: Proceedings of the 14th International Joint Conference onArtificial Intelligence, vol. 2, pp. 1137–1143, 1995.

[11] J. Chou and D. Bui, "Modeling heating and cooling loads by artificial intelligence for energy-efficient building design," Energy and Buildings, vol. 82, pp. 437-446, 2014.

[12] M. Cheng and M. Cao, "Accurately predicting building energy performance using evolutionary multivariate adaptive regression splines," Applied Soft Computing, vol. 22, pp. 178-188, 2014.

[13] G. Duarte, P. Capriles, L. Goliatt and A. Lemonge, "Prediction of energy load of buildings using machine learning methods," in: Proceedings of the 4th Conference of Computational Interdisciplinary Science (CCIS), 2016.

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***Abstract*—This paper mostly presents the application of wildfire mobile field survey in Nan province by using free and open source software. Geographic Information Systems (GIS) technology is ideally suited as a tool for the presentation of data derived from continuous monitoring of locations and used to support and deliver information to environmental managers and the public. Combined with GeoServer, PostgreSQL/PostGIS, it extends the web GIS capabilities in providing real-time data from the notify activities. Forest fire officer was reporting from the field via a mobile network. Both geographic data and geo-referenced remotely sensed image data are served, and ground truth of Google map remote sensing is also identified as further potential study.**

Keywords—Wildfire, Mobile Field Survey, Web GIS, Nan province

I. INTRODUCTION

Environment, Industrial and home hazards has been identified as the main causes of deaths, disabilities, deformation and natural loss in many countries and thus it accounts for millions of deaths and losses worldwide. The delay between the first signs of smokes and fire outbreak with respect to emergency calls for response and intervention has a large variation among different situations and locations resulting to fatal consequences. Later with evolution and advancement of communication technologies, new strategies are being adopted in order to reduce delays and ascertain rate of impact for appropriate response [1,2]. Wildfire monitoring is one possible solution.

Wildfire are expensive disasters in terms of both property loss and life safety. Wildfire often occurs in environmental sensitive regions such as forest, park, and grassland area or along the urban-wild land interface. Environmental monitoring in such terrain must be environmentally appropriate, which requires easy installation, low maintenance and relatively inexpensive instrumentation. Forest fires, also known as wildfires are uncontrolled fires occurring in wild areas and can cause significant damage to natural and human resources [1,2].

The aim of this research is to implement a user-friendly Mobile GIS interface to collect the fire situation and send to administrators and show fire situation with photo, coordinate (Lat/Long), reporter, and date on web base station.

Mobile GIS is a mature technology which takes geospatial technology beyond the walls of an office. Therefore, mobile applications have extended to field use which allows the user easy access, storage, updates, analysis and real-time visualization of field data. Till recently, mobile GIS applications were mainly used as a navigation or location-aware system. Mobile GIS technology nowadays offers a potential alternative to fill the gaps of traditional GIS systems. With Mobile GIS technology, wildfire officers and many other field workers have the potential to access the enterprise geospatial data from the server-side to accomplish their tasks with high level of accuracy. More importantly, it is also possible to update these geospatial enterprise data in real time [3].

II. MATERIAL AND METHOD

A. Study area: Nan Province

The study area was conducted at the Nan province, northern part of Thailand (Figure 1). Nan province comprises 15 district, 99 sub-districts. The province covers an area of 11,472 sq.km. with geographical location between 18◦00’ N to 19◦30’ N and 100◦340’ E to 101◦30’ E. It is mostly covered with forested mountain, with an approximate elevation of 2,079 meters about mean sea level.

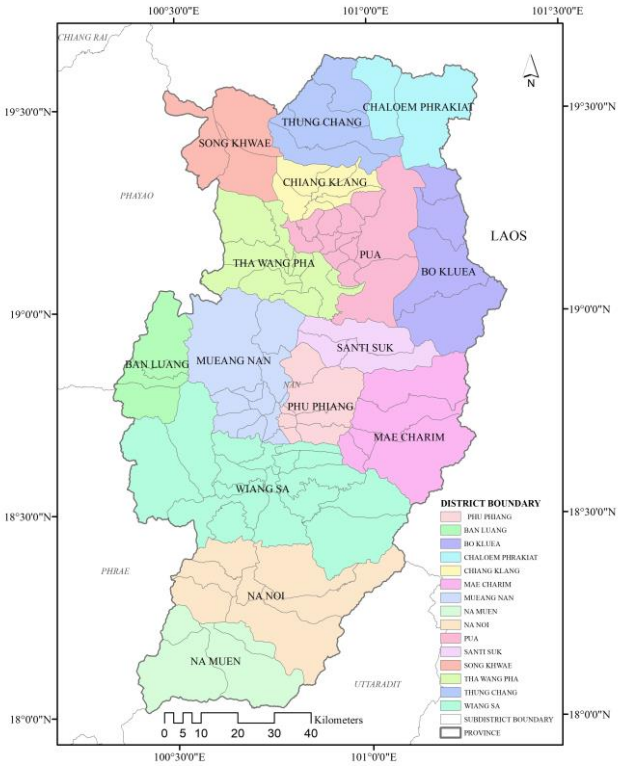


Fig. 1. Geographical location of the study area

B. *Mobile GIS*

The mobile GIS use the client/server architect that is common in internet-based applications. jQuery Mobile (jQM) provides a rich set of jQuery plug-ins, widgets and a cross-platform API for creating mobile applications. It is more or less similar to the jQuery User Interface (jUI) in terms of code implementation. The jQM is freely available as an Open Source codebase and provides a rich user experience on web browsers running on mobile devices [4]. jQM uses HTML5, JavaScript, AJAX and CSS3 features to enhance basic HTML markup in order to create a consistent mobile experience across supported platforms. jQM based application work on mobile devices without JavaScript, even thought a lot of redundant HTML is transferred over the network. For users who have a browser that supports JavaScript, the server only generates HTML on the first request and then subsequent requests use JSON and client-side templates to dynamically render the page. JSON is the syntax for storing and exchanging text information. JSON documents are typically smaller than XML, and faster and easier to parse [3]. The server-side provides access to geospatial data and performs online spatial requests such as spatial query, find, measure, and proximity analysis based on requests made by from client-side. On the other hand, the user at the client-side can display and navigate through different GIS layers of the geospatial data hosted by the server-side. The main components of the Wildfire field survey using Mobile GIS technology are presented in Figure 2.

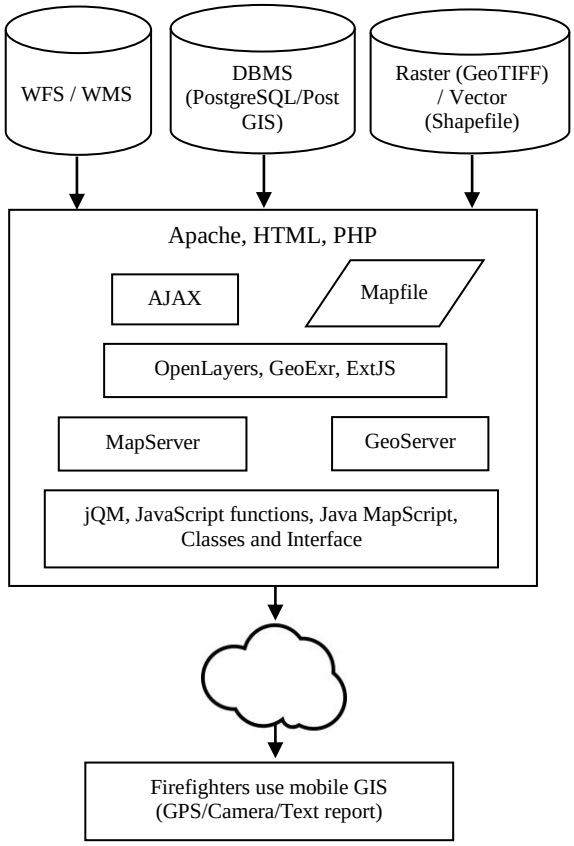


Fig. 2. Architecture of Wildfire Mobile GIS

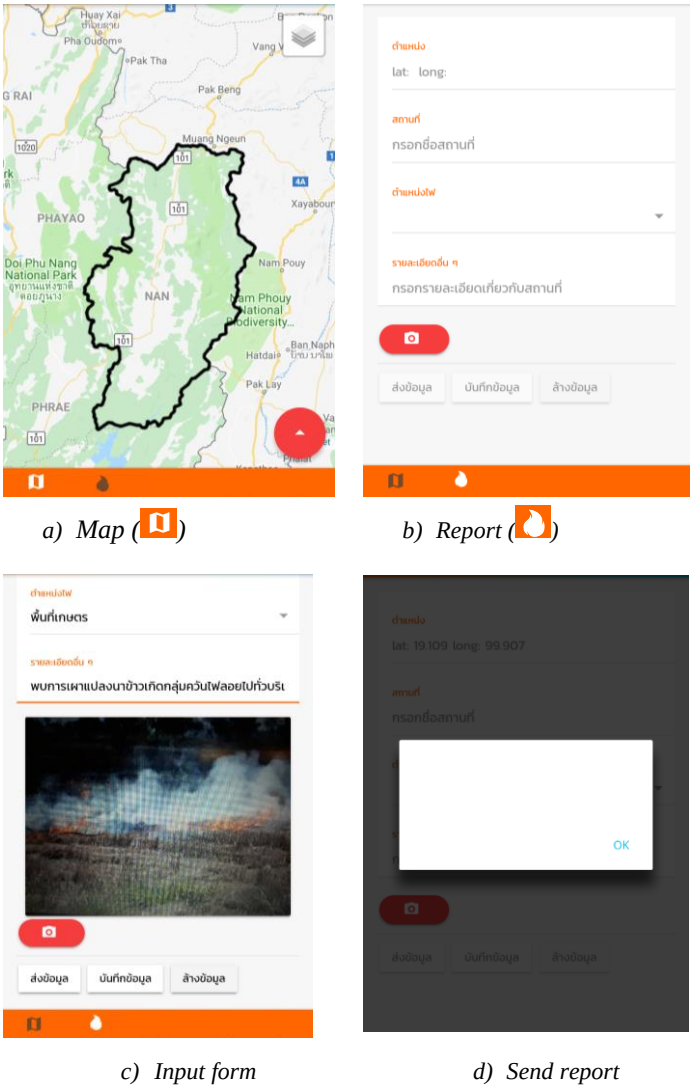
The system is being practices in Nan province, Thailand. The firefighters have basic information of all the wildfire in the area database such as geography, climate, elevation etc. that were corrected. However, they were unable to identify the location of the fire situation.

III. RESULTS

A. *Mobile Application*

Implementation of the mobile side of the system was focused on the mobile application. The original application was used for fire situation report from the geospatial filed survey. The firefighters from login in to the app, then identify their current location. The GPS location in the smartphone is capable of pinpoint the current location automatically. Once the current location has been identified, the user will be able to start entering the data using the input form.

Figure 3 shows the flow and some screenshots of the application.



a) Map ( ) *b) Report ( )*

c) Input form *d) Send report*

Fig. 3. Shown screenshots of the wildfire field survey using Mobile GIS in Nan province

B. *Software Environment*

Implementation of the wildfire field survey consists of the software used and details of item software version. The wildfire field survey using Mobile GIS technology in Nan

province was designed and developed with a user-friendly main interface (Figure 3a). The main screen of the application provides access to the reporting tools. Reporting tool for field data which included data and image files of current location (Figure 3 (b, c, d)).

The application development environment and tool are shown in table 1.

TABLE I. APPLICATION DEVELOPMENT ENVIRONMENT AND TOOL

No.	Wildfire Field Survey using Mobile GIS	
	Software and Hardware	***Software***
1.	Server	Cloud Server
2.	Operating System Server	Ubuntu Server
3.	Web Server	Apache 2, PHP5
4.	Application Server	Apache Tomcat, MapServer, GeoServer 2.9
5.	Database Server	PostgreSQL 9.3
6.	Spatial Database	PostGIS 2.0
7.	User Interface	OpenLayers 2.13, GeoExt and ExtJS, jQuery Mobile (jQM), Java for Android
8.	Client Web Browser	Chrome, Firefox, Internet Explorer, Safari

The web interface for wildfire field survey is shown in Figure 4. The firefighters can visualize the reporting points of real time field survey that send data, and the can make use of that data for recording and analyzing purposes.

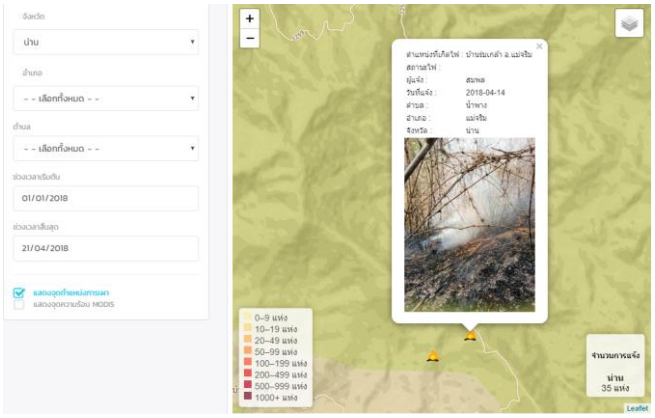


Fig. 4. web interface for wildfire field survey

By clicking on a pinpoint represents the location of the fire on the map, the information associated with the image such as latitude, longitude, fire status, reporter, date, and automatically link with geographic are subdistrict, district, and province.

IV. CONCLUSION

A prototype of a wildfire field survey using Mobile GIS platform is presented in this research. This study reports that an open source package was one of those smart choices to complete real-time field survey [5]. The implemented Mobile GIS platform provides the basic GIS functionalities and location. The Client/Server GIS framework that was developed is an independent application, which can be run in every modern Mobile smartphone without requiring to any other additional software. This application helps the field parties to gather data from wildfire field survey and provide inputs for monitoring and protection. The application provides managers the opportunity to visualize and grasp the current situation of the wildfire and thereby decide the needed action plans.

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REFERENCES

[1] Y. Li, Zhiwang, and Y. Song, “Wireless Sensor Network Design For Wildfire Monitoring”, National Laboratory of Industrial Control Technology Zhejiang University Hangzhou, China, Campus science Tigique-B.P239.

[2] A.N. Aniedu, C.I. Chukwuneke, D.C. Asogwa, and C.S. Nwokoye, “Real-Time Wildfire Monitoring and Alert System Using GSM Technology”, IOSR Journal of Mobile Computing & Application (IOSR-JMCA) Vol. 3, Issue 4, pp 1-10.

[3] S. Choosumrong, V. Raghavan, P. Jeefoo, and N. Vaddadi, “Development of Service Orinted Web-GIS Platform for Monitoring and Evaluation using FOSS4G,” Int. J. Geoinformatics, vol. 12, No. 3, pp. 67-77.

[4] F. Ableson, jQuery Mobile and JSON, Learn how to Create Mobile Web Applications Powered by jQuery Mobile. Available from: https://www.ibm.com/developerworks/xml/tutorials/x-jquerymobilejsontut/index.html

[5] P. Jeefoo, “Real-time Field Survey Using Android-based Interface of Mobile GIS,” 2014 International Conference on Information Science and Applications IEEE (ICISA2014), Seoul, South Korea, May 6 – 9, 2014. ISBN: 978-1-4799-4443-9, pp, 1-3.

Information Flow Complexity Analysis for Design Flaws Detection in Object-Oriented Software

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***Abstract*—The detection of design flaws is one of the most important aspects of software extendability and availability, and the process should therefore be an integral part of the development and also the maintenance of software. It is possible to lower costs and extend the useful like cycle of the software simply by detecting design flaws at an early stage, and therefore attempts have been made to automate the procedures involved in detecting and fixing these flaws. This research study seeks to develop an enhanced method to improve threshold determination to be applied in metrics-based flaw detection using Information Flow Complexity. Metrics including fan-in and fan-out, code length and procedure call are focused on the improved information flow complexity estimation method, which is used to evaluate the static measure of the software source code and facilitates the limitation of the existing work. The results shows that the proposed method established more supporting thresholds for metric-based design flaw detection.**

***Keywords*—software metrics, information flow complexity, flaws detection, software maintenance**

I. Introduction

Software is critical for human life today, and the aim of software development is to create efficient and reliable software to ease the burdens in peoples lives, resulting in greater productivity. While software efficiency may not always seem as obvious as remarkable inventions such as airplanes, combustion engines, or the printing press, the impact can be just as significant, as it can affect every aspect of our lives today, encompassing, work, leisure, entertainment, health, and so forth. Although developers have been creating software now for around 75 years, there are still problems which arise during the development stage which lead to flaws. In particular, there are flaws which arise during the design of new software, which are known as design flaws [1].

Design flaws are those which incorporate problems within the rules or architecture of the software, and thus have a negative effect upon the overall structure quality of the design, leading to ongoing problems in the software development life cycle. Design flaws might not be described as wholly incorrect, and might not cause the failure of a program, but they can lead to slower operational use of a program and lead to a greater risk of errors arising in the future. Design flaws have long been seen as indicators of poor design and program selection, and in some cases they are the result of designers making decision which have sought to achieve simplicity but have involved sub-optimal choices [2].

One common technique used to detect and solve design flaws is the refactoring process [3]. It offers a means of checking the simple and meaningful design of the code without any need to change what the code actually does. The process involves making additions and changes to the source code through introducing reappearances, but the use of regular refactoring is not straightforward because factored codes are inclined towards decomposition. A number of forms can be produced through a factored/class, duplicate code, and other stages of mixed or discontinuous code. For all time periods, code modification without refactoring leads to degradation. This degradation of the source code is highly frustrating for the programmers since it takes up their time while lowering the overall useful lifetime of the software.

A code inspection approach performed manually can allow early detection of design flaws [4]. The source code must be meticulously examined, along with the documentation and design of the software, so that the examiner might uncover flaws based on his own long experience. Unfortunately, this method relies upon the skill of the examiner and takes a long time to complete. Furthermore, it cannot be scaled or repeated. One approach which could detect design flaws is declarative meta programming, since in such environments, it is possible to narrow the design flaw domain to allow easier detection with fewer metrics, or in the absence of metrics [5]. The approach is, however, more complex in terms of flaw identification. To simplify matters, heuristic metrics are suggested for the identification of software design flaws. The process of software metric detection applies a predetermined threshold or thresholds to support the interpretation of the process results [6], [7]. While metric-based flaw identification can effectively detect flaws, the approach relies upon the quality of the metrics and thresholds used, and therefore the detection of flaws based on metrics will be variable as it relies upon the threshold selection; there is always the potential for false negatives or false positives if the threshold is not finely tuned to take into account these possibilities. The threshold must be set so as to obtain the right kind of information about the presence of any design flaws. The developer is

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therefore responsible for selecting the right approach to allow refactoring to remove any detected design flaws. The way in which software metrics are related to design flaws has been widely studied, given its importance.

A study of information flow is the observation of many data blocks that are relevant to one module in same work area than those outside of it. Fenton and Pfleeger [8] described the information flow contain both inter modular and intra modular attribute in a system. In this paper intra modular Information Flow Complexity (IFC) measure using proposed metrics such as sum of fan-in (FI) and fan-out (FO), code length (CL) and procedure call (PC). Information flow measure in [8] explained using metrics like fan-in, fanout, and length, and the methods insufficient to identify the misinterpretation of the code in the sequential data in various operations. Such method is consistent to measure the information flow in all cases.

This study proposes a new method to support the detection of design flaws using metrics. The concept involves finding software design flaws by applying the information flow complexity with facts and rules metrics. Information flow complexity metrics including fan-in (FI) and fan-out (FO), code length (CL) and procedure call (PC) are focused on the improved information flow complexity estimation method, which is used to evaluate the static measure of the software source code and facilitates the limitation of the existing work. The performance of the model was evaluated using three different software datasets, with the experiments demonstrating that the new method could provide more appropriate thresholds for use in detecting design flaws through a metric-based technique. The simplicity and time-saving benefits of the new system were further advantages, along with the fact that no expertise was required for its implementation, representing an improvement over traditional approaches using metrics. This new concept would therefore be useful for software project managers and developers who would have access to reliable design flaw indicators for their software systems.

The structure of the paper takes the following form. Section 2 presents the concepts of related background. The new proposed methodology is discussed in detail in Section 3. Section 4 describes the experimental studies, presents the results, and compares the new method with other detection approaches. Finally, conclusions are drawn in Section 5.

II. Flaw Detection Background

A. Types of Design Flaws

When design flaws arise in the development of software they can cause significant problems in the subsequent design and maintenance of the software system. In such scenarios, Fowler provides a new concept, whereby different design flaw types are detected [9]. Subsequent approaches have found other types of design flaws in programs. The software development design flaws are very closely tied to the task of refactoring these flaws from the code in order to improve the operational reliability of that code. Where many developers are working to produce a single software system, they must identify any potential problems, which are referred to as bad smells, and determine whether these issues are likely to pose problems for the system with regard to functionality, maintenance, performance, or quality. This approach can enhance the search for laws and ease the refactoring process as flaws in the code are addressed. Within software systems, design flaws are often indicative of further problems. It is therefore necessary to perform refactoring and then re-check the system in order to improve its performance. One processing approach is provided by Kent Beck [3], and enhances software quality through design flaw refactoring. Typical design flaws and their detection in software systems using a metrics-based approach are described as follows:

- Large Class (LC): These classes possess large quantities of instance variables and many lines of code. Because they are large, they often exhibit software duplication issues. Related metrics to detect this flaw are described as follows:
- Long Parameters (LP): Such parameters can be very challenging to detect within software systems, since the parameters exceed the limit. Related metrics to detect this flaw are described as follows:
- Dead Code (DC): In some cases, coding modules are designed but are not subsequently used within the software system. These unused modules are referred to as dead code. The problem is that such dead code increases the memory consumption and makes the system more expensive to operate. Related metrics to detect this flaw are described as follows:
- Lazy Class: These classes perform minimal work and the number of methods is null. Related metrics to detect this flaw are described as follows:
- Duplicate Code: When code is duplicated, it is much more complicated to complete the updating process. It can also lead to longer detection times when the code appears more than once, and makes it harder to improve the system. Related metrics to detect this flaw are described as follows:

B. Information Flow Complexity Concept

Henry and Kafura [8] described measure the Information Flow Complexity (IFC) for a module *M* as

$$IFC(M) = length(M) * \Big((fan{-}in(M) * fan{-}out(M) \Big)^2$$

From the positive side multiplication of fan-in and fan-out in their measure, the modules with either a low fan-in or low fan-out are, in a sense, isolated from the system and hence have low complexity [8]. Fan-in indicates how many modules directly control a given module where as fan-out is a measure of the number of modules that are directly controlled by another module. To be exact fan in of a module M is explained, the number of local flows that terminate at M, plus the number of data structures from which information is retrieved by M. Similarly, the fan-out of a module M is the

number of local flows that emanate from M, plus the number of data structures that are updated by M.

Shepperd refinement to the Henry and Kafura measure of Information Flow Complexity for a module M as

$$Shepperd\ IFC(M) = \Big((fan{-}in(M) * fan{-}out(M)\Big)^2$$

Shepperd refinements attempt to capture a specific view of information flow structure, and are thus consistent with measurement theory. His empirical validation studies examined how closely the measure correlates with a specific process measure, namely development time. Interestingly, the relationship between development time and the Henry and Kafura measure was not significant for Shepperds data, but Shepperds pure-information flow-structure is significantly related. Thus the level of information flow is closely correlated with development time [8].

III. Proposed Methodology

In this study, the design flaw detection procedure relies upon mixing the facts and rules metrics with the information flow complexity so that design flaws can be identified. This optimization approach allows verification of the software modules so that any design flaws in the source code can be determined. The algorithm is able to improve both the metric thresholds and the derived contribution facts and rules of the metrics. The model threshold values are then selected to fit the requirements of the software data input. Application of the fact and rule metrics supports the processing of the source code and identification of the software modules in many different programming languages. The new method also makes use of refactoring approach to improve the software system performance. Different programming languages have different program structures and syntax, so the new approach works with these through the use of fact and rule processing, forming a link between the software module and the detection network in order to provide superior detection of design flaws. This technique is capable of working with C#, Java, and software systems involving refactoring in order to identify a range of design flaws.

A. Research Methodology

Figure 1 presents the workflow used in design flaw detection. This step-by-step process presents the inputs from the software system and is able to distinguish the modules from the larger systems. The input data makes use of the fact and rule programming which form a bridge connecting the software modules and the design flaw processing system using the metric. In the process described, step 4 allows the analysis of the source code flaws, which can be verified at the next stage. The verified data then serve as the output for the user seeking to detect the design flaws. Refactoring is then suggested to resolve design flaws and improve the software system performance. Limits are introduced in testing so as to evaluate the performance of the novel method in comparison to current approaches in order to encourage superior performance. The steps used are explained as follows:

- Step 1: Source code modules are input to detect the design flaws. First of all, the source code modules are selected (Java, C#, or other types of object-oriented software) to detect the flaws in the software system.
- Step 2: Source code modules are verified and divided into attributes, classes, and methods with the relationships classified on the basis of an abstract syntax tree of determined fact and rules. The required metrics are also calculated in the form of LOC (line-of-code), used variables.
- Step 3: In the stage the facts and rules of metrics are applied for the modules. The divided fraction of the source code is used in determining the facts and rules required to carry out the detection of design flaws.
- Step 4: The source code is measured and analyzed with regard to the specified software metrics. The metrics used in detecting the design flaws are formulated on the basis of the determined facts and rules. This stage is where comparisons are made between the detection metrics and the determined primary threshold values.
- Step 5: The information flow complexity is used for performance enhancement. In this case, information flow complexity metrics is employed. This stage help to supporting choosing the final threshold values.
- Step 6: The results and variables are presented at this stage after the detection stage is complete. The system performance can be analyzed and the results presented to the end user.

IV. Results and Discussion

Datasets of software design flaws were collected from previous research to conduct experiments. Online data entry software was also used to test the applicability of the proposed methodology. Table I lists the three datasets used.

TABLE I: Experimental datasets

Number	Datasets
1	CommonCLI v1.0
2	JUNIT v1.3.6
3	GANTTPROJECT v1.10.2

The performance of detection approaches for two-class (i.e. fault-prone and nonfault-prone) problems was commonly evaluated using the pattern set in the confusion matrix, shown in Table II.

TABLE II: The confusion matrix

		Predicted class	
		Class = 0	Class = 1
Actual class	Class = 0	f_{00}	f_{01}
	Class = 1	f_{10}	f_{11}

In Table II, f_{ij} expresses that the number of actual class = i is classified into class = j, where $i, j \in 0, 1$. Detection accuracy,

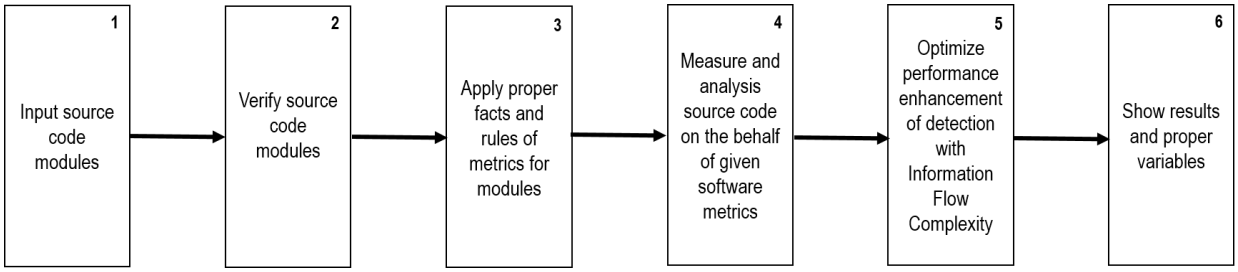

Fig. 1: Processes of the proposed research work

a commonly used detection performance measure, was used to quantitatively evaluate the detection approaches. This measure was derived from the confusion matrix as follows:

$$\frac{f_{00} + f_{11}}{f_{00} + f_{01} + f_{10} + f_{11}} \quad (1)$$

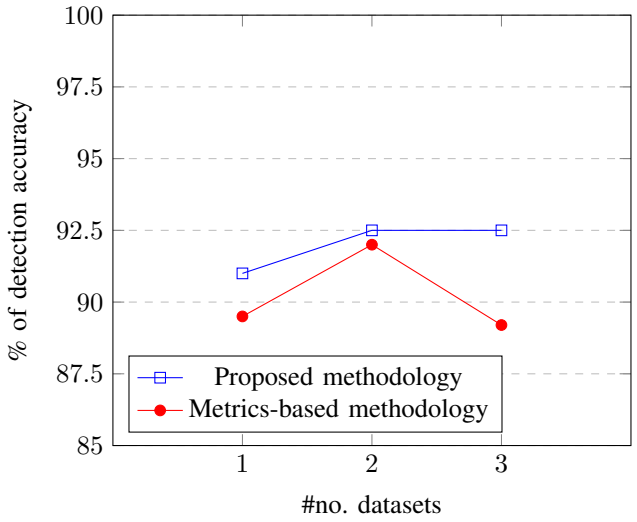

Fig. 2: The detection accuracy of the proposed approach and the metric-based approach on *Large Class* flaw detection

The detection accuracy rates for the three systems were 91%, 92.5%, and 92.5% according to Figure 2, in order of the dataset numbers for the technique in which Large Class flaws were detected. In order to make comparisons with other common methods, the results of this experiments were assessed against findings obtained using the standard metric-based technique. The results are indicated in Figures 2.

V. Conclusion and Future Works

This study put forward a novel approach to improve design flaw detection using metrics. The technique involved an information flow complexity which was used to assist in selecting appropriate metrics to support the process of flaw detection. The study also proposed the evaluation function used to calculate the contribution threshold for each of the metrics in accordance with the requirements of the software data input. The experimental results showed that the proposed model established more suitable thresholds for metric-based design flaw detection.

It may be possible in future studies to examine the potential of other complexity algorithms to be used for optimization to improve the detection accuracy. Furthermore, it may also be possible to improve the algorithm performance through increasing the search for software design flaws since many other parameters can be applied in the process of design flaw detection.

Acknowledgment

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References

[1] T. Tourwe and T. Mens, "Identifying refactoring opportunities using logic meta programming," in *Seventh European Conference on Software Maintenance and Reengineering, 2003. Proceedings.*, March 2003, pp. 91–100.

[2] A. Chatzigeorgiou and A. Manakos, "Investigating the evolution of bad smells in object-oriented code," in *2010 Seventh International Conference on the Quality of Information and Communications Technology*, Sept 2010, pp. 106–115.

[3] M. Fowler, K. Beck, J. Brant, W. Opdyke, and D. Roberts, *Refactoring: Improving the Design of Existing Code*. Addison-Wesley Professional, June 1999.

[4] D. A. Wheeler, B. Brykczynski, and R. N. Meeson, Jr., Eds., *Software Inspection: An Industry Best Practice for Defect Detection and Removal*, 1st ed. Los Alamitos, CA, USA: IEEE Computer Society Press, 1996.

[5] S. Mekruksavanich and P. Muenchaisri, "Using declarative meta programming for design flaws detection in object-oriented software," in *2009 International Conference on Signal Processing Systems*, May 2009, pp. 502–507.

[6] S. Mekruksavanich, "Identifying behavioral design flaws in evolving object-oriented software using an ontology-based approach," in *2017 13th International Conference on Signal-Image Technology Internet-Based Systems (SITIS)*, Dec 2017, pp. 424–429.

[7] N. Moha, Y.-G. Gueheneuc, L. Duchien, and A.-F. Le Meur, "Decor: A method for the specification and detection of code and design smells," *IEEE Trans. Softw. Eng.*, vol. 36, pp. 20–36, Jan. 2010.

[8] N. Fenton and S. Pfleeger, *Software Metrics: A Rigorous & Practical Approach*, 2nd ed. International Thomson Computer Press, 1998.

[9] M. Fokaefs, N. Tsantalis, and A. Chatzigeorgiou, "Jdeodorant: Identification and removal of feature envy bad smells," in *2007 IEEE International Conference on Software Maintenance*, Oct 2007, pp. 519–520.

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The Application of Intelligent Database for Modern Information Management

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***Abstract*—The integration of Artificial I ntelligence and Database Management System technologies plays an importance role in shaping the future of computing and management. The integration of both technologies is crucial for the next generation computing of Database Management System technology development. This work proposes the intelligent database methodology which integrate Artificial Intelligence with Database Management System for knowledge management. The motivations supporting the integration of two technologies include the need for (1) access to large amounts of shared data for knowledge processing, (2) efficient m anagement o f d ata, a nd (3) i ntelligent p rocessing of data. In addition to these motivations, the application of the proposed method is also developed to manage research knowledge institute.**

***Keywords*—Intelligent database, Database Management Systems, Artificial I ntelligence, D atabase integration**

I. Introduction

Databases are extensively utilized in private and public information systems in a huge variety of application areas. Software tools that are deliberated for the correct and safe manipulation of databases are known as Database Management Systems (DBMS). These systems create a connection amid the user or programmer level data representation and the physical level data storage. The data models are focused towards the illustration of information from real world situation. Therefore, they are used by DBMS for user or programmer level data representation. During the initial days of the database technology, data models were of a very low abstraction level, denoting data that have structures adjacent to physical storage level. In 1970, Codd [1] proposed the Relational Data Model with the idea of conceiving a data representation completely independent of storage structures. This data model works on basis of the concept of relation founded in the Set Theory (mathematical concept of relation). At present time, most of the DBMSs are based on the Relational Data Model [2].

Databases are built to facilitate the data storage, processing, and retrieval activities associated with data management in information systems. Database management systems offer competent task maintenance and remarkable gain in productivity. Database systems are significant in the implementation of data management [3]. Database technique support is necessitated by data management. Characteristically, database technology is application oriented. Owing to the developments and in-deep applications of computer technologies, the widespread applications of web technology in various areas to be precise, databases have turned out to be the repositories of huge volumes of data [3]. It is crucial to administer and utilize the valuable data resource for efficient problem solving and decision making. The research and development of intelligent databases have lately emerged as a fresh discipline and have attracted rising attention. The knowledge discovery in databases and data mining remains a witness of the same.

Database (DB) applications apply simplified constructs to represent data and store a huge quantity of instances of the data. The retrieval of a large amount of the same type of data is very efficient, even though the user should know completely the DB schema to formulate the queries [4]. Knowledge-based systems (KBS) can apply powerful abstract constructs to model a domain and operate robustly with few instances of these constructs. The user is not required to know fully the model to interact with the system. Relational database management systems (RDBMS) were designed to solve a particular class of problem-store, manage and consult a large amount of the same type of data – in opposition to KBSs, which are intended to extract new useful knowledge from knowledge that is already represented and stored [5].

Intelligent database (IDB) systems integrate resources from both RDBMSs and KBSs to provide a natural way to manage information, making it easy to store, access and apply [6]. The term Intelligent Database was introduced in 1989 by the book *Intelligent Databases* by Kamran Parsaye, Mark Chignell, Setrag Khoshafian and Harry Wong. This concept postulated three levels of intelligence for database systems: High level tools, The user interface and the database engine. The high level tools manage data quality and automatically discover relevant patterns in the data with a process called data mining. This layer often relies on the use of artificial intelligence techniques. Intelligent databases have artificial intelligence components that provide help with the intellectual operation of the search, have ways of representing knowledge, and are based on connectionist neural network models. An intelligent database provides expanded and more flexible options for

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conducting queries. For example, a user might type in a question as a full sentence. The database then provides a list of hits arranged according to the likelihood (from highest to lowest) that the resulting data contains a useful answer to that question. The Artificial Intelligence (AI) may correct suspected errors (such as inaccurate spelling) input by the user. Some intelligent databases display synonyms for keywords and phrases. In order to derive the most benefit from an intelligent database, the user must formulate queries with forethought, phrasing them with care, just as is necessary when interrogating a person.

So this work proposes the intelligent database application which integrate AI with DB for knowledge management. The motivations driving the integration of these two technologies include the need for accessing to large amounts of shared data for knowledge processing, supporting efficient management of data as well as knowledge, and promoting intelligent processing of data. The application is developed to store the research data of the faculty. In addition to these motivations, the design of Intelligent Database Interface (IDI) was also motivated by the desire to preserve the substantial investment represented by most existing databases.

The structure of the paper takes the following form. Section II presents the concepts of advances in intelligent databases and information system. Section III proposes an account of the framework used to develop the intelligent database application, while Section IV contains the conclusions.

II. Advances in Intelligent Databases and Information System

In last decades, significant progress in the field of intelligent database and information system has been observed. Progress is focused mainly on two major issues of intelligent databases namely – 1) Intelligent information processing in databases and 2) Intelligent aspects of databases.

A. Intelligent information processing in databases

Intelligent information processing has become one of the key issues on our way to a knowledge society. Recent research has led to exciting advances in technologies that will shape our future. Intelligent Information Processing is studying on fundamental theory and advanced technology of intelligence and knowledge for information processing. Knowledge-based systems have matured to provide services in a well-founded ontological framework, and intelligent knowledge management can be supported by tools that are ready for practical applications. Artificial intelligence techniques can be useful tools in this context. Intelligent systems can be applied to searching the Internet and data-mining, interpreting Internet derived material, the human Web interface, remote condition monitoring and many other areas. The following are some of the problems related with intelligent information processing in databases:

- Most of the algorithms and approaches that deal with data mining and especially those emphasizing on the task of association rule mining have assumed that all the items are only positively correlated, and looked only into those items that remained in a shopping basket finally. Very few works have proposed for the existence of negative correlations between items, based though on the absence of items from transactions rather than on their actual removals. Kouris, Makris, and Tsakalidis [7] look into mining that takes into consideration valuable information from rejected items and propose various alternatives for taking the specific items into account efficiently.
- Outlier detection is one of the important research issue in the data mining field. The number of cells in the cell-based disk algorithm increases exponentially. The performance of this algorithm decreases with the increased number of cells and data points. Sun et. al. [8] find that there are many empty cells that are useless to outlier detection. They propose a novel index structure, called CD-Tree, in which only non-empty cells are stored, and a clustered technique is used to store the data objects in the same cell into linked disk pages.
- Deletion of records in databases is commonly seen in real-world applications. In the field of data mining, it is very important to develop an efficient mining algorithm that can incrementally maintain the information. Hong and Wang [9] propose an incremental mining algorithm for maintenance of association rules as new transactions are inserted. A novel algorithm is proposed to maintain discovered association rules for deletion of records.
- Inductive databases have been proposed as general purpose databases to support the KDD process. The heterogeneity of the discovered patterns and of the different conceptual tools used to extract them from source data makes difficult the integration in a unique framework. Meo and Psaila [10] explore the feasibility of using XML as the unifying framework for inductive databases, and propose a new model, XML for Data Mining (XDM).
- A major goal for database research has been the incorporation of additional semantics into the data model. Classical data models suffer from their incapability of representing and manipulating imprecise and uncertain information that may occur in many real-world applications. Therefore, fuzzy set theory has been extensively applied to extend various data models. To satisfy the need of modeling complex objects with imprecision and uncertainty, recently many researches have been concentrated on fuzzy semantic (conceptual) and object-oriented data models. Ma and Yan [11] reviews fuzzy database modeling technologies, including fuzzy conceptual data models and database models. Concerning fuzzy database models, fuzzy relational databases and fuzzy objectori-ented databases are discussed, respectively.

B. Intelligent aspects of Database Systems

The following are some of the intelligent aspects of database systems:

Wolff [12] describes some of the kinds of *intelligence* that may be exhibited by an intelligent database system based

on the SP theory of computing and cognition. The author introduces the SP theory and its main attractions as the basis for an intelligent database system: that it uses a simple but versatile format for diverse kinds of knowledge, that it integrates and simplifies a range of AI functions, and that it supports established database models when that is required. Then with examples and discussion, the author illustrates aspects of intelligence in the system: pattern recognition [13] and information retrieval, several forms of probabilistic reasoning, the analysis and production of natural language, and the unsupervised learning of new knowledge.

Integrity constraints are a key tool for characterizing the well-formedness and semantics of the information contained in databases. In this regard, it is essential that intelligent database management systems provide their users with automatic support to effectively and efficiently maintain the semantic correctness of data with respect to the given integrity constraints. Martinenghi, Christiansen, and Decker [14] give an overview of the field of efficient integrity checking and maintenance for relational as well as deductive databases. It covers both theoretical and practical aspects of integrity control, including integrity maintenance via active rules. The authors outline new lines of research, particularly with regard to two topics where a strong impact for future developments can be expected: integrity in XML document collections and in distributed databases. Both pose a number of new and highly relevant research challenges to the database community [15].

III. The Framework of Artificial Intelligence and Database Integration

The integration of AI and DBMS technologies promises to play a significant role in shaping the future of computing. As noted in, AI/DB integration is crucial not only for next generation computing but also for the continued development of DBMS technology and for the effective application of much of AI technology. The proposed application of intelligent database is shown in Fig. 1.

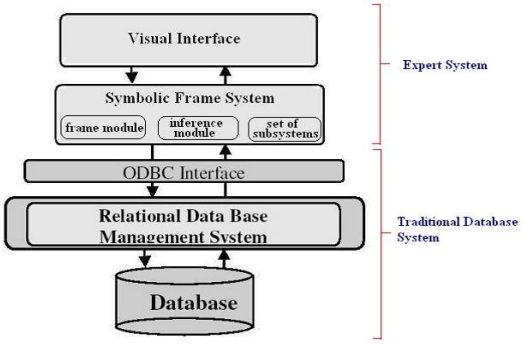

Fig. 1: The proposed framework of Artificial Intelligence and Database Integration

The proposed application of intelligent database is detailed as follows:

- Visual interface allows user to effectively interact with the system. Users can perform quantitative analysis as well as visual evaluation through various interfaces provided by this module.
- Symbolic system is at the heart of the architecture. A frame module keeps the schema structure of entire domain. It also maintains the knowledge graphs.Inference module tries to match several parts of the case submitted by the user against the nodes in the knowledge graph. The set of subsystems support many aspects of petrographic description task such as statistics and quantitative analysis.
- Traditional DB: The symbolic frame system is connected to RDBMS module by a standard SQL interface such as ODBC.

While both DBMS and AI systems, particularly expert systems, represent well established technologies, research and development in the area of AI/DB integration is comparatively new. The motivations driving the integration of these two technologies include the need for

- access to large amounts of shared data for knowledge processing,
- efficient management of data as well as knowledge,
- intelligent processing of data.

In addition to these motivations, the design of Intelligent Database Interface (IDI) was also motivated by the desire to preserve the substantial investment represented by most existing databases. To that end, a key design criterion for IDI was that it supports the use of existing DBMSs as independent system components. Several general approaches to AI/DB integration have been investigated.

A. Extending the AI system

The AI system is extended with DBMS capabilities to provide efficient access to, and management of, large amounts of stored data. In general, such systems do not incorporate full DBMS technology. Rather, the emphasis is on the AI system and the DBMS capabilities are added in an ad hoc and limited manner, e.g., implements only the data access layer.

Alternatively a new generation knowledge-based system such as Logic Data Language (LDL) may be constructed. In either case, this approach effectively involves re-inventing some or all of DBMS technology. While such systems typically provide sophisticated tools and environments for the development of applications which must access existing databases will be exceedingly difficult if not impossible (e.g., when the database is routinely accessed and updated via more traditional kinds of applications).

B. Extending the DBMS system

This approach extends a DBMS to provide knowledge representation and reasoning capabilities, e.g., POSTGRES. Here, the DBMS capabilities are the central concern and the AI capabilities are added in ad hoc manner. The knowledge representation and reasoning capabilities are generally quite limited and they lack the sophisticated tools and environments

of most AI systems. Such systems do not directly support the use of existing DBMSs nor can they directly support existing AI applications (e.g., expert systems) without substantial effort on the part of the application developer. In some sense, this is the opposite of the previous approach.

IV. Conclusion

In this paper, we have presented an approach to build an intelligent database system by integrating Artificial Intelligence with Database System. AI techniques provide semantic support to a DB system and DB techniques to aid an AI system to deal with large amount of information. Our approach to AI/DB integration conforms to the belief that one of the key factors for this integration resides in exploitation of the equivalence between data models developed in DB field and knowledge representation systems of AI.

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References

[1] E. F. Codd, "A relational model of data for large shared data banks," *Commun. ACM*, vol. 13, no. 6, pp. 377–387, Jun. 1970. [Online]. Available: http://doi.acm.org/10.1145/362384.362685

[2] ——, "Relational completeness of data base sublanguages," in *Database Systems*, 1972.

[3] C. Zaniolo, "Intelligent databases: Old challenges and new opportunities," *Journal of Intelligent Information Systems*, vol. 1, no. 3, pp. 271–292, Dec 1992. [Online]. Available: https://doi.org/10.1007/BF00962921

[4] E. Bertino, B. Catania, and G. P. Zarri, *Intelligent Database Systems*. Boston, MA, USA: Addison-Wesley Longman Publishing Co., Inc., 2001.

[5] N. Mattos, *An approach to knowledge base management*, ser. Lecture notes in computer science. Springer-Verlag, 1991.

[6] K. Parsaye and M. Chignell, *Intelligent Database Tools and Applications: Hyperinformation Access, Data Quality, Visualization, Automatic Discovery*, 1st ed. New York, NY, USA: John Wiley & Sons, Inc., 1993.

[7] L. T. Nguyen and N. T. Nguyen, "An improved algorithm for mining class association rules using the difference of obidsets," *Expert Syst. Appl.*, vol. 42, no. 9, pp. 4361–4369, Jun. 2015. [Online]. Available: http://dx.doi.org/10.1016/j.eswa.2015.01.002

[8] H. Sun, Y. Bao, F. Zhao, G. Yu, and D. Wang, "Cd-trees: An efficient index structure for outlier detection," in *Advances in Web-Age Information Management*, Q. Li, G. Wang, and L. Feng, Eds. Berlin, Heidelberg: Springer Berlin Heidelberg, 2004, pp. 600–609.

[9] T.-P. Hong, C.-Y. Wang, and Y.-H. Tao, "A new incremental data mining algorithm using pre-large itemsets," *Intell. Data Anal.*, vol. 5, no. 2, pp. 111–129, Apr. 2001. [Online]. Available: http://dl.acm.org/citation.cfm?id=1294141.1294143

[10] R. Meo and G. Psaila, "Toward xml-based knowledge discovery systems," in *2002 IEEE International Conference on Data Mining, 2002. Proceedings.*, Dec 2002, pp. 665–668.

[11] Z. Ma and L. Yan, "Fuzzy xml data modeling with the uml and relational data models," *Data and Knowledge Engineering*, vol. 63, no. 3, pp. 972 – 996, 2007, 25th International Conference on Conceptual Modeling (ER 2006). [Online]. Available: http://www.sciencedirect.com/science/article/pii/S0169023X07001140

[12] J. G. Wolff, "Towards an intelligent database system founded on the sp theory of computing and cognition," *Data and Knowledge Engineering*, vol. 60, no. 3, pp. 596 – 624, 2007. [Online]. Available: http://www.sciencedirect.com/science/article/pii/S0169023X06000723

[13] ——, "Medical diagnosis as pattern recognition in a framework of information compression by multiple alignment, unification and search," *CoRR*, vol. abs/1409.8053, 2014. [Online]. Available: http://arxiv.org/abs/1409.8053

[14] D. Martinenghi, H. Christiansen, and H. Decker, *Integrity Checking and Maintenance in Relational and Deductive Databases - and Beyond*. Idea Group Publishing, 2006, pp. 238–285.

[15] T. W. Ling, "Integrity constraint checking in deductive databases using the prolog not-predicate," *Data and Knowledge Engineering*, vol. 2, no. 2, pp. 145 – 168, 1987. [Online]. Available: http://www.sciencedirect.com/science/article/pii/0169023X8790019X

Hybrid-ALEACH-Plus: Hybrid-Advance-Low Energy Adaptive Clustering Hierarchy for Wireless Sensor Network

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***Abstract*—Wireless Sensor Networks (WSNs) is an advanced technology that provides fundamental elements for various Internet-of-Things (IoT) applications. Operation with low energy consumption is one of the requirements in designing routing protocol in WSN since each node has limited and non-renewable source of energy. In this paper, we proposed the Hybrid-ALEACH-Plus and Hybrid-ALEACH-Plus2 protocol with the main goal to increase wireless sensor network lifetime. The protocol introduces a new cluster head based routing algorithms with two cluster head selection processes that employ neighbor node threshold and ALEACH-Plus threshold as the selection criteria. We evaluated the performance of both proposed protocols by comparing with existing cluster head based routing protocols such as LEACH and ALEACH. Simulation results showed that our proposed protocols outperform the existing cluster head based routing protocols in terms of energy consumption level, the first dead node (FDN), last dead node (LDN) and amount of delivered data message.**

I. Introduction

Wireless Sensor Networks (WSNs) is composed of a large number of sensors nodes deployed in a target area with the main objective to identify, transmit, and process sensed information according to application requirements. Such applications are wide range including health, wildlife, and security monitoring [1]. The data processing and forwarding are triggered by the occurrence of specific events in the environment where sensors nodes are deployed. In some applications, data collected from sensor nodes may aggregate before forwarding to the base station. The main challenges in WSNs protocol design is aiming at balancing trade-offs between responsiveness and efficiency. Protocol designer must balance this under the constraint of the limited processing and communication capacity of sensor nodes. Sensor nodes are supplied by non-rechargeable batteries so minimizing energy consumption to extend the WSNs lifetime is one of the most important issues in sensor network design. An efficient routing algorithm design may significantly reduce WSNs energy consumption [2][3][4]. Among various routing techniques, hierarchical (or cluster head based) routing protocols are considered one of the most promising approaches in WSNs routing [4][5].

In this paper, we introduced the Hybrid-ALEACH-Plus and Hybrid-ALEACH-Plus2 as energy efficient cluster head-based routing protocols for the wireless sensor network. The proposed protocols make use of sensor nodes' location, energy information and neighbor node information along with modified cluster head selection based on threshold condition and message forwarding method in order to reduce sensor network's energy consumption. The rest of this paper is organized as follows. Section II describes related works. Section 3 describes the proposed routing protocols. Simulation results and conclusions are presented in Section 4 and 5.

II. Related Work

In sensor network hierarchical routing, the main idea is to divide a group of sensor nodes into several areas called clusters. Each cluster then selects a cluster head (CH) node for coordinating activities within its members and between other clusters. One of the well-known cluster head based protocol is LEACH (Low Energy Adaptive Clustering Hierarchy). It was proposed in [6] to solve the problem of the sensor node's energy load balancing. LEACH's cluster head selection relies on a random select technique. Within a cluster group, only one sensor node becomes CH according to the probability threshold as shown in (1). In this equation, P is the desired percentage of CH, r is the current round, and G is the set of nodes that have not been selected as CH in last $1/P$ rounds. If the number is less than a threshold, the node becomes CH in the current round and will not repeatedly become CH within $1/P$ rounds. As a result, the probability that the remaining nodes can be CH increases with the number of rounds.

$$T(n) = \begin{cases} \frac{P}{1-P*(rmod(1/P))} & \text{If n } \epsilon \text{ G} \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

Advanced-LEACH or ALEACH [7] proposed a new probability threshold for cluster head selection where nodes make autonomous decisions without any control. The advantage of this approach is that there is no long-distance communication with base station. ALEACH introduced general probability (as in LEACH) and current state probability as show in (2).

$$T(n) = \frac{P}{1 - P * (rmod(1/P))} + \frac{E_{current}}{E_{initial}} * P \quad (2)$$

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Amini [8] presented DBS algorithm that includes distance of sensor nodes from base station in the clustering formation process. LEACH-C protocol [9] proposed a centralized clustering algorithm where each sensor node sends information about its current position and residual energy to BS in order to arrange clusters. A. Y. Mostafa [10] presented the hybrid routing protocol that combines the advantages of the LEACH-C protocol and direct transmission to base station.

III. Proposed Algorithm

This section presents details of Hybrid-ALEACH-Plus protocol and its family Hybrid-ALEACH-Plus2. The proposed protocols improve the cluster head selection process by considering factors including node's energy, location, distance to BS, the number of neigibor, and midified threshold condition based cluster formation with the main goal to reduce sensor node energy consumption. The proposed protocol is designed based on following assumptions: 1) All nodes have equal initial energy. Their batteries are not rechargeable, 2) Sensor nodes are randomly distributed in the square shaped sensor field, 3) Each sensor node has knowledge of its current position and remaining energy, 4) Each sensor node may communication directly to the base station, 5) Each sensor node has computational capabilities of sensing and aggregating data, and 6) At every round of cluster head selection, it is assumed that every node has data to send to BS.

A. Energy Dissipation Model

In this work, we adopt the same radio model as in previous works [6][7][8][9]. The radio model of energy comsumption of the network is described as follows:

$$E_{TX}(k,d) = \begin{cases} kE_{elec} + k\varepsilon_{fs}d^2 & d < d_0 \\ kE_{elec} + k\varepsilon_{mp}d^4 & d \geq d_0 \end{cases} \quad (3)$$

$$E_{RX}(k) = (E_{elec} + E_{DA}) * k \quad (4)$$

$$d_0 = \sqrt{\varepsilon_{fs}/\varepsilon_{mp}} \quad (5)$$

In (3) and (4), there are two types of energy: 1) the transmission energy denoted by E_{Tx} transmits k bits packet within distance d, and 2) the reception energy denoted by E_{Rx}. The E_{elec} refers to the energy dissipated per bit used to process transmitted and received data. The E_{DA} refers the energy of data aggregation dissipated per bit. Parameter ε_{fs} and ε_{mp}, correspond to free space propagation model and the two-ray propagation model, are used in calculating necessary energy to transmit data. Distance between node and BS is represented by d. Parameter d_0, as shown in (5), represents the threshold value of the reference distance.

B. Hybrid-ALEACH-Plus Cluster Head Selection Process

In LEACH protocol, it is assumed that all sensor nodes use the same energy model. The first method of the Hybrid-ALEACH-Plus cluster head selection process is the neighbor node threshold. Here, a node that has number of neighbor node exceeds the average number of neighbor node in the network is a potential cluster head node according to cluster head selection process. Another method is to use the ALEACH-Plus threshold which includes energy and location information of each sensor node into the calculation of the cluster head selection threshold $T(n)$.

1) Neighbor Node Threshold: This process starts at each node by calculating number of neighbor node within the $R_{Distanceneighbor}$ radius. Number of neighbors of a sensor node here is defined as number of sensor nodes that are within the $R_{Distanceneighbor}$ range from that sensor node. This can be calculated as shown in (6).
The $M * M$ is the square area which sensor nodes are distributed. If a node has neighbors more than the average of neighbor node of a network (considered as high-level of neighbor), it can become a cluster head since this node has a high level of neighbor nodes (potential cluster members). For example as illustrated in Fig.1, the average number of neighbor in the network is appapproximately 2.67. Node A has high-level of neighbor (3 neighbor nodes), while node B and node C have low-level of neighbor.

$$R_{Distanceneighbor} = \sqrt{\frac{M * M}{\text{number of node in sensor field}}} \quad (6)$$

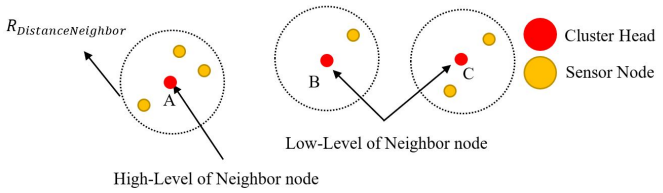


Fig. 1: Node A is a high level of neighbor nodes. Node B and C are low-level of neighbor nodes. Average number of neighbor node in the network is appapproximately 2.67.

2) ALEACH-Plus Threshold: ALEACH-Plus threshold is the probability that a low-level of neighbor sensor node n will also be selected as a cluster head. Each node picks a random number between 0 to 1. If the selected random number exceeds T(n), this sensor node will be chosen as a cluster head for this round. The process of cluster head selection follows as

$$T(n) = \frac{P}{1 - P * (rmod(1/P))} + En(n) * ReCH(r) * P \quad (7)$$

$$En(n) = \frac{E_{cur}(n)}{E_{init}} + (\frac{dtoBS_n}{dtoBS_{avg}} * nonCH(r)) \quad (8)$$

$$R_{CoverCH} = R_{Distanceneighbor} * 1.5 \quad (9)$$

In (7), P represents target percentage of cluster head to the total number of sensor node at the current round r. The threshold neighbor also considers other important factors namely $En(n)$ and $nonCH(r)$. The $ReCH(r)$ represents a fraction of sensor nodes that have not been elected as cluster heads in the past $1/p$ round to the total number of nodes

that are still alive. The $ReCH(r)$ is reset every $1/p$ round. The $En(n)$, which is calculated as shown in (8), is the new parameter used in selection of cluster heads at (7). From (8), E_{cur} is current energy of node n. E_{init} is the initial energy level. The $dtoBS_n$ is the distance between a sensor node n to the base station, and $dtoBS_{avg}$ is an average distance of sensor nodes in the network to the base station. Parameter $nonCH(r)$ is the number of consecutive rounds which a sensor node n had not been selected as a cluster head. The Hybrid-ALEACH-Plus proposes a method to ensure that the distance between any two cluster heads are greater than the $R_{CoverCH}$ threshold (calculated as shown in (9)).

Fig. 2 shows a case that when node A is selected as a cluster, node B and node D cannot become cluster head at the same round. This is because the distance between node A and node B is within the $R_{CoverCH}$ threshold. Node C still has chance to become a cluster node since the distance between C and its neighbors are greater than $R_{CoverCH}$ threshold.

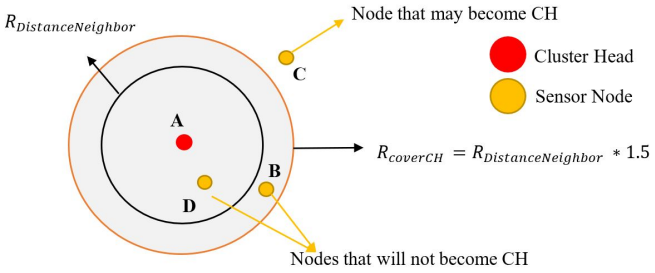


Fig. 2: A case where node B and node D will not be selected as cluster heads at the same round since they are too close (within the $RcoverCH$ range) to a cluster head A.

3) The optimal number of clusters: LEACH-C calculates the expected opportunity of cluster head in each round K_{opt} as shown in (10). In Hybrid-ALEACH-Plus, the cluster formation algorithm creates cluster head which the expected number of clusters per round is K_{newopt} by the system parameter analysis. LEACH-C assumes that there are N nodes distributed uniformly in an $M * M$ area. Where d_{toBS}, the distance from cluster head to the base station, assumes that the distance is greater than distance threshold (d_o). Determination of the optimal value K_{newopt} in the Hybrid-ALEACH-Plus uses the computation and communication energy model in the network as shown in (11). $NN_{Average}$ is the average number of neighbor node in the network, $node$ is number of nodes in the network from an initial phase, and $alivenode$ is a number of nodes that still have the remaining energy.

$$K_{opt} = \frac{\sqrt{N}}{\sqrt{2\pi}} * \frac{\sqrt{\varepsilon_{fs}}}{\sqrt{\varepsilon_{mp}}} * \frac{M}{d_{toBS}^2} \tag{10}$$

$$K_{newopt} = K_{opt} * \frac{\text{alive node}}{\text{node in network}} + NN_{average} \tag{11}$$

C. The Clustering Formation

In LEACH protocol, a sensor node forwards data to its nearest cluster head. In this work, we look at an opportunity that sometimes a sensor node is located closer to the base station than to its cluster head. Sending directly to base station may help network reduce total energy consumption. The proposed algorithm using Minimum Transmissionn Energy (MTE) before forwarding data to cluster head with two conditions. If the distance between a sensor node and its nearest cluster head is greater than distance between a sensor node and the base station, sensor node will forward data directly to the base station.

D. Algorithm Process

In Hybrid-ALEACH-Plus, cluster head had been selected with regards to 2 selection processes. The first selection process selects cluster head from the high-level neighbor nodes. The second selection selects cluster heads from low-level neighbor nodes. The protocol arranges total number of clusters in each round based on the K_{newopt} value in network. If the number of cluster head is not greater than the K_{newopt} in neighbor node process, the low-level neighbor node will be selected as cluster head by ALEACH-Plus threshold process. As a result, this reduces energy consumption and the density of cluster head in each round.

E. Hybrid-ALEACH-Plus2 Protocol

To improve network lifetime, we also proposed Hybrid-ALEACH-Plus2 protocol. We adopt the ALEACH-Plus protocol with an addition of the energy condition in selection of the cluster head and the increment of $R_{CoverCH}$ in (12). The energy condition is that the node that become cluster head must have the energy level greater than the average energy of all node in the network.

$$R_{CoverCH} = R_{Distanceneighbor} * 2 \tag{12}$$

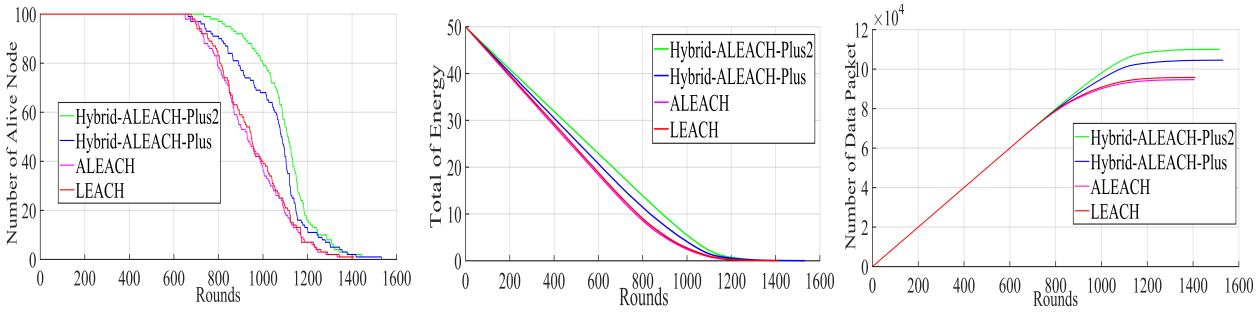
F. Performance Metrics

The performance metrics used here include various evaluation aspects used in comparisons of cluster-based routing algorithm for wireless sensor network. It is listed as 1) energy consumption, 2) number of alive nodes (First Dead Node, Last Dead Node), and 3) number of data messages.

IV. Results and Discussions

We evaluate performance of our proposed protocols with the LEACH and ALEACH protocol. We implemented simulation scenarios by using MATLAB R2017a. In our simulations set up, we randomly deployed 100 sensor nodes within the area of $100 * 100$ m^2. Base station is located at the center of the sensor field. Parameters used in our simulations are shown in Table 1.

Simulation results for varied network topology scenario are presented in Fig. 3. In Fig. 3(a), Hybrid-ALEACH-Plus and Hybrid-ALEACH-Plus2 show better results in term of the number of round when the first dead node and the last



(a) (b) (c)

Fig. 3: Comparison resutls of (a) number of alive node, (b) energy consumption, and (c) number of transmitted packets between Hybrid-ALEACH-Plus, Hybrid-ALEACH-Plus2, LEACH, and ALEACH protocols

TABLE I: Simulation Parameters

No	Description	Parameters	Value
1	Location of BS	BS	(50,50)
2	Number of sensor nodes	N	100 node
3	Energy in electronics	E_{elec}	50 nJ/bit
4	Energy for path-loss	ε_{fs}	10 pJ/bit/m^2
5	Energy for multipath-loss	ε_{mp}	0.013 pJ/bit/m^2
6	Initial energy	E_0	0.5 J
7	Threshold distance	d_0	87.705 m
8	Data aggregation	E_{DA}	5 nJ/bit/signal
9	Packet length	P_{Length}	6400 bits
10	Desired percentage of cluster head	P	0.1

dead node occurs. Hybrid-ALEACH-Plus2 extends number of round of first dead node further than that of Hybrid-ALEACH-Plus protocol. But for the last dead node, Hybrid-ALEACH-Plus has the longest the network lifetime. Fig. 3(b) represents results on energy consumption. Both Hybrid-ALEACH-Plus protocols' energy level decrease slower than LEACH and ALEACH protocols. The energy level of Hybrid-ALEACH-Plus2 even decreases slower than Hybrid-ALEACH-Plus. The amount of data packets that are successfully delivered to BS in proposed protocols also outperforms that of the LEACH and ALEACH approximately 12-15%. Moreover, Hybrid-ALEACH-Plus2 beats Hybrid-ALEACH-Plus around 5-10%.

V. Conclusions

In this paper, we proposed Hybrid-ALEACH-Plus and Hybrid-ALEACH-Plus2, the cluster head based energy efficient routing protocols for wireless sensor network. Our simulation results indicated that Hybrid-ALEACH-Plus and Hybrid-ALEACH-Plus2 outperformed existing cluster head based routing protocols in terms of energy consumption, network lifetime, and amount of delivery data. For future works, we look to explore protocol's performance with different network topology, and new conditions that help improve WSNs lifetime.

References

[1] I. F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, "A survey on sensor networks," *IEEE Communications Magazine*, vol. 40, no. 8, pp. 102–114, Aug 2002.

[2] N. A. Pantazis, S. A. Nikolidakis, and D. D. Vergados, "Energy-efficient routing protocols in wireless sensor networks: A survey," *IEEE Communications Surveys Tutorials*, vol. 15, no. 2, pp. 551–591, Second 2013.

[3] A. Chunawale and S. Sirsikar, "Minimization of average energy consumption to prolong lifetime of wireless sensor network," in *2014 IEEE Global Conference on Wireless Computing Networking (GCWCN)*, Dec 2014, pp. 244–248.

[4] D. Peng and Q. Zhang, "An energy efficient cluster-routing protocol for wireless sensor networks," in *2010 International Conference On Computer Design and Applications*, vol. 2, June 2010, pp. V2–530–V2–533.

[5] A. S. Toor and A. K. Jain, "A survey of routing protocols in wireless sensor networks: Hierarchical routing," in *2016 International Conference on Recent Advances and Innovations in Engineering (ICRAIE)*, Dec 2016, pp. 1–6.

[6] W. R. Heinzelman, A. Chandrakasan, and H. Balakrishnan, "Energy-efficient communication protocol for wireless microsensor networks," in *Proceedings of the 33rd Annual Hawaii International Conference on System Sciences*, Jan 2000, pp. 10 pp. vol.2–.

[7] M. S. Ali, T. Dey, and R. Biswas, "Aleach: Advanced leach routing protocol for wireless microsensor networks," in *2008 International Conference on Electrical and Computer Engineering*, Dec 2008, pp. 909–914.

[8] N. Amini, M. Fazeli, S. G. Miremadi, and M. T. Manzuri, "Distance-based segmentation: An energy-efficient clustering hierarchy for wireless microsensor networks," in *Fifth Annual Conference on Communication Networks and Services Research (CNSR '07)*, May 2007, pp. 18–25.

[9] W. B. Heinzelman, A. P. Chandrakasan, and H. Balakrishnan, "An application-specific protocol architecture for wireless microsensor networks," *IEEE Transactions on Wireless Communications*, vol. 1, no. 4, pp. 660–670, Oct 2002.

[10] A. Y. Mostafa, S. S. Soliman, N. El-Gaml, R. M. Daoud, H. H. Amer, and A. Khattab, "Wsn lifetime elongation

via hybrid routing," in *2016 28th International Conference on Microelectronics (ICM)*, Dec 2016, pp. 177–180.

Experimental Study of DVB-T2 Threshold

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***Abstract*—This paper describes the Threshold of Digital Terrestrial Television second generation network in Thailand. The measured result were carried out from 22 measured location, located in 22 district in Bangkok, Thailand.**

Keywords—Noise Margin, Carrier to Noise Ratio, DVB-T2, Modulation Error Ratio, Bit Error Rate, Threshold

I. INTRODUCTION

Nowadays the television network in Thailand has been upgraded from analog to digital system. The new system that has been selected is DVB-T2 (Digital Video Broadcasting Terrestrial Second Generation) The advantage of DVB-T2 are offer HDTV (High Definition Television), SDTV (Standard Definition Television), UHD (Ultra Definition Television), Mobile Television. And the DVB-T2 can be used to simultaneous transmit the multiple services which difference configuration. The objective of this research is to study the signal quality that archive QEF (Quasi Error Free) point and signal quality between QEF point and threshold point of DVB-T2 that operating in Thailand that will let us know the characteristic of the new system, which is DVB-T2 that have been used to broadcast DTTN (Digital Terrestrial Television Network) in Thailand.

The measurement have been conducted at 22 measured location that located in each district in Bangkok Thailand by measurement tools set consists of DVB-T2 analyzer, Antenna, Attenuator with the parameter that recommended by NBTC (National Broadcasting Telecommunication Commission).

The rest of paper is structured as follow: Section II will describe the Overview of DVB-T2 Standard. Field Measurement and Analysis will be described in Section III. Result of Measurement will be described in Section IV finally the Conclusion in Section V.

II. OVERVIEW OF DVB-T2 STANDARD

A. DVB-T2 Structure

The structure of digital television that are using to broadcast in Thailand is using the function of OFDM (Orthogonal Frequency Division Multiplexing) DVB-T2 has used the OFDM (Orthogonal Frequency Division Multiplexing), that is a multi-carrier method that consists of so many subcarrier that composite of orthogonal and frequency division multiplex that are at right angles to another one and division of the information into many subcarrier respectively. Each subcarrier is independently modulated and its own dependently information of the other. Each subcarrier is used vector modulation by QAM (Quadrature Amplitude Modulation) is 16-QAM, 64-QAM and 256-QAM etc.[1] The multiple subcarrier can be described in figure 1 [2] for each single carrier is dependently modulated by QAM modulator with mapper.

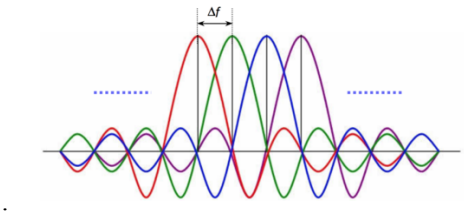

Fig. 1 Orthogonality in OFDM [2]

There are many FFT size in DVB-T2 system that can be used to define how many subcarriers will be used to transmit On the 8 MHz bandwidth the number of subcarriers are 1K, 2K, 4K, 8K, 16K and 32K in Thailand the 16K FFT size with extended mode that mean there are 13,921 subcarriers are transmitted.

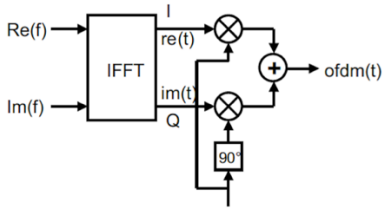

Fig. 2 The Implementation of an OFDM modulator [1]

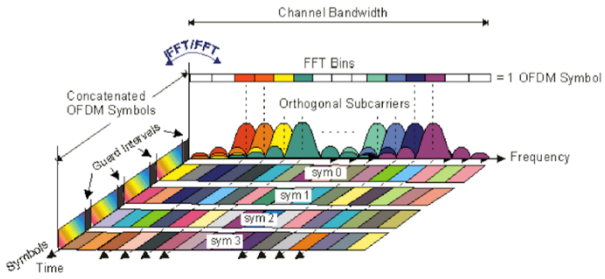

Fig. 1 Frequency and Time Domain in OFDM

Each subcarrier has been modulated independently of others. The OFDM symbol has been generated by a multiple mapping these two table, which are real and imaginary table are now input signals for the processing process so-called IFFT (Inverse Fast Fourier Transform) therefore these symbols have been changed to time domain.

B. Transmission Channel

In DVB-T2 there are 3 type of transmission path consists of Gaussian Channel that usual starting point for understanding of The DVB-T2 transmission channel that there is only one signal path arrived at the received antenna. The second channel is Rice Channel that there are direct signal and multiple echo arrived at the received antenna and the last one

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is Rayleigh Channel that there are only multiple echo arrived at the received antenna [1]. These of 3 transmission channel will degrade the DVB-T2 signal quality. There are three basic cause that impact DVB-T2 signal propagation which are reflection, diffraction and scattering these [3]

Reflection will occurs when the propagated RF signal impinges on a smooth surface with vary large dimension compared to RF signal wavelength.

Diffraction will occurs when the signal path between a transmitter and receiver is obstructed by an object with dense and large dimension compared to RF signal wavelength.

Scattering will occur when the propagated RF signal impinges whether any surface that dimension are on the order of RF signal wavelength or less

III. Field Measurement and Analysis

A. Measurement Configuration

The research was conducted accordingly to the research procedure that shown in figure 4 and conducted at 22 measured location in each district in Bangkok Thailand illustrate in figure 5

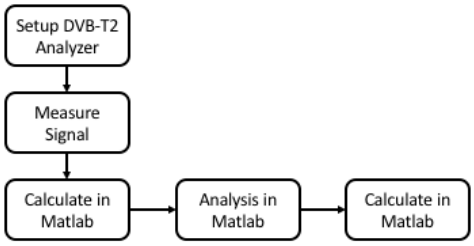

Fig. 4 Research Procedure.

This measurement was carried out the quality of DVB-T2 signal which is BER (Bit Error Rate) that used to indicate the DVB-T2 signal quality. And in this research we analyzed the signal quality after the signal quality lower than QEF point as well. And the signal will passed through so many obstruction lead to so many multi path were created along the way to received antenna. The measurement conducted by using measurement tools comprise of DVB-T2 portable analyzer, antenna with antenna high 6 meter above the ground and attenuator used to reduce the signal power to study what will happen after the signal quality lower that QEF point.

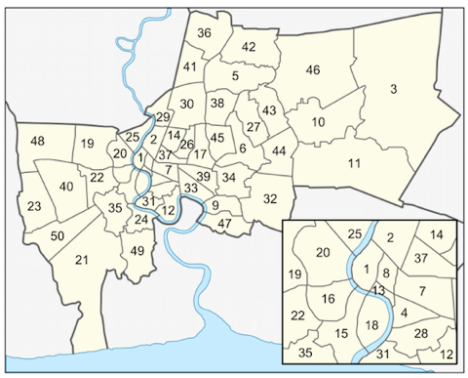

Fig. 5 22 measured location in 22 District in Bangkok.

This research were conducted following the procedure illustrated in figure 4 The DVB-T2 analyzer can be collected the measured raw data and these raw data have been imported to analyze in computer software later.

During the measurement were conducted the antenna will not be moved and will not close to the big object to avoid the multipath the can be crated from these object. The antenna directional to transmitter that located at Baiyoke building 2 or GPS location 13˚45’ 16.77” N, longitude 100 ˚32’ 25.34” E the antenna is high for 328 meter above from sea level. In Thailand the operator of DVB-T2 are consist of 4 organize and 5 MUX belong to a government. The gain of antenna is 14.31 dBd and the radiation pattern of antenna is horizontal polarization. Nowadays in Thailand is still operating in fixed rooftop reception therefore in this research focused only rooftop reception condition only the other reception condition will be conducted in next research.

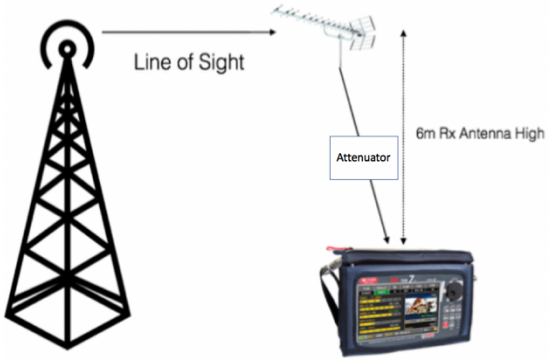

Fig. 4 Measurement Configuration.

B. Transmitted Parameter Used to Broadcast

There are 4 operator and 5 transmitter in Thailand consists of NBT channel for 1 operator license which is channel 26 transmitted frequency is 514 MHz transmitted power is 4 kW, Royal Thai Army for 2 operator license which are ARMY 1 channel which is channel 36 transmitted frequency is 594 MHz transmitted power is 4.3 kW and ARMY 2 which is channel 52 transmitted frequency is 722 MHz transmitted power is 4.3 kW, MCOT for 1 operator license which is channel 40 transmitted frequency is 626 MHz transmitted power is 4 kW and TPBS for 1 operator license which is channel 44 transmitted frequency is 658 MHz transmitted power is 3.9 kW [4] The parameter that have been used to broadcast defined by NBTC shown in table 1 and have been used in this research.

TABLE I. Transmitted Parameter

Parameter	Value
Bandwidth	8 MHz
FFT Mode	16k Extended Mode
Pilot Pattern	PP2
Guard Interval	19/128
Constellation	64 QAM
Constellation Rotation	Off
Code Rate	3/5

C. MER (Modulation Error Ratio)

The MER (modulation error ratio) can be explained that the constellation point exhibit deviations compared to nomal position in the center. If the deviations are too great it lead to bit error occur.

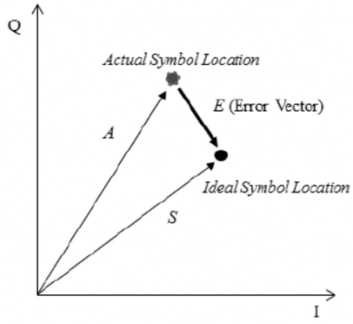

Fig. 5 Error Vector on I,Q constellation diagram. [5]

To evaluate the performance of DVB-T2 that used the QAM modulation scheme such as 16-QAM, 64-QAM etc. MER will be used to measure and evaluate the sum of actual symbol point of received signal that occurred on the constellation diagram to analyze the error of amplitude and phase. In figure 6 the red scatted point will lead to the decision boundaries are crossed therefore the bit error rate occur in figure 6 (a) there are so many red scatted points more than figure 6 (b) that mean (a) will give lower MER and higher bit error than (b). The equation that used to calculate MER has been shown in (1) [5]

(a) (b)

Fig. 6 Cloud of symbol in constellation diagram. [1]

$$MER = 10\,x\,log_{10}\left\{\frac{\Sigma_{J=1}^{N}\left(I_j^2+Q_j^2\right)}{\Sigma_{J=1}^{N}\left(\delta I_j^2+\delta Q_j^2\right)}\right\} \quad (1)$$

D. BER (Bit Error Rate)

In DVB-T2 the quality of signal are indicated by BER that is the ratio between bit error and transmitted bit. There are 2 type of BER in DVB-T2 used to evaluate which are bBER and LBER that can be described that is the ratio of error before and after FEC (forward error correction) the FEC consists of 2 part which are LDPC (Low Density Parity Check) and BCH (Bose–Chaudhuri–Hocquenghem) illustrate in figure 6. For this research we will analyze of these two type of BER.[7] The BER can be calculated by using equation (3)

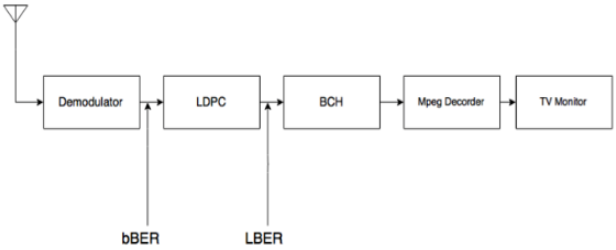

Fig. 6 FEC block diagram [5]

$$BER = \frac{(number\ of\ error\ bits)}{(Total\ number\ of\ bits)} \quad (1)$$

IV. Result Of Measurement

In this section will illustrate the measurement result, that have been measured for 22 measured location located in Bangkok, Thailand.

A. Threshold

The measured results that were carried from 22 measured location consists of MER, bBER and LBER to study the correlation between these parameter and to study the quality of signal after QEF point that is 13dB illustrate in figure 7. From this measurement the threshold or the minimum MER that can be used is 2 dB that lower than QEF point by used the attenuator to reduce the signal level until picture disappear from the screen. When the MER is lower than QEF point the picture still appear on the screen with error appeared on the screen more than one time within 30 second.

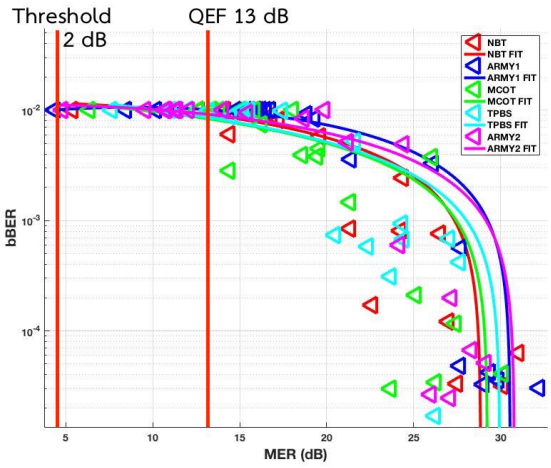

Fig. 7 Threshold of DVB-T2 [8]

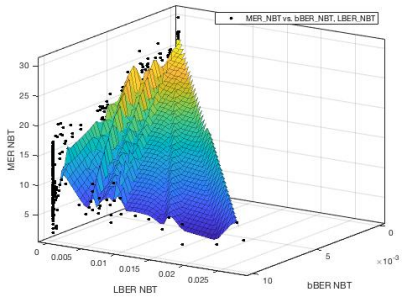

Fig. 8 Quality of DVB-T2 in term of MER - NBT

The correlation between MER and BER whether bBER and LBER are illustrated in figure 8-12 for 5 MUX can be described that after MER is lower that QEF point the picture still appeared on the screen until MER is lower than 2dB. However bBER is increased, when signal is passed through LDPC the signal have been error corrected by LDPC therefore the picture still appear on the television screen.

The quality of DVB-T2 in term of MER for NBT MUX is shown in figure 8 the LBER level are still same value from highest MER until 13 dB QEF point and after the MER value lower than 13 dB the picture still appeared on the screen with more than 1 error within 30 second. Until the MER level is lower than 2 dB the picture disappeared from the screen. Regarding to the DVB-T2 system is the new television broadcasting system that have been selected to replace the existing system which is analog therefore there are not much information about DVB-T2 in Thailand used to improve the signal quality. This result lead us know how much the error happen and it is the information that can be used to improve the DVB-T2 signal quality in the future.

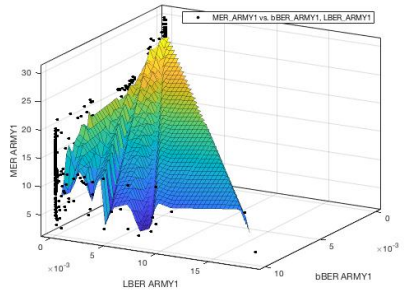

Fig. 9 Quality of DVB-T2 in term of MER – ARMY1

From this measured results found that the LDPC have corrected the wrong bit to the corrected one therefore whenever the BER is higher from the lowest point it still have been corrected by LDPC lead to corrected bit out from FEC block to use in MPEG decoder

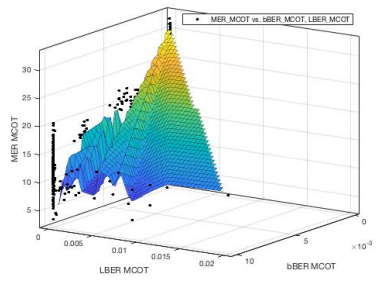

Fig. 10 Quality of DVB-T2 in term of MER - MCOT

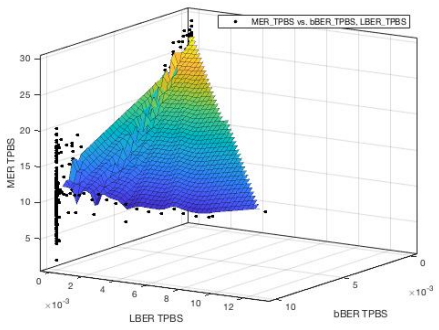

Fig. 11 Quality of DVB-T2 in term of MER - TPBS

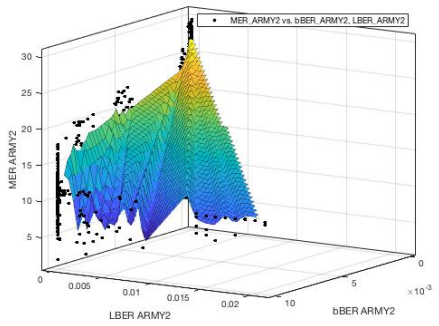

Fig. 12 Quality of DVB-T2 in term of MER – ARMY2

The quality of DVB-T2 in term of MER for the rest MUX which are ARMY1, MCOT, TPBS and ARMY2 have been illustrate as figure 9, 10, 11 and 12 respectively. For all MUX can be summarized that when the MER signal level lower than around 20 dB the bBER will significantly decrease. However, from these measured results bBER value are decreased, the LBER still are in good quality due to LDPC block. When MER value is lower than 13 dB QEF point there are some measured location are still good quality the LBER still low until 2 dB the picture disappeared. For the previous research [8] can be illustrate as table 2. However the MER value of MCOT Mux is low, the bBER is still low as well refer to table 2 from previous research[8] the lowest standard deviation in term of MER belong to MCOT MUX therefore the LBER value is low.

TABLE II. TABLE OF MER NOISE MARGIN STATISTICAL [8]

Frequency (MHz)	Mean 0f Noise Margin	Variance of Noise Margin	Standard Deviation of Noise Margin
514	7.88	52.72	0.34
594	6.86	75.20	0.41
626	7.11	51.11	0.34
658	6.56	65.84	0.38
722	7.36	80.34	0.42

V. CONCLUSION

From this measurement have been conducted from 22 measured location in each district in Bangkok, Thailand lead us know the threshold of DVB-T2 that can be received and picture still appeared on the television screen. Until MER value is about 7.5 dB the LBER will significantly increase but still received the DVB-T2 signal until 2 dB threshold. This

information lead us know how we far from QEF point in term of LBER and can be used to improve the signal quality of DVB-T2 in Thailand in the future and lead us know the ability of LDPC block that used to correction the wrong bit to the corrected bit. This researcher focuses on fixed reception condition only the rest reception such as portable and mobile reception will be research in future work. In the future work the DVB-T2 propagation will be researched to solve and improve the DVB-T2 signal quality in the rest transmission channel which are Ricean and Rayleigh channel as well.

REFERENCES

[1] Walter Fischer "Digital Television A Practical Guide for Engineers" ROHDE&SCHWARZ

[2] Revolution Wifi by Andrew "How OFDM Subcarriers Work" http://www.revolutionwifi.net Jun 1 2015

[3] Jerry D. Gibson "Mobile Communications Handbook Second Edition" IEEE press

[4] A. Ingun, "DVB-T2 field trial and optimized parameters in Thailand," in Electrical Engineering Congress (iEECON), 2014 International, pp. 1-4, 19-21 March 2014

[5] Mitsuhito Iwamoto, Shingo Matsuoka, Hiroki Iwasaki, and Hiroyuki Otsuka, "Transmission Performance of OFDM with 1024-QAM in the Presence of EVM Degradation," *APWiMob 2014, Bali 28-30 Augustus 2014*

[6] B. Ruckveratham,S. Promwong, "Performance evaluation of DVB-T2 for outdoor reception," 2016 13th International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology pp.1-5 (ECTI-CON), 2016

[7] Ron Hranac BER and MER Fundamentals Cisco Systems, Inc 2007

[8] Chairak Deepunya, Nattapan Suwansukho and Sathaporn Promwong "Evaluation of Noise Margin in DVB-T2" The 6th Global Wireless Summit (GWS-2018) Chiang Rai, Thailand. November 25-28, 2018

[9] Digital Video Broadcasting (DVB): Implementation Guidelines for a Second Generation Digital Terrestrial Television Broadcasting System (DVB-T2), ETSI Technical Specification TS 102 831 V1.1.1, Oct. 2010.

[10] Digital Video Broadcasting (DVB); Frame Structure channel coding and modulation for a second generation digital terrestrial television broadcasting system (DVB-T2), *ETSI Standard EN 302 755 V1.4.1 (2015-07)*

Body Area Network Transfer Function Measurement with Frequency Band From 3 GHz to 9 GHz

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***Abstract*— Body area network (BAN) technology is becoming an increasingly important part of the wireless body communication system and short range applications. Characteristic of impulse radio-ultra wide band (IR-UWB) wave propagation should be study is very important parameters. The body transfer is more complex than other applications. Anyway, to understand the characteristics of the channel distribution on the human body is so important. In this study we are present the characteristics of waveform transmission due to body channel and without body for short range wireless applications based on measurement data. We introduce the matched filter at the receiver side to maximize the signal-to-noise ratio (SNR) for evaluated BAN system. In this report, the results are evaluated based apply the Friis' formula. In this technique to gives a very useful and more accurate the results for the design and evaluation of BAN transmission for wireless medical applications, especially focusing on the effect of waveform distortion.**

Keywords: BAN, UWB, WBAN, pat h loss, delay time

I. INTRODUCTION

An body area network (BAN) is wireless technology has become an important topic for short range microwave communication because of its low power consumption potentials [1], [2]. The BAN will be support by UWB technology it's different from other radio frequency (RF) technologies. UWB transmits very short pulse and power spectral density (PSD) in the range of ultra wide frequency spectrum instead of using narrow band radio frequency in traditional RF technologies. The UWB is a unique and new usage of recently legalized frequency spectrum. The FCC specified that UWB signal has frequency spectrum ranging from 3.1 GHz to 10.6 GHz [3], and have a fractional bandwidth equal or greater than 0.20, or occupied bandwidth equal or greater than 500 MHz. The fractional bandwidth defined as

$$B_f(f) = 2\frac{(f_H - f_L)}{f_H + f_L} \geq 0.2, \qquad (1)$$

with f_L is lowest frequency and f_H is highest frequency at the -10 dB point, respectively.

The power spectrum of UWB signal does not exceed the FCC part 15
limits or -41.3 dBm/MHz, so that the PSD of UWB waveform is considered as the noise for other radio communication systems. Therefore, the technology of UWB radio can coexist with other RF communications without interference. Moreover, the technology UWB impulse radio is an ideal candidate that can be utilized for commercial, short-range, low power, low cost indoor communication systems such as wireless personal area networks (WPANs) [4].

We apply the Friis' transmission formula because of this formula is widely used to calculate the free space propagation loss for narrowband communication systems [5]. The complex form of Friis' transmission formula is developed for the UWB transmission system [6]-[8]. The matched filter receiver is used as the UWB receiver [9]-[11]. Although the rectangular waveform distorted by UWB free space channel is used to derive the theoretical SNR gains [12], there are no considerations about the measured channel and UWB antennas.

BAN has become an important part of short range wireless communication. BAN is based on the development of the u-health and Information Technology (IT) – Biology Technology (BT) convergence technology. The WBAN is a conceptual term for a short range wireless network technology targeted for use within 1 to 3 meters of the human body. According to the application field, BAN is classified for both medical and non-medical uses. The use of WBAN for medical treatment requires such factors as power consumption efficiency and reliability. For the case of non-medical treatment, high-speed data transfer rate is required for a transmission including the sound and image. Depending upon the device location, WBAN can be classified either as an implant or as a wearable device. The implant case is primarily used for medical treatment, and the wearable device is mainly used for entertainment via wireless communications [13]-[15].

The standardization of WBAN is defined in IEEE 802.15.6 TG, including information about the physical layer, data link layer, network layer and application layer. Channel modeling is important for the development of any communication link. Channel models of WBAN are classified as off-body, on-body, or in-body. However, a corrected model describing the characteristics of a WBAN channel does not exist. For this

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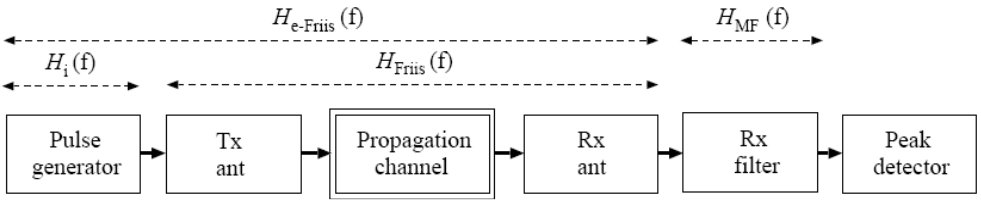

Fig. 1: Block diagram of BAN transmission model for WBAN system.

reason, it is difficult to design a suitable communication system.

In this paper, evaluate of human body (HB) effect in UWB transmission waveform. This scheme is based on the Friis' transmission formula, adapted for UWB. Therefore, the evaluation of channel and UWB signal are concentrated in this paper and also a summary on experimental body area network model. Moreover, this paper also uses Friis' transmission formula in complex form applies to UWB transmission for evaluation process and the vector network analyzer (VNA) to measure the transfer function of UWB transmission. UWB channel models that are suitable to be used in wireless medical application research.

II. THEORY OF BAN TRANSFER FUNCTION

In this research, we focus on waveform transfer function with human body evaluation of the BAN system in free space.

In narrowband systems, the link budget of the free space propagation loss is usually estimated by using Friis' transmission formula. However, it is not directly applicable to the UWB-IR transmission system, as the formula is expressed as a function of the frequency. Moreover, the waveform may be distorted due to the frequency characteristics of the antenna [7] treats the special cases of the constant gain and the constant aperture, but no general discussion had been made although it suggested the use of the time-domain antenna effective length. The Friis' transmission formula has been widely used, and can be applied to the calculation of these LOS channels.

$$G_{\text{Friis}}(f)=\frac{P_{\text{r}}(f)}{P_{\text{t}}(f)}=G_{\text{f}}(f)G_{\text{r}}(f)G_{\text{t}}(f), \tag{2}$$

Where G_r and G_t are Rx and Tx antenna gain

$$G_{\text{f}}(f)=\left(\frac{\lambda}{4\pi d}\right)^2, \tag{3}$$

$G_{\text{f}}(f)$ is the free space propagation gain (less than unity in practice), $\lambda=\frac{c}{f}$ is the wavelength, c is the velocity of the light, f is the operating frequency, and d is the separation between transmitter and receiver antennas.

It is noted, however, that Eq.(2) is satisfied only at some certain frequency, and is not directly applicable to UWB systems. The Friis' transmission formula shall be extended to take into account the transmission signal waveform and its distortion as well.

Input signal $v_{\text{i}}(t)$ at the transmitter port is expressed as the convolution of an impulse input and the pulse shaping. It $h_{\text{i}}(t)$ as

$$v_{\text{i}}(t)=\delta(t)*h_{\text{i}}(t), \tag{4}$$

With

$$\int_{-\infty}^{\infty}h_{\text{i}}^2(t)dt=\int_{-\infty}^{\infty}\left|H_{\text{i}}(f)\right|^2df=1 \tag{5}$$

The receiver, the matched filter $H_{\text{MF}}(f)$ is introduced to maximize the SNR of the receiver output, as shown in Fig. 1.

$$H_{\text{MF}}(f)=\frac{H_{\text{e-Friis}}^*(f)}{\sqrt{\int_{-\infty}^{\infty}\left|H_{\text{e-Friis}}^*\right|^2\,\text{d}f}}, \tag{6}$$

and in the isotropic case

$$H_{\text{MF,Iso}}(f)=\frac{H_{\text{e-Friis}}^*(f)}{\sqrt{\int_{-\infty}^{\infty}\left|H_{\text{e-Friis}}^*\right|^2\,df}}, \tag{7}$$

to satisfies by following constant noise output power condition

$$\int_{-\infty}^{\infty}\left|H_{\text{MF}}(f)\right|^2\,\text{d}f=1 \tag{8}$$

In this case, $E_{\text{i}}=1$ the output waveform, and the spectrum of the receiver output are $h_{\text{e-Friis}}(t)$ and $H_{\text{e-Friis}}(f)$ respectively. The waveform of the output from the matched filter $v_{\text{MF}}(t)$ is

$$\begin{aligned}v_{\text{MF}}(t)&=h_{\text{e-Friis}}(t)*h_{\text{MF}}(t)\\&=\frac{h_{\text{e-Friis}}(t)*h_{\text{MF}}(-t)}{\sqrt{\int_{-\infty}^{\infty}h_{\text{e-Friis}}^2(t)\text{d}t}},\end{aligned} \tag{9}$$

and for the isotropic case

$$v_{\mathrm{MF,Iso}}(t) = h_{\mathrm{e-Friis,Iso}}(t) * h_{\mathrm{MF,Iso}}(t) = \frac{h_{\mathrm{e-Friis,Iso}}(t) * h_{\mathrm{MF,Iso}}(-t)}{\sqrt{\int_{-\infty}^{\infty} h^2_{\mathrm{e-Friis,Iso}}(t)\mathrm{d}t}}, \quad (10)$$

and the spectrum of the output from the matched filter $v_{\mathrm{MF}}(t)$

$$v_{\mathrm{MF}}(f) = H_{\mathrm{e-Friis,Iso}}(f) H_{\mathrm{MF}}(f) = \frac{|H_{\mathrm{e-Friis}}(f)|^2}{\sqrt{\int_{-\infty}^{\infty} |H_{\mathrm{e-Friis}}(f)|^2 \,\mathrm{d}f}}, \quad (11)$$

to taking its maximum as

$$\max_t v_{\mathrm{MF}}(f) = \int_{-\infty}^{\infty} V_{\mathrm{MF}}(f) df = \sqrt{\int_{-\infty}^{\infty} |H_{\mathrm{e-Friis}}(f)|^2 df} \quad (12)$$

Equation (12) is the UWB extension of Friis' transmission formula. It includes three elements, namely the frequency characteristics of the antennas, the frequency characteristics of free space propagation, and the spectrum of the transmit signal. It is clear from Eq. (12) that the transmission gain of the UWB signal cannot be defined as the product of gains of antennas and a free space channel as Friis' formula (2). Instead, the total transmission gain including the effect of the waveform can be obtained as Eq. (12). For the normalization, the reference isotropic antenna with $H_{\mathrm{Iso}}(f) = 1$ is considered. The UWB transmission gain can be defined as

$$G_{\mathrm{UWB}} = \frac{\max_t v_{\mathrm{MF}}(t)}{\max_t v_{\mathrm{MF,Iso}}(t)} \quad (13)$$

III. BAN EXPERIMENT SYSTEM

A. *Experiment scheme*

By using the vector network analyzer (VNA), complex transfer functions can be measured [16]. However, this transfer function is a product of transfer functions of Tx and Rx antennas as well as the indoor channel.

B. *Measurement and Modeling setup*

In experiments designed to measure in this study. The model is divided into two types between with human body. And without human body, which will look like for example at

In this experiment to measure both model. Transmitter and receiver antennas are mounted on the body in areas defined as 7 points in which each point can be placed in different parts of the body, according to figure 2 of the transmitter and the receiver antenna facing out from the body. The transmitter antenna is mounted on the front of the body at 1 point and the front of the receiver antenna by the transmitter antenna and the receiver is set to the same as shown in figure 2.

In this experiment to measure both model. Transmitter and receiver antennas are mounted on the body in areas defined as

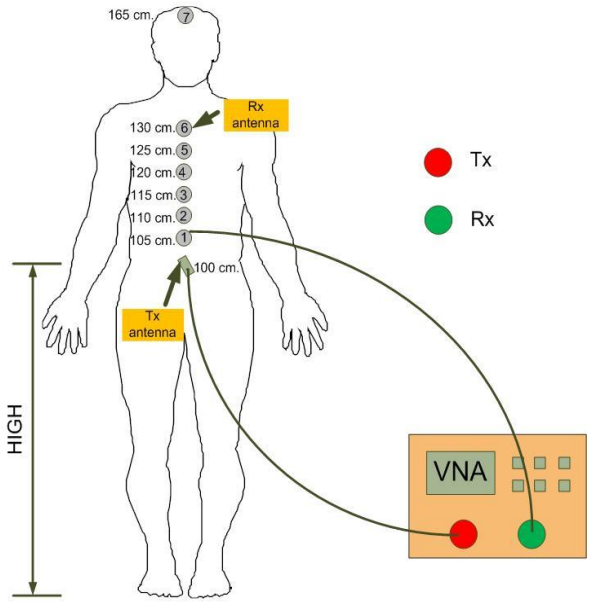

Fig. 2 : Experimental model without human body and with human body

7 points in which each point can be placed in different parts of the body, according to figure 2 of the transmitter and the receiver antenna facing out from the body. The transmitter antenna is mounted on the front of the body at 1 point and the front of the receiver antenna by the transmitter antenna and the receiver is set to the same as shown in figure 2.

C. *BAN signal model*

The transmit signal waveform that fully covers the FCC band [3], i.e., 3 - 9 GHz. The center frequency and the bandwidth were therefore set to be f_0 = 6 GHz and f_b = 6 GHz, respectively. The transmit waveform assumed in the simulation was a single ASK pulse with the carrier frequency f_0. To satisfy the bandwidth requirement of f_b, the pulse length was set to be $2/f_b$. Then the signal was band-limited by a Nyquist roll-off filter with roll-off factor α =0 in Gaussian distribution $\left(f_0 - \frac{f_b}{2}, f_0 + \frac{f_b}{2}\right)$. Figures 3 show the transmit pulse waveform of IR model. The transmission process of the pulse waveform is simulated based on the measured transfer function of the antennas.

D. *Parameters of experiments*

The important parameters for the experiments are listed in Table 1. It is noted that calibration is done at the connectors of the cables to be connected to the antennas. Therefore, all impairments of the antenna characteristics are included in the measured results.

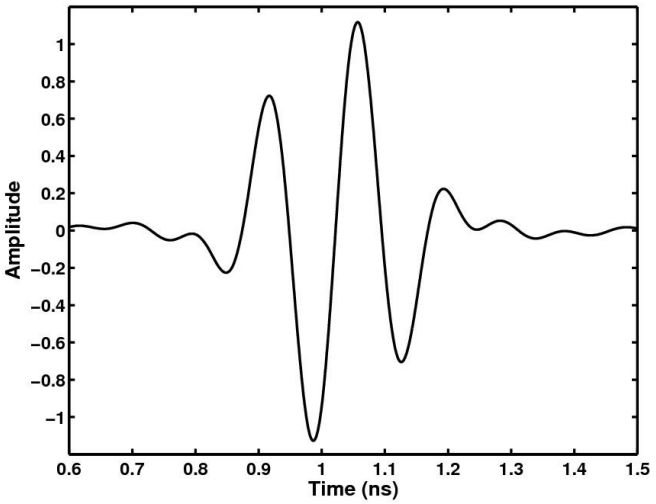

Fig. 3: The transmitted waveform of BAN system.

E. *Parameters of experiments*

The important parameters for the experiments are listed in Table 1. It is noted that calibration is done at the connectors of the cables to be connected to the antennas. Therefore, all impairments of the antenna characteristics are included in the measured results.

Table 1: Measurement setup parameters

Parameter	Value
Frequency range	3.0 GHz - 9.0 GHz
Number of frequency point	801 points
Type of Antenna	middle line
Number of points	7 points
length of the transmission antenna	1 m

IV. MEASUREMENT RESULTS

This section describes the graphical compilation of the experiment results.

In figure 5 shows the comparison path loss of human body versus without human. We can particularly see the path loss of each pointing. We can see that the same point of within human body case have most path loss than without human body

Figure 6 shows the without human body case of power delay profiles of the measured transfer function and it's within human body case is also shown in figure 7. We can particularly see the frequency characteristic of the transfer function and delay spread at each pointing. The effects of human body shadowing on the UWB antenna propagation, Signal level at each point down. The lowest level of the signal due to the distance from the antenna

In figure 8, we can see the case of the without human body is root mean square (rms) delay spread value is changed slightly. In the case of the human body is a signal to the rms delay spread is higher as a result of the human body causes the multipath fading

V. CONCLUSION

This paper described the measurement and evaluation of BAN transfer function for WBAN by based on apply formula of Friis' in order to take into account the transmit waveform and the matched filter at the receiver into the system.

The experiment system using VAN and the minder line antennas as the transmitter and the receiver are presented. This scheme may be effective especially to evaluated the characteristics of human body transfer function effect. The overall performance can be evaluated only by the term of the path loss and delay of the transfer function channel of BAN.

VI. REFERENCES

[1] K. Siwiak, "Ultra-Wide Band Radio: Introducing a New Technology," 2001 Spring IEEE Vehicular Technology Conference (VTC), vol. 2, pp. 1088-1093, May 2001.

[2] K. Siwiak, "Ultra-Wide Band Radio: The emergence of an Important RF Technology," 2001 Spring IEEE Vehicular Technology Conference (VTC), vol. 2, pp. 1169-1172, May 2001.

[3] Federal Communications Commission, "Revision of Part 15 of the Commission's Rules Regarding UWB Transmission Systems," First Report, FCC, Apr. 2002.

[4] J. Farserotu, A. Hutter, F. Platbrood, J. Gerrits and A. Pollini, "UWB Transmission and MIMO Antenna Systems for Nomadic User and Mobile PAN," Wireless Personal Communications, no. 22, pp. 197-317, 2002.

[5] H. T. Friis, "A Note on a Simple Transmission Formula," Proc. IRE, Vol 34, no 5, pp. 254-256, May 1946.

[6] S. Promwong, W. Hachitani and J. Takada, "Experimental Evaloation Scheme of UWB Antenna Performance," Technical Meeting on Instrument and Measurement, IEE Japan, IM-03-35, June 2003.

[7] S. Promwong, W. Hachitani, J. Takada, P. Supanakoon and P. Tangtisanon, "Experimental Study of Ultra Wideband Transmission Based on Friis' Transmission Formula," The Third International Symposium on Communications and Information Technology (ISCIT) 2003, vol. 1, pp. 467-470, Sept. 2003.

[8] X. Xu and R. M. Narayanan, "Impact of Different Correlation Receiving Techniques on The Imaging Performance of UWB Random Noise Radar," 2003 IEEE International Geoscience and Remote Sensing Symposium (IGARSS), vol. 7, pp. 4525-4527, July 2003.

[9] S. Promwong, J. Takada, P. Supanakoon and P. Tangtisanon, "Path Loss and Matched Filter Gain for UWB System," 2004 International Symposium on Antenna and Propagation (ISAP), pp. 97-100, Aug. 2004.

[10] S. Promwong, J. Takada, P. Supanakoon and P. Tangtisanon, "Path Loss and Matched Filter Gain of Free Space and Ground Reflection Channels for UWB Radio Systems," IEEE TENCON 2004 on Analog and Digital Techniques in Electrical Engineering, pp. 125-128, Nov. 2004.

[11] Z. Bai, W. Zhang, S. Xu, W. Liu and K. Kwak, "On The Performance of Multiple Access DS-BPAM UWB System in Data and Impage Transmission," IEEE International Symposium on Communications and Information Technology (ISCIT), vol. 2, pp. 851-854, Oct. 2005. [13]

[12] D. Raskovic, T. Martin, E. Javanov, "Medical monitoring application for wearable computing," The computer Journal, vol.47, no.4, pp. 495-504, July 2004.

[13] R.S.H Isepanian, E. Jovanov, Y.T. Zhang, "Guest editorial introduction to the special section on M-health: beyond seamless mobility and global wireless health-care connectivity," IEEE Trans. Inform. Technol.Biomed., vol. 8, no.4, pp. 405-414, Dec. 2004.

[14] Jae-Myeong Choi, Heau-Jo Kang, Yong-Seok Choi, "A study wireless body area network applications and channel models," in Proc. FGCN '08, vol.2, pp.263-266, Dec. 2008.

[15] S. Promwong, J. Takada, P. Supanakool, and P. Tangtisanon, "ExperimentalStudy on the applicability of the Complex Form Friis'Transmission Formula in Fresnal Region for UWB Free Space Channel Model,"

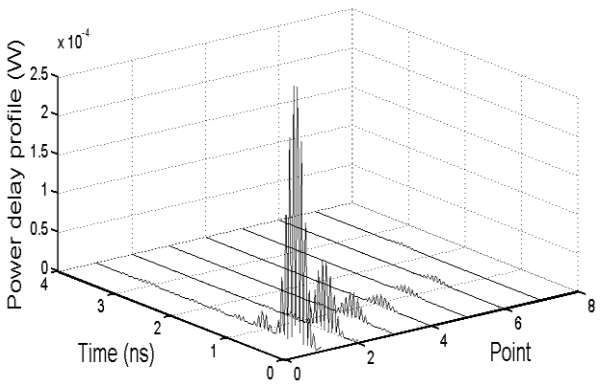

Fig.6: Power delay profile of the BAN channel of without human body.

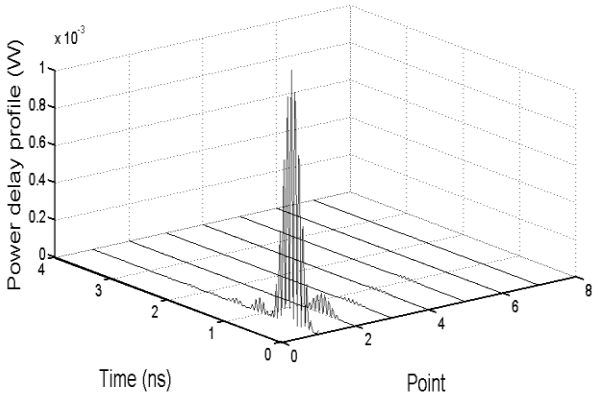

Fig.7: Power delay profile of the BAN channel with human body.

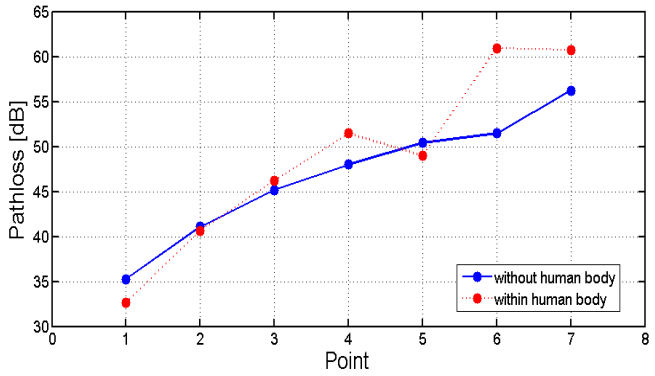

Fig.5: Comparison of the path Loss of without and with human bodys

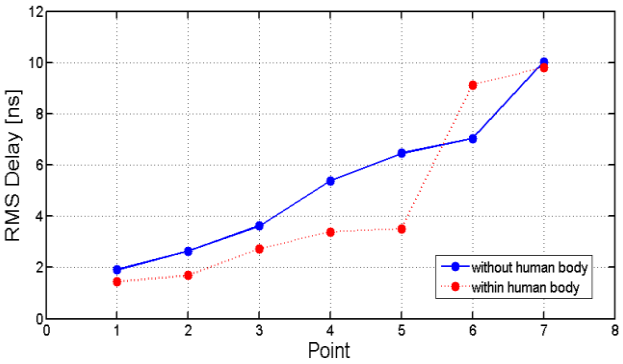

Fig.8: Comparison of the RMS Delay of without and with human body.

HB Channal Measurement and Modeling in UWB for WBAN

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***Abstract*—The human body (HB) with ultra-wideband (UWB) is wireless technology for short range wireless communication systems. In particular, wireless body area network (WBAN) based on IEEE802.15.6. Therefore, the effect with human body is very importance to know a channel characterization. In this paper, we present a UWB transmission waveform with HB in line-of-sight (LOS) and non-LOS (NLOS) models for WBAN. The measurement is covered as a full-band 3.1 GHz to 10.6 GHz FCC regulation, includes the antenna under test and vector network analyzer (VNA) is provided. In order to investigate some of the parameter, path loss and power delay profile (PDP) are discussion.**

***Keywords*—HB, UWB, WBAN, impulse radio, Friis' transmission formula**

I. INTRODUCTION

Recently, an ultra-wideband (UWB) technology draws much attention because of its potential low cost, ultra-low power communication and anti-multipath capabilities [1]-[3]. To re- duce the interference with existent systems, the UWB is foresee to be mainly used in indoor environment such as wireless body area network and wireless personal area network. The UWB impulse radio is different from other radio frequency (RF) technologies, very short pulse and low power spectral density (PSD) in the range of ultra wide frequency spectrum instead of using narrow band radio frequency in traditional RF technologies. The FCC specified that UWB signal has the frequency spectrum ranging from 3.1 GHz to 10.6 GHz, and have a fractional bandwidth greater than or equal 0.20 or a bandwidth greater or equal to 500 MHz measured at -10 dB points [4]-[8].

Wireless body area network (WBAN) has become an important role of short range wireless communication. WBAN is a conceptual term for a wireless network technology targeted for use within 1 to 3 meters of the human body. According to the application field, WBAN is classified for both medical and non-medical uses. The use of WBAN for medical treatment requires such factors as power consumption efficiency and reliability. For the case of non-medical treatment, high-speed data transfer rate is required for a transmission including the image and sound. Depending upon the device location, WBAN can be classified either as an implant or as a wearable device. The implant case is primarily used for medical treatment, and the wearable device is mainly used for entertainment via wireless communications [9]-[11].

In this paper, we present a HB-UWB transmission waveform with LOS and NLOS models for WBAN system. In LOS case, transmission channel is measured by using a biconical antenna provides the transmitter and microstrip patch antenna composes in front of human body of the receiver. In contrast, the receiver is moved to behind of human body.

The model of LOS and NLOS helps to distinguish. The effect of human body (HB) for WBAN communication. Moreover, our transmission channel is based on an extension Friis' formula of UWB signal and covered 3.1 GHz to 10.6 GHz by FCC regulation. However, this paper shows usefully of UWB channel measurement and gracefully in an impact of a human body.

The organization of this paper as follows. Section II describes the transmission formula. Section III describes the measurement setup, and models. Section IV the results are show and discussions. Finally, some concludes will be shown.

II. HB- UWB TRANSMISSION WAVEFORM

The Friis' transmission formula [5] has been widely used, and can be applied to the calculation of these LOS channels.

The root raised cosine passband waveform is the waveform with root raised cosine spectrum and its spectral density is defined as

$$G_{\text{Friis}}(f) = \frac{P_{\text{r}}(f)}{P_{\text{t}}(f)} = G_{\text{f}}(f) G_{\text{r}}(f) G_{\text{t}}(f) \quad (1)$$

Where $P_{\text{t}}(f)$ is input power to the transmitter antenna, $P_{\text{r}}(f)$ is output power from the receiver antenna, $G_{\text{r}}(f)$ and $G_{\text{t}}(f)$ are R_X and T_X antenna gain,

$$G_{\text{f}}(f) = \left(\frac{\lambda}{4\pi d} \right)^2 \quad (2)$$

This is the free space propagation gain (less than unity in practice), $\lambda = C / f$ is the wavelength, C is the velocity of the light, f is the operating frequency, and d is the separation between transmitter and receiver antennas.

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In this research we mpply the Friis' transmission formula is extended taking into account the transmission waveform as

$$H_{\text{e-Friis}}(f)=\frac{V_{\text{r}}(f)}{E_{\text{i}}}=H_{\text{f}}(f)H_{\text{i}}(f)\mathbf{H}_{\text{r}}(f)\cdot\mathbf{H}_{\text{t}}(f) \quad (3)$$

where

$$\text{H}_{\text{f}}(f,d)=\frac{\lambda}{4\pi d}\exp(-jkd) \quad (4)$$

is the free space transfer function where

$$k=\frac{2\pi}{\lambda} \quad (5)$$

This is the propagation constant, $H_{\text{i}}(f)$ is transmitted signal transfer function, $\mathbf{H}_{\text{r}}(f)$ is received antenna transfer function and $\mathbf{H}_{\text{t}}(f)$ is transmit antenna transfer function.

The PDP is the meaning of relative powers of the taps for the channel, also defined as the variation of mean power in the channel with delay, thus

$$\bar{\tau}=\frac{\sum_{i=1}^{n}a^2\tau_i}{\sum_{i=1}^{n}a_i^2}=\frac{\sum_{i=1}^{n}P(\tau_i)\tau_i}{\sum_{i=1}^{n}P(\tau_i)} \quad (6)$$

with $\bar{\tau}$ is mean excess delay, a_i is signal level of path i, $P(\tau_i)$ is power level of signal path i and τ_i is time delay of signal path i.

The path loss of HB-UWB can be defined as the ratio between the maximum amplitude of the transmitted and received signal waveforms.

$$P_{\text{UWB}}(dB)=20\log\left[\frac{\max|v_{\text{t}}(t)|}{\max|v_{\text{r}}(t)|}\right] \quad (7)$$

$$v_{\text{t}}(t)=\int_{-\infty}^{\infty}\text{H}_{\text{t}}(f)e^{j2\pi f_c t}dt \quad (8)$$

$$v_{\text{t}}(t)=\int_{-\infty}^{\infty}\text{H}_{\text{r}}(f)e^{j2\pi f_c t}dt \quad (9)$$

with $v_{\text{t}}(t)$ is amplitude of the transmitted signal waveform and $v_{\text{r}}(t)$ is amplitude of the received signal waveform.

III. HB MEASUREMENT WITH LOS AND NLOS MODEL

A. Measurement setup

In the complex transfer functions measurement we consider used the vector network analyzer (VNA) [4]. However, this transfer function is a product of transfer functions of T_X and R_X antennas as well as the indoor channel, according to Fig. 1. The measurement model is divided into three types. That is LOS, NLOS and free space.

The receiver antennas are mounted on the body in areas defined as 10 points in which each point can be placed in different parts of the body, according to Fig. 2. The receiver antenna facing out from the body. The transmitter antenna is placed in front of the body separate 1 m.

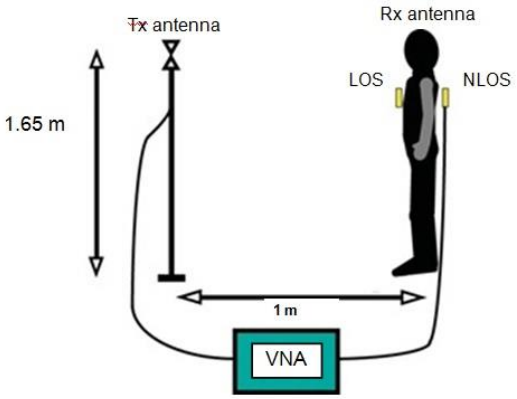

Fig 1. The measurement setupl for LOS and NLOS.

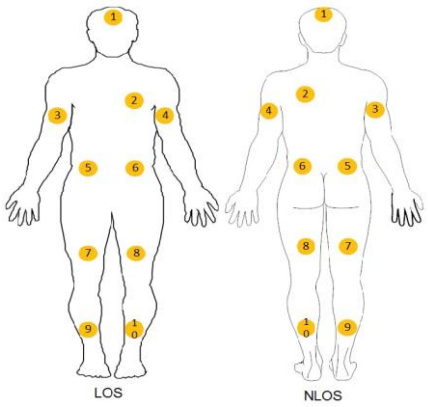

Fig 2. The measurement model with positions on human body.

B. HB-UWB transmittedl waveform

For UWB transmitted signal waveforms, the rectangular pass band is considered as the UWB transmitted waveform in time domain and its spectral density in frequency domain. These waveforms can satisfy the FCC definition of UWB signal and FCC spectral masks for indoor and outdoor limits. The parameters obtained from maximum bandwidth, amplitude and average power optimizations, which are proposed in [12], are used. The rectangular pass band transmitted waveform in time domain and its spectral density function are given by

$$v_t(t) = \frac{1}{f_b}[\, f_H \sin c(2 f_H t) - f_L \sin c(2 f_L t)] \quad (10)$$

$$V_t(f) = \begin{cases} \dfrac{A}{2 f_b} \left\| f \right| - f_c \right| \le \dfrac{f_b}{2} \\ 0 \left\| f \right| - f_c \right| > \dfrac{f_b}{2} \end{cases} \quad (11)$$

where A is the maximum amplitude, f_b is the occupied bandwidth, f_c is the center frequency, f_L and f_H are the minimum and maximum frequencies. This waveform has the $A/2f_b$ constant magnitude of spectral density in $-f_H$ to $-f_L$ and f_L to f_H frequency ranges. Then this waveform has the A maximum amplitude at $t = 0$. This is the ideal case of UWB waveform then it used to consider the upper limit of maximum bandwidth, amplitude and average power for UWB waveform. In Fig. 3 show the transmitted waveform of UWB system.

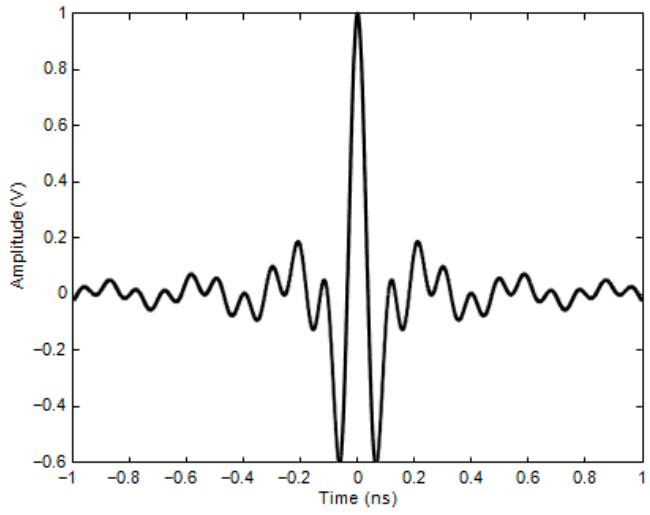

Fig 3. The transmitted waveform of HB-UWB system.

The important parameters for the experiments are listed in Table 1. It is noted that calibration is done at the connectors of the cables to be connected to the antennas. Therefore, all impairments of the antenna characteristics are listed in Table 1. It is noted that calibration is done at the connectors of the cables to be connected to the antennas. Therefore, all impairments of the antenna characteristics are included in the measured results.

Table 1: MEASUREMENT SETUP PARAMETER

Parameters	Values
Frequency range (GHz)	3 - 11
Frequency sweep points	801
Transmitter antenna type	Biconical antenna
Reciever antenna type	Microstrip patch antenna
Tx antenna height (cm)	165
Rx antenna height (cm)	15 - 165
Human body height (cm)	165
Distance between T_x and Body (cm)	100
Measurement number (point)	10

IV. EXPERIMENTAL RESULT

The results, Fig. 4 show the comparison path loss with free space, LOS and NLOS. We can see the path loss of each pointing in free space and LOS are similar by Increased with distance. In order to NLOS have the Path Loss more than free space and LOS.

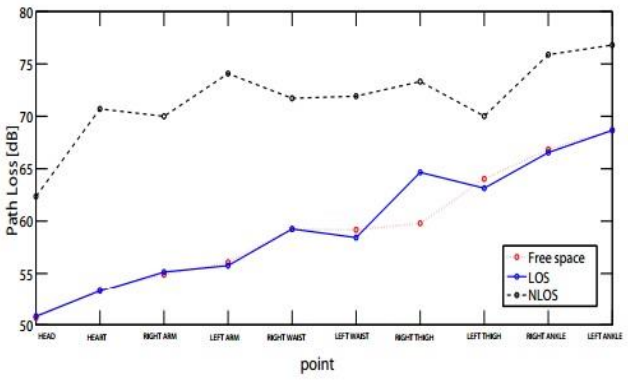

Fig 4. The path loss between free space, LOS and NLOS.

We can see the in the figures 5, 6 and 7 shows the power delay profiles of free space, LOS and NLOS. Which that shows about Receive signal power is a position and time. We can see that is a significant solution with NLOS has power delay profile less than free space and NLOS. The effects of human body shadowing on the UWB antenna propagation, Signal level at each point down. At the lowest level of the waveform due to the distance from the antenna.

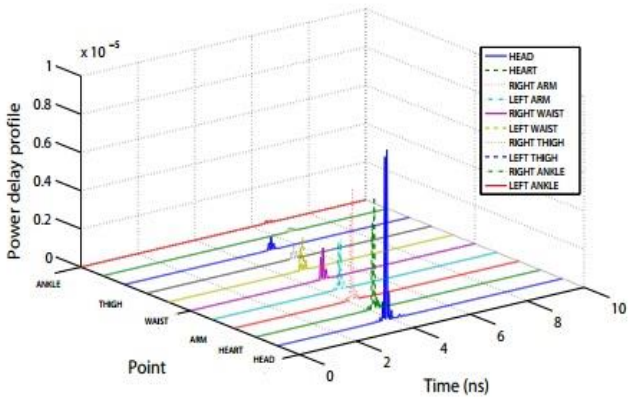

Fig 5. The power delay profile of HB-UWB free space.

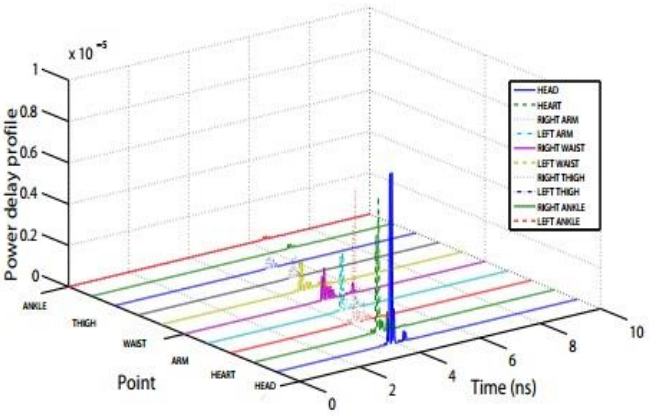

Fig 6. The power delay profile of HB-UWB in LOS case.

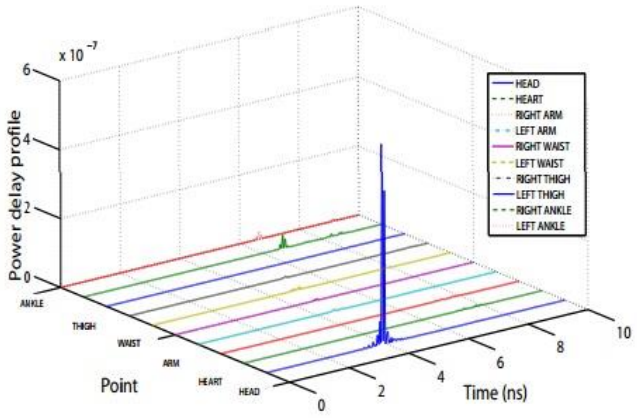

Fig 7. The power delay profile of HB-UWB in NLOS case.

V. CONCLUSIONS

In this report, we evaluated the HB-UWB transmission waveform with LOS and NLOS models for WBAN system. In order to investigate some of effects on the human body, which become significantly for HB-UWB transmission waveform. The effect of human body can be known by the measurement results as the channel transfer function, path loss, and PDP successfully. These results shown that the side effect from human body has been shadowed, it can be leaded to the selective channel for UWB-BAN communications. Therefore, deployment to provide of UWB receiver in NLOS has to consider in WBAN.

REFERENCES

[1] K. Siwiak, “Ultra-Wide Band Radio: Introducing a New Technology,” 2001 Spring IEEE Vehicular Technology Conference (VTC), vol. 2, pp. 1088–1093, May 2001.

[2] K. Siwiak, “Ultra-Wide Band Radio: The emergence of an Important RF Technology,” 2001 Spring IEEE Vehicular Technology Conference (VTC), vol. 2, pp. 1169–1172, May 2001.

[3] Federal Communications Commission, “Revision of Part 15 of the Commission’s Rules Regarding Ultra-Wideband Transmission Systems,” First Report and Order, FCC 02–48, Apr. 2002.

[4] S. Promwong, J. Takada, P. Supanakool, and P. Tangtisanon, “Experi-mentalStudy on the applicability of the Complex Form Friis’ Transmis-sion Formula in Fresnal Region for UWB Free Space Channel Model,” 2004 International Symposium on Antennas and Propagation, August 17–21, 2004. (to be presented).

[5] H.T. Friis, “A note on a simple transmission formula,” Proc. IRE, vol. 34, no. 5, pp. 254–256, May 1946.

[6] J. Takada, S. Promwong and W. Hachitani, “Extension of Friis’ Trans-mission Formula for Ultra-Wideband Systems,” IEICE Tech. Rep., WBS2003-8/MW2003-20, May 2003.

[7] S. Promwong, W. Hachitani and J. Takada, “Experimental Evaloation Scheme of UWB Antenna Performance,” Technical Meeting on Instru-ment and Measurement, IEEE Japan, IM-03-35, June 2003.

[8] S. Promwong, W. Hachitani, J. Takada, P. Supanakoon, and P. Tangti-sanon “Experimental Study of Ultra-Wideband Transmission Based on Friis’ Transmission Formula,” The Third International Symposium on Communications and Information Technology (ISCIT) 2003, vol. 1. pp. 467–470, Sept. 2003.

[9] D. Raskovic, T. Martin and E. Javanov, “Medical monitoring application for wearable computing,” The computer Journal, vol. 47, no. 4, pp. 495-504, July 2004.

[10] R. S. H Isepanian, E. Jovanov and Y. T. Zhang, “Guest editorial introduc- tion to the special section on M-health: beyond seamless mobility and global wireless health-care connectivity,” IEEE Trans. Inform. Technol. Biomed., vol. 8, no. 4, pp. 405–414, Dec. 2004.

[11] J. M. Choi, H. J. Kang, Y. S. Choi, “A study wireless body area network applications and channel models,” in Proc. FGCN ’08, vol. 2, pp. 263–266, Dec. 2008.

[12] P. Supanakoon, K. Wansiang, S. Promwong and J. Takada, "Simple Waveform for UWB Communication," The 2005 Electrical Engineering/Electronics, Computer, Telecommunication, and Information Technology International Conference (ECTI-CON 2005), pp. 626-629, May 2005.

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Modulation Error Ratio Gain of Single Frequency Network in DVB-T2

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***Abstract*— DVB-T2 broadcasting with a single frequency network allows an efficient management of frequency utilization and extend the coverage area, which will enable more people to view a broadcast. The SFN mode also increases the concentration of the signal in overlap areas. However, some different of overlap areas in actual use of SFN networks may have some degradation of the received signal due to the effect of the SFN. In this research, we analyze SFN broadcasting in SISO mode. This paper represents the effects of delays on the SFN signal over different delay times within the guard interval by analyzing the minimum reception threshold. The analysis of received signal power, MER, bBER, LBER, and noise margin are studied using an actual digital television transmitter for the experiment. The results show that the minimum thresholds for a delay time at 0 microseconds will require higher receive signal power than other delay times within the GI. The results of this experiment are useful in designing the SFN network and make it possible to determine the appropriate C/N threshold for the design of the digital terrestrial television network.**

Keywords— DTTV, DVB-T2, SFN, MER, DVB-T2 measurement

I. INTRODUCTION

DVB-T2 digital terrestrial television [1]. In addition to multi-frequency network (MFN) broadcasting, there is another transmission broadcasting mode called single frequency network (SFN) [2], which has more advantages than the MFN mode. The SFN system can manage the proper frequency and bandwidth efficiently. Another advantage of the SFN mode is that the coverage area can be easily expanded using the same frequency. Using a low-power transmitter makes the SFN system highly flexible. For example, if one or the main transmitter fails, then the coverage area does not entirely disappear because some areas can receive signals from other SFN transmitters. For example, the viewer may still be able to receive signals from another transmitter in the network area if the signal is stronger than the minimum threshold requirement.

Many studies have analyzed SFN transmissions for DVB-T2 by finding the minimum carrier-to-noise (C/N) requirement for real broadcasts compared with implementation guidelines and laboratory measurements [3]. The SFN channel was determined by finding the path loss gain by analyzing and evaluating the effects of the multipath channel. In[4], studied and investigated the SFN gain from real broadcast measurements. In [5], propose the SFN Gain calculation of the difference of signals received from various overlap transmitters. In [6, 7], proposes an analysis of the SFN gain when the modulation error ratio (MER) changed due to the propagation channel and receiving a signal from more than one transmitter.

In some SFN coverage areas, the quality of the received signal may deteriorate due to the effect of the SFN propagation channel. In [8], propose XiaBertoni model and a model based on the Hata for analyzing the SFN propagation. In [9], propose the analysis of long path delays for received signal multipath in an SFN. The performance of SFN depending on different Doppler frequencies that are presented by laboratory and field measurement. The quality of service (QoS) is shown by the result of MER at the receiver, especially the delay of received signals from the SFN network will affect the MER. The effect of interference in SFN of DVB-T2 depending on the influence of Guard Interval (GI) duration., present the result of bit error rate due to the GI duration. Furthermore, many echoes delays produce the power and IQ imbalance that causes degrade the signal quality. Study of IQ imbalance and residual Carrier Frequency Offset (CFO) affect the capacity symbol error rate (SER). Inter symbol interference (ISI) also occurs due to the echo delay effect. A new channel estimation and an interpolation technique to eliminate the effect of phase rotation caused by symbol timing offset (STO) which can help to solve inter-symbol interference (ISI) problems.

The objective of this study is to obtain digital TV reception in the SFN mode in different areas. The receivers can receive signals from multiple transmitters that transmit within the same GI time. In each reception area, the echo delay is different. Although the echo delay is different, the echo delay is still inside the GI, and the receivers can receive the signal. The main objective of this research is an analysis of the minimum threshold reception of DVB-T2 in SFN mode and the development of an experimental model for the SFN in SISO. The analysis of the delay effects during the GI such as the SFN gain, received signal power and modulation error ratio (MER). In our analysis, comparison between the normal received signal power result and the minimum received signal power 1 result was used for evaluation, and the minimum threshold of the SFN signal of DVB-T2 was obtained. Correlation was used to analyze the effect of the minimum signal delay requirement within the GI time. Measuring the difference in the echo delay is difficult in the field test. Therefore, in this research, a laboratory measurement model was used to simulate all delay time situations in the GI. Two SFN transmitters were used, and the static local delay time of both transmitters was changed during the GI time to analyze and find the minimum threshold reception for the desired SFN signal.

II. DVB-T2 TRANSMISSION MODEL

A. DVB-T2 Analysis

The modulation error ratio (MER) is a measure of modulation quality performance for digital television. It is measured from the coupling RF test port at the transmitter or

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even measured from the broadcast reception. For quadrature amplitude modulation (QAM) transmission, the measured signal is in the form of a constellation diagram. The MER measurements can be shown, such as the dot amplitude and phase error in the constellation diagram. The vector error of the IQ signal is the value obtained from the comparison of the measurement of the ideal IQ signal and error IQ signal, given the sum of the squares of the ideal signal vector size (I_j, Q_j) divided by the sum of the squares of the error vector (I_j, Q_j). The MER has units of dB. Consequently, the MER is equal to the ratio of the mean square (RMS) between the reference signal and the error vector, as calculated from the following equation

$$MER[dB] = 10\log\sum_{j=1}^{N}\left(I_j^2 + Q_j^2\right) - 10\log\sum_{j=1}^{N}\left(\delta I_j^2 + \delta Q_j^2\right) \quad (1)$$

The correlation of the typical strength of the DVB-T2 signal for SFN transmission during normal signal strength 18 and minimum signal strength can be verified by a correlation coefficient. Knowing the correlation makes it possible to understand how the two signal strengths affect the same reception or difference. If we have serial data of the measurements, X and Y can be written as x_i and y_i, where i = 1; 2; ...; n for which the sample correlation coefficient can be used to estimate the Pearson correlation r between X and Y , which is the sample correlation. The coefficient can be given as

$$r_{xy} = \frac{\sum_{i=1}^{n}\left(x_i - \overline{x}\right)\left(y_i - \overline{y}\right)}{\sqrt{\sum_{i=1}^{n}\left(x_i - \overline{x}\right)^2 \sum_{i=1}^{n}\left(y_i - \overline{y}\right)^2}} \quad (2)$$

where $\overline{x}$ and $\overline{y}$ are the mean of the random variables of X and Y , and sx and sy are the standard deviations of the variables X and Y .

B. Single Frequency Network

SFN is the transmission of the same data at the same frequency and time on multiple transmitters. Consequently, the receiver will receive the signal from several transmitters. However, the signal looks like multipath signals. The receiver can receive the signal successfully when all of the signals from all transmitters arrive at the same time within the GI range. In the DVB-T2 system, the GI can be appropriately configured to coverage area suitable design of SFN network. However, it may still be necessary to analyze the performance to achieve the best performance. The received signal of a SFN is shown in Figure 1. In DVB-T2, there are several setting modulation parameters to select appropriate multipath protection. The field test of the DVB-T2 modulation parameter is presented in [15]. Choosing the right GI will solve the ISI and multipath problem because the multiple carrier has a fixed value per symbol. The value of the reflections that are shorter than the GI indicates the error of the pilot frequency response. If the pilot signal that inserted in the symbol fails, the receiver cannot estimate and correct the frequency response. If the multipath is longer than the GI, then the received signal will suffer ISI. The gap between the carrier

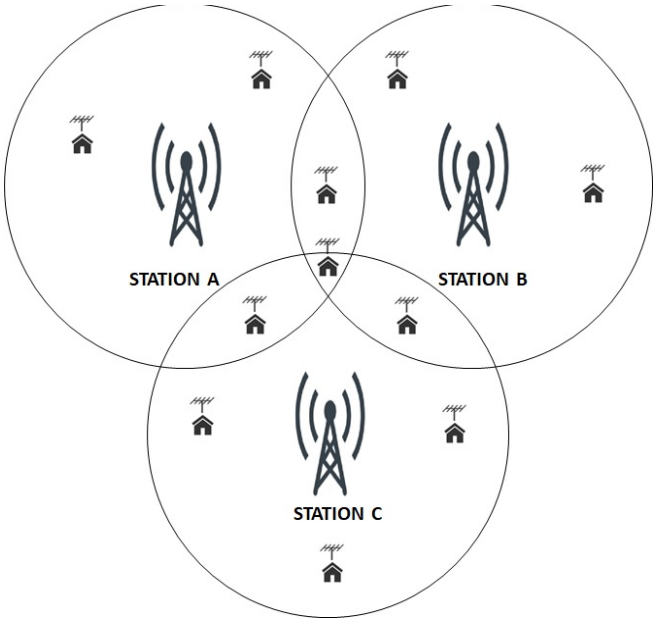

Fig. 1. Single Frequency Network structure

prevents the Doppler shift effect caused by ISI. If the Doppler shift is very small compared to spacing, then the signal will be fairly immune from ISI. The symbol period and the number of frequencies can be adjusted according to the DVB-T2 standard and GI depending on this parameter setting. Consequently, the implementation of the SFN is many different settings. The best reception of DVB-T2 occurs when the appropriate equalization value is chosen. The signal delay time within the GI.

III. DVB-T2 Experimental System

The experimental equipment is shown in Figure 3. The MPEG 2 Transport Stream (TS) is derived from the MUX provider. This experiment uses TS signals from the MCOT MUX provider. MCOT is one of the four MUX providers in Thailand. TS signals are sent to the DVB-S2 modulator from the head-end center and sent to satellites for distribution to the DTV network. Integrated receiver/decoder (IRD) receivers receive signals from the head-end center via satellites. The received signal output is the TS signal, which is sent via the asynchronous serial interface (ASI) port both output ports of the IRD. The signal from the IRD is the modulator interface signal (T2-MI). This T2-MI signal of DVB-T2 is based on DVB Document A136. The modulation parameter of the T2-MI signals is shown in Table 1. T2-MI signals are sent to both DVB-T2 transmitters. The minimum signal requirement threshold for the SFN was tested using the modulation parameters broadcast in Thailand. Digital television terrestrial broadcasting in Thailand is regulated by the National Broadcasting and Telecommunications Commission (NBTC), which assigns parameters for broadcast. The frequency range in Thailand is 510 MHz to 790 MHz. This experiment uses a frequency of514 MHz for transmission. The maximum bit rate

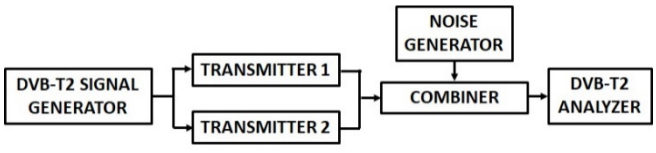

Fig. 2. Block diagram of DVB-T2 Ecperiment

TABLE I. EXPERIMENTAL PARAMETERS OF DVB-T2

Parameter	Values
Operate Frequency	514 MHz
Operate Bandwidth	8 MHz
Pilot Pattern	PP2
Guard Interval	19/128
Constellation	64 QAM
Constellation Rotation Mode	On
Code Rate	3/5

that can be sent with this parameter is 27.4 Mbps. One multiplexer (MUX) can broadcast 8 channels, divided into six standard definition (SD) and two high definition (HD) channels. The transmission rate of each data channel is approximately 1.28-1.6 Mbps for SD and 5.92-7.2 for HD. The change in the data transfer rate depends on the performance of the parameter modulation encoding.

IV. EXPERIMENTAL RESULTS

The result from the DVB-T2 signal analyzer is shown in MER in Figure 3 shows the results of the simulation experiments based on the laboratory measurements to find the received signal strength compared with the delay time between two transmitters for SFN transmission. At 0 µs of the delay time in GI, the degradation of the received signal is approximately 12 dB from 87 dBµV of approximately signal strength. The PRM is used to display the predictive value of the received signal based on the experiment. The minimum threshold requirement of the DVB-T2 received signal in the SFN system is roughly 66 dBµV. The degradation rate is also significant during the delay period of 0 µs. The degradation is reduced to approximately 3 dB compared to the delay time in other time periods. The correlation coefficient was used to compare the correlation between the normal strength and the minimum received signal required threshold strength 1 and was 0.6266, which is considered to be in the same direction but not exactly the same. This experimental test of the delay times between 0 µs and 270 µs covers the delay time of the GI. The GI of the SFN parameter setting for this experiment is 266 µs.

Figure 4 shows the MER of the received signal at the normal strength is approximately 17 dB, which, at the delay time of 0 µs, requires an increase of the MER by approximately 6 dB because at this delay time, 6 the effect of the 0 dB echo causes interference and degradation. For the MER at the minimum received signal threshold, the average value for all of the delay times in the GI is approximately 8 dB, and a higher MER at a 8 delay time of 0 µs of approximately 6 dB is required. The correlation coeffcient is 0.6973. The correlation is 9 in the same direction for the normal signal and the minimum signal required. the MER value which represents the quality and efficiency of the received signal at the receiver. The minimum MER that can be received at approximately 8 dB throughout within GI time. At 0 µs, the signal is subject to severe fluctuations because of the effect of 0 dB echo, it requires a very high MER to the received signal success, so the receiver required the MER at approximately 13.5 dB, which is higher than the average of 5.5 dB for the success of signal reception.

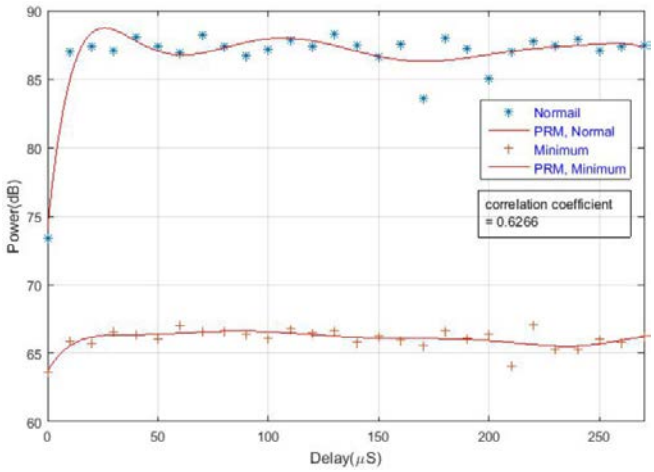

Fig. 3. Comparison of DVB-T2 transmission between Received Power and Delay

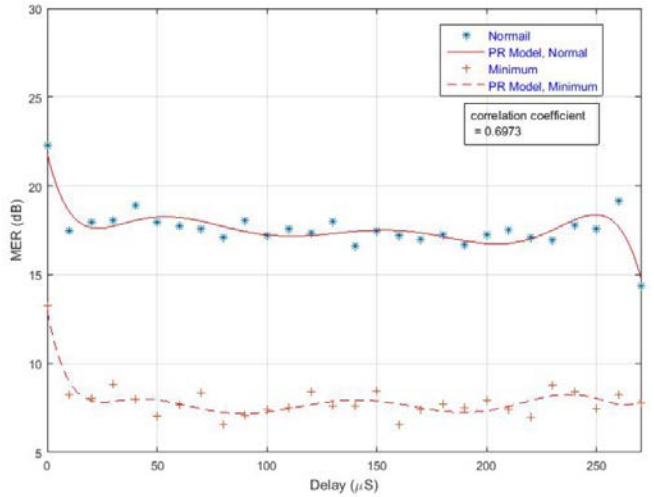

Fig. 4. Comparison of DVB-T2 transmission gain between MER and Delay

V. CONCLUSIONS

In this paper, present experiment in the laboratory using real transmitters in the broadcast. We experiment with the SFN transmission on the SISO mode of DVB-T2. This experiment has shown the effect of receiving signal delays between two SFN transmitters throughout the GI range of 0 µS to 270 µs in large numbers to ensure reliability. Every 10 µs of the delay time is repeatedly measured 20 times, dividing the delay time into 27 ranges from 0 µs to 270 µs. We measured both the normal reception and minimum receiving signal. The measurement data were the MER. The total number of measurements was 5,400 times. The received signal threshold at the QEF criteria throughout the delay time within the GI corresponded to the received signal power is 66.03 dB, MER is 7.93 dB. Since the experiment was a closed system, no multipath and external noise existed, the measurement channel is equivalent to a Rician channel. The limitations of this experiment are used modulation parameters for broadcasting in Thailand only. The evaluation of SFN specifically analyzes the received signal power from two transmitters that broadcast to the receiver at the equal of signal strength level. This scenario is the most likely to affect the received SFN signal. In reality, the signals from both transmitters may reach the receiver with different signal strengths. Even in the real propagation channel, the received

signal will be affected by the environment and terrain, which may be different from these results. However, the experimental results can be used as a guide for network planning design and network efficiency improvement for SFN broadcasting, as well as for designing a gap filler system.

REFERENCES

[1] I. Eizmendi, M. Velez, D. Gomez-Barquero, J. Morgade, V. Baena-Lecuyer, M. Slimani, and J. Zoellner, "DVB-T2: The Second Generation of Terrestrial Digital Video Broadcasting System", IEEE Transactions on Broadcasting, Volume: 60, Issue: 2, pp. 258 - 271, June 2014.

[2] A. Mattsson, "Single frequency networks in DTV", IEEE Transactions on Broadcasting , Volume: 51, Issue: 4, pp. 413 - 422, 12 Dec. 2005.

[3] I. Eizmendi I, G. Prieto, G. Berjon-Eriz, I. Landa, and M. Velez, "Empirical DVB-T2 Thresholds for Fixed Reception", IEEE Transactions on Broadcasting, Volume: 59, Issue: 2, pp. 306 - 316, June 2013.

[4] M.V. Guerra, C.V.R. Ron, L. da Silva Mello, "Experimental characterization of a SFN digital broadcast channel", IEEE Latin-America Conference on Communications, 7-9 November 2012

[5] D. Plets, W. Joseph, P. Angueira, J.A. Arenas, L. Verloock, and L. Martens, "On the Methodology for Calculating SFN Gain in Digital Broadcast Systems", IEEE Transactions on Broadcasting, Volume: 56, Issue: 3, pp. 331 - 339, Dec. 2010.

[6] E. Kroon and J.T.J. Penttinen, "SFN gain estimations based on frequency response", 2010 IEEE International Symposium on Broadband Multimedia Systems and Broadcasting (BMSB), pp. 1 - 6, 24 - 26 March 2010.

[7] I. Udroiu, I. Tache, N. Angelescu, and I. Caciula, "The Analyze of MER Variation Concerning the Quality of Transmission for DVB-T Signals", WSEAS International Conference on DATA NETWORKS, COMMUNICATIONS, COMPUTERS, pp. 169-172, 7-9 November 2009.

[8] M. Tomos, C. Tanougast, A. Dandache, P. Bertillon, and P. Kasser, "Experimental performance of mobile DVB-T2 in SFN and distributed MISO network", 2012 19th International Conference on Telecommunications (ICT), 23 - 25 April 2012.

[9] P. Ladistav and T. Kratochvil, "In
uence of IQ-errors on DVB-T2 performance and its suppression by different methods", 2017 IEEE International Symposium on Broadband Multimedia Systems and Broadcasting (BMSB); 7 - 9 June 2017.

RECOGNITION OF YOGA POSES USING EMG SIGNAL FROM LOWER LIMB MUSCLES

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***Abstract*—Yoga exercises can lead to an increase in muscle strength, muscular and cardio-respiratory endurance, the range of movement and general flexibility. However, many times of the people often are not sure how to exercise posture correctly. It can do not benefit from the best exercise and may cause injury. This paper presents a prediction model for the correctness of posture during yoga exercise using machine learning techniques. If the wrong muscle groups used, the model will not predict correctly. This paper used the Electromyography (EMG) signal for analyzing the motion of four lower-limb muscles during yoga exercise. The raw EMG was rectified and filtered using a bandpass filter to the envelope of the EMG. The accuracy of the classification EMG data is 92.54 percent. In conclusion, EMG data during exercise of four lower-limb muscles were unique to implement in yoga application in the future.**

Keywords—Electromyography, Yoga, lower-limb muscles, machine learning.

I. INTRODUCTION

Yoga is a group of ancient India based physical, mental and spiritual practices or disciplines. There is a wide range of schools, practices, and goals for yoga. Regular yoga practice helps to create natural harmony and functional balance between different organ systems, increasing health and a sense of wellness-being. Yoga exercises can lead to an increase in muscle strength, muscular and cardio-respiratory endurance, the range of movement and general flexibility [1]. However, it is essential to make the correct choice and the sequence of yoga asanas (exercises) for the prevention of exercise injury. It can happen for several reasons. Improper postures or incorrect training ways are the most common types of injury [2].

According to the problems mentioned above, researchers present a method to check the accuracy of the posture from lower-limb muscles. EMG is widely used in various fields to investigate the muscular activities. EMG is an electrical activity that occurs in the muscle layer during active motion. This EMG signal used for many purposes including for the diagnosis of muscle disease, studying the biomechanics of human movement or other muscle diseases [3].

II. RELATED WORK

A. Electromyography

Electromyography is an electrodiagnostic medical technique used to evaluate and record skeletal muscle electrical activity [1]. EMG is used to create a record called an electromyogram using an instrument called electromyography. EMG detects the electrical power of muscle cells [2] when these cells are electrically or neurologically activated. Signals can be analyzed to identify medical abnormalities, level of activation or order of recruitment, or to examine the biomechanics of human or animal transport.

Two popular methods of getting EMG are well known as invasive EMG technique (electrode inserted EMG system) and non-invasive EMG technique (surface EMG system). As surface EMG system is more accessible in the application, this technique widely used in getting the muscle information. However, the reliability of detection in this type of EMG technique depends on the placement of its electrode. The power line interference also should be reduced, and the artifacts avoided. Implementation modalities and performance of electrode grids should be progressively improved. For dry electrode systems, the conductive gel employed for enhancing time-stability and reducing artifacts [4]. In the study part of the EMG sensor, Michael et al. [5] presented a performance test of the modern touch control device called MYO armband to compare with medical Signal Measurement (BIOPAC) with EMG.

Sakamoto et al. [7] presented EMG analysis from lower-limb muscles for integrity analysis of knee joint. This research selected related muscular co-activities with knee flexor-extensor actions for analysis. The result shows voltage amplitudes of EMG in reversed proportional with increasing ages.

B. Machine learning

Machine learning is a subset of computer science artificial intelligence which often uses statistical techniques to enable computers to learn with data without being explicitly programmed. Machine learning is a method used in the field of data analysis to develop complex models and algorithms that can be predicted.

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In [5] presented how to combine multi-sensor for new robotic control for humans using a physical feature called the BioSleeve. BioSleeve is a flexible bandage-like wearable device on the user's arm, it combines 16 dry contacts EMG and the Inertial Measurement Unit (IMU) sensor on the user's arm and hand to the Support Vector Machine (SVM) classification hand and arm. The results of the classification are 96 percent accurate.

III. THE PROPOSED METHOD

The proposed system architecture was divided into five parts: (1) muscles selection; (2) EMG acquisition; (3) data preparation; (4) classification; and (5) evaluation, as shown in Figure 1.

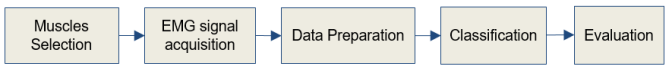


Figure 1. The proposed system architecture.

The following example is the envelope of EMG of the right leg muscles for a single subject. Figure 2 shows the pattern of EMG during one yoga posture cycle.

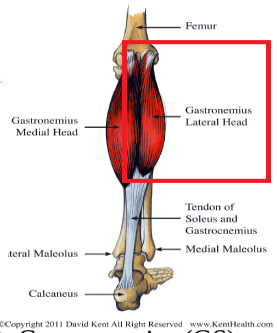
A. *Muscles Selection*

Selection of the lower-limb muscles was based on literature review [7], we were chosen EMG data of 8 lower-limb muscles during stretching (*Rectus Femoris, Vastus Lateralis, Bicep Femoris, Gastrocnemius Lateralis*), as shown in Figure 2.

(a).Rectus Femoris (RF)

(b).Vastus Lateralis (VL)

(c). Bicep Femoris (BF)



(d). Gastrocnemius (GS)

Figure 2. Selection of lower limb muscle right side [13].

We have selected four yoga postures from beginner posture [2], which consists of Triangle Pose, Warrior I, Warrior II and Tree Pose.

(a). Tree pose

(b). Triangle pose

(c). Warrior I

(d). Warrior II

Figure 3. Yoga postures.

B. *EMG signal acquisition*

1) *MyoWare Muscle Sensor*

MyoWare (AT-04-001) which is manufactured by Advancer Technologies company was chosen for this specific project. The MyoWare Muscle Sensor is a prefabricated PCB that contains the necessary hardware to translate small variations in voltage in a muscle into analog values that can be read by a microcontroller. MyoWare is used to measure the muscle activation via electric potential, referred to as surface electromyography (sEMG), that has traditionally been used for medical research and diagnosis of neuromuscular disorders. With the advent of ever more powerful microcontrollers and integrated circuits, however, EMG sensors have gone into prosthetics, robotics, and other control systems.

The electrode material forms the contact layer with the skin needs to realize an excellent electrode-skin contact. We were chosen Myoware sensor for EMG data acquisition by EMG surface electrode. In this research, we were used disposable Ag/AgCl and circular (oval) electrodes shape and size is more 24 mm to be used for sEMG recordings. These electrodes provide a stable transition with relatively low noise.

Figure 4. MyoWare Muscle Sensors and qualification [14].

In part of EMG hardware, we used Myoware muscle sensor for according to the objective of the present work. This type of surface EMG sensors is more natural in implementation and specially designed for microcontrollers. The Myoware sensor has a built-in electrical circuit for filtered and rectified electrical activity of a muscle. In this paper, we corrected EMG from the filtered and rectified channel, as shown in Figure 5.

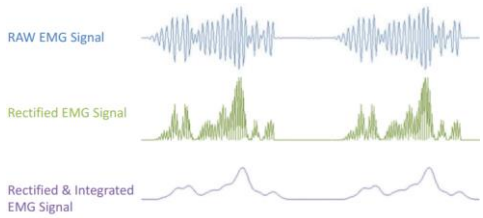


Figure 5. MyoWare Muscle Sensor and qualification [14].

2) *Embedded system*

In part of the hardware for data acquisition, we used Lattepanda for connected filtered and rectified EMG from 8 Myoware muscle sensor on lower-limb muscles and develop software for data acquisition, as shown in Figure 6. Lattepanda is a complete minicomputer integrated with Arduino running full version Windows 10. The EMG value for data acquisition has 0–1023 from the analog-read library of Arduino. Arduino is an open-source electronics platform based on hardware and software that is easy to use.

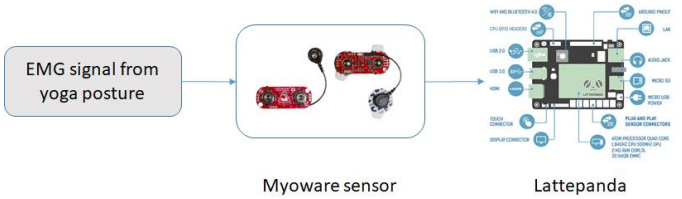
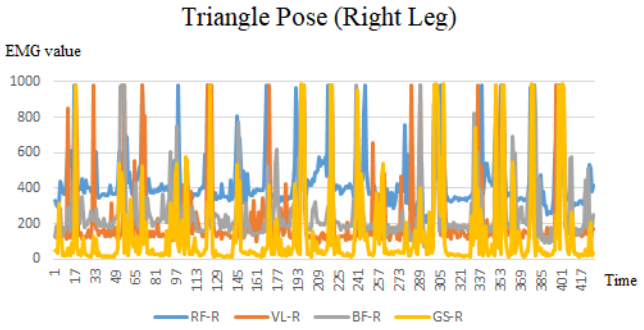


Figure 6. Hardware for data acquisition [15].

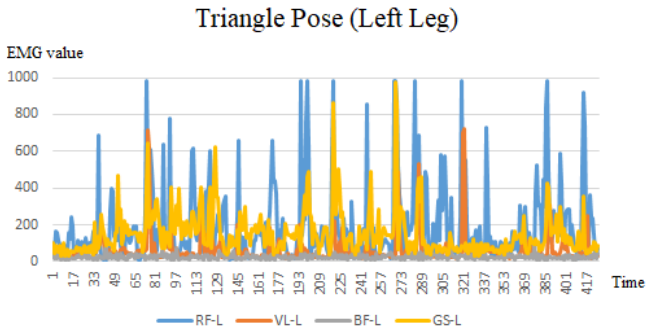
C. *Data preparation*

1) Data collection

We were setup Myoware sensor and a disposable electrode at an activity of the RF, VL, BF and GS muscles from 8 subjects (4 males and 4 females), the electrode placement for the muscles set up at the most distal palpable portion of the selected muscle while the muscle was being contracted on both lower-limb and prepared the skin by cleansing and shaving (if necessary) of each subject with isopropyl alcohol. EMG activity was recorded as shown example data of triangle pose in Figure 7. We were recorded for 10 seconds per time during 15 each trial, and 30-second rest was provided between tests.



(a) EMG value from during triangle poses by right leg.

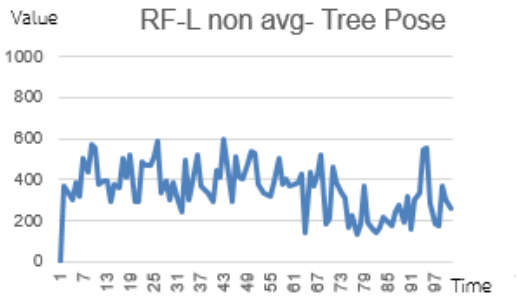


(b) EMG value from during triangle poses by left leg.

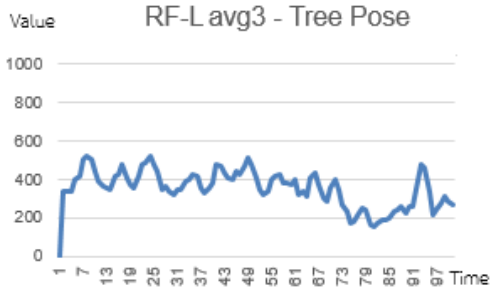
Figure 7. EMG signal of lower muscle from triangle pose.

2) Data Preparation

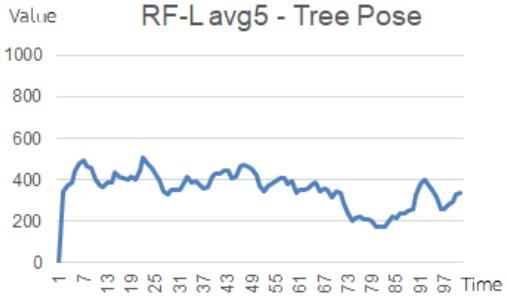
After EMG data were collected. In the data preparation process, we were used mean value theorem to average our EMG data by three and five number of terms. We have used EMG data with five number of terms (Avg 5) and send our data to the classification process.



(a) Non-average EMG signal of RF-L muscle.



(b) Average ever 3 value of RF-L muscles EMG signal



(c) Average ever 5 value of RF-L muscles EMG signal

Figure 8. Non-average and average EMG signal data of RF from tree pose.

D. Classification

In this research, we have chosen two classifiers, which consists of Decision Tree and Sequential minimal optimization (SMO). Because we knew our feature space would be small, and the kernel that the *SMO* uses will increase the dimensionality of the feature space. Decision Tree is commonly used in operational research, particularly in decision analysis, to identify a strategy that is most likely to achieve a goal but is also a popular machine learning tool [11].

IV. THE EXPERIMENTAL RESULT

In order to address the problem of yoga poses, we were examined on 18,466 records, which are EMG data with five number of terms from lower-limb muscles. Machine learning software, Weka program, is employed to construct the *DT* (*J48 and Random forest*) and *SMO*. We were used 10-fold cross validation for evaluation as shown in Table I.

TABLE I. CLASSIFICATION RESULTS

Classifiers	Correction Rates (%)	Error rates (%)
SMO	54.02	45.98
J48	85.25	14.75
Random forest	**92.54**	**7.46**

Confusion matrix

The confusion matrix of classification results is shown in Table II-VI.

TABLE II. RESULTS OF SMO CLASSIFIER.

	A	B	C	D	Classified as
	1660	1103	470	1043	A = tree pose
	251	2466	442	873	B = triangle pose
	167	830	1676	1037	C = warrior I pose
	347	1382	546	4173	D = warrior II pose

TABLE III. RESULTS OF J48 CLASSIFIER.

	A	B	C	D	Classified as
	3508	264	182	322	A = tree pose
	213	3429	168	222	B = triangle pose
	180	172	3094	264	C = warrior I pose
	292	195	250	5711	D = warrior II pose

TABLE IV. RESULTS OF RANDOM FOREST CLASSIFIER.

	A	B	C	D	Classified as
	3768	175	124	209	A = tree pose
	72	3762	87	111	B = triangle pose
	68	86	3391	165	C = warrior I pose
	78	95	108	6167	D = warrior II pose

The primary objective of this research used EMG to characterize the muscle activity of RF, VL, BF, and GS during four yoga exercise variations: Tree Pose, Triangle Pose, Warrior I and Warrior II. The results of this research confirm that yoga exercise and result in significant differences in EMG activity of the RF, VL, BF, and GS muscles.

V. CONCLUSION

This paper presented a prediction model for the correctness of posture during yoga exercise using machine learning techniques. The EMG signals were used to analyze the motion of four lower-limb muscles during yoga exercise. The way to approach for extracting the EMG signals and applying *J48*, *Random forest* and *SMO* for classifying was a quietly sophisticated method in studying the EMG pattern. The Random forest classifier was able to achieve 92.54 percent

classification accuracy. In future work, more participants should be involved in this research so that the classification process can achieve a better result and better accuracy.

REFERENCES

[1] David Gordon (2011), Yoga, Brief History of an Idea.

[2] S. Patil, A. Pawar, A. Peshave, A. N. Ansari, and A. Navada, “Yoga tutor visualization and analysis using SURF algorithm,” in Proc. IEEE Control and System Graduate Research Colloquium, 43-46, 2011

[3] Carlo I. De Luca. (1997). The Use of Surface Electromyography in Biomechanics.

[4] Direk Sueaseenak, Chainarong Khawdee, Nednapa Pakornsirikul, Chamaiporn Sukjamsri. (2017). A Performance of Modern Gesture Control Device with Application in Pattern Classification., 2017

[5] Michael T. Wolf, Christopher Assad, Matthew T. Vernacchia, Joshua Fromm, and Henna L. (2013). Gesture-Based Robot Control with Variable Autonomy from the JPL BioSleeve., 2013

[6] Guan-Chun Luh, Yi-Hsiang Ma, Chien-Jung Yen and Heng-An Lin. (2016). Muscle-gesture robot hand control based on sEMG signals with wavelet transform features and neural network classifier.,2016

[7] Sakamoto, Md. T. I. Khan and T. Kurita. (2015). EMG signals in co-activations of lower limb muscles for knee joint analysis. 2015

[8] Darma Setiawan Putra, Adhi Dharma Wibawa and Mauridhi Hery Purnomo (2016). Classification of EMG during walking using principal component analysis and learning vector quantization for biometrics study.

[9] Stephen P. Good. (2013). Surface Electromyography Signal Processing and Classification Techniques., 2013

[10] Supposedly paraphrased from: Samuel, Arthur (1959). "Some Studies in Machine Learning Using the Game of Checkers". IBM Journal of Research and Development. 3 (3): 210–229. doi:10.1147/rd.33.0210

[11] "Machine Learning: What it is and why it matters". www.sas.com. Retrieved 2016-03-29.

[12] https://superstarfloraluk.com/4736123-Biceps-Femoris-Muscle.html

[13] https://www.kenhub.com/en/library/anatomy/the-quadriceps-femoris-muscle

[14] https://www.sparkfun.com/products/13723

[15] http://www.lattepanda.com

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Classification of Gait Pattern with Wearable Sensing Data

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***Abstract*—Human gaits are the various ways in which a human can move, either naturally or as a result of specialized activities. In the recent years, classification o f g ait p attern has been studied to explore and understand human behaviors with different types of data: image data, floor s ensing d ata and wearable sensing data. This paper studies the performance of the wearable sensors from smartphones in gait classification problem. We present ensemble learning-based approaches to improve accuracies of the gait pattern classification. Moreover, we evaluate their roles on two body positions: arm position and waist position, while classifying three different gait patterns: walking, walking upstairs, and walking downstairs. The experimental results show that the ensemble learning-based approaches can improve the classification p erformance f or u sing t he wearable sensing data with an accuracy of 98.5333 percent.**

***Keywords*—gait pattern, classification, w earable s ensing data, ensemble learning**

I. Introduction

For years, analysis of human gait is an important and challenging research topic on both of medical field and engineering field [1]. O n t he m edical fi eld, ga it pa ttern ex pose th e key information about quality and healthy of persons individually. The gait information clinically enhances the diagnostic and treatment process. For engineering research field, classification of gait pattern has been studied to explore and understand human behaviors with different types of data: image data, floor sensing data and wearable sensing data [2].

Contemporary, smartphones mostly incorporate many diverse and powerful embedded built-in sensors such as accelerometers, temperature sensors, gyroscopes, and so forth [3]. One of the most recent, challenging, and appealing applications in both fall detection [4] and activity classification [5] consists of sensing human body motion using smartphones to gather data of movement about people's activities. The use of smartphones with the sensors is an alternative solution for the problems. Consequently, some works aiming to understand human behavior using smartphones have been proposed: for instance, in [6], one of the first approaches to exploit an Android smartphone for activity in daily living (ADL) classification employing its embedded accelerometers. Extended research studies have also been presented in [7], [8]. Improvements are still expected in topics such as multi-sensor fusion for better classification performance with standardization of performance evaluation metrics [9].

To understand human gait, wearable sensing data from smartphones emerge as a preferable research option, as the smartphones are portable, widespread, and relatively easy to operate [10]. Gait analysis mostly studied draw upon wearable sensing data from accelerometers and gyroscopes, because they can assess gait patterns with a reliability. Until now, studies of gait pattern have exclusively examined a smartphone's accelerometer and gyroscope [11].

In recent years, various machine leaning algorithms have been used to build gait pattern classification and ADL classification systems to be applicable in automatic healthcare systems [12] such as the support vector machine [13], back propagation neural network [14], decision tree [15], and more. Recently, combinations of multiple learning, which are called ensemble learning, have become an alternative machine learning paradigm. Many research studies have investigated and shown that ensemble learning can achieve much better classification performance than a single learning model [16-19]. Therefore, we assume that ensemble learning will improve the performance of the gait pattern classification problem.

In this paper, we focus on the gait pattern classification problem. We study two ensemble-based approaches: majority voting and stacking, for solving the problem from wearable sensing data obtained from smartphones at the arm position and waist position.

The rest of this paper is organized as follows: Section II presents the proposed framework of gait pattern classification. Section III describes ensemble learning to solve the problem. We describe an experimental design and show experimental results in Section IV. Finally, we give our conclusion of the paper in Section V.

II. The Proposed Framework

The proposed framework of gait pattern classification consists of three stages: data acquisition, feature extraction, and classification by machine learning. These stages must be incorporated with a classification system, using a generic model to describe the system flow as indicated Fig. 1.

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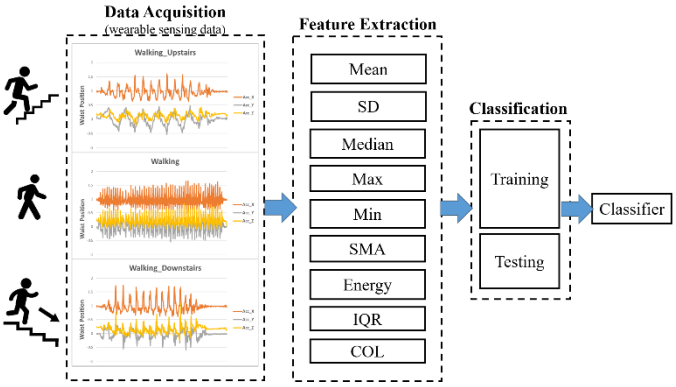

Fig. 1: The proposed framework of gait pattern classification

The details of each stage of the process of gait pattern classification which is proposed by this study are described as set out below:

A. Data Acquisitions

This study used data obtained from ten participants aged 19–23. The participants wore two monitoring devices, one at the arm and one at the waist, and then carried out the three gait patterns that are walking, walking upstairs, and walking downstairs.

The data were gathered using an iPhone8Plus which used iOS version 12.1.2. The study used the SensorLog smartphone application which is available from the App Store. The data are collected from the sensors of the smartphone at a sample rate of 30 Hz, and comprise both accelerometer data and gyroscope data. Ten sample values were recorded for each of the three gait patterns by each participant for each of the x, y,and z directions on the Cartesian axes for accelerometer and gyroscope data. The total dataset therefore comprises 300 sample values for participant activity. Fig. 2 and Fig. 3 present some examples of the accelerometer and gyroscope data.

B. Feature Extraction

It is not possible to complete the classification step directly using the accelerometer and gyroscope data. It is first necessary to perform feature extraction as a means of pre-processing the data. The various feature types are thus extracted from the raw data provided by the sensors. The creation of suitable feature sets serves to maximize the efficiency of the machine learning model.

If S_t denotes the fragment of data in a data window, then S_i indicates the i_{th} data item acquired from the gyroscope or accelerometer sensors. Features extracted are the mean value, standard derivation, median absolute deviation, maximum value, minimum value, signal magnitude area, energy measure, interquartile range, and correlation between axes. The nine features function used in this paper is calculated using the formulas shown in Table I.

C. Machine Learning and Classification

The classification of human gait patterns is often a problem addressed via supervised learning; the most widely used models which apply supervised learning are decision tree classifiers, and multilayer perceptrons, and support vector machines. For some gait pattern, one classifier type might be more effective than another; for instance, more complex actions such as ascending or descending stairs can be more readily classified by multilayer perceptron models [20]. In contrast, the decision tree provides the best outcomes for detecting simple actions including standing or sitting [21].

1) Decision Tree (DT): Decision trees are the most common classification approach [22]. They can determine the un-

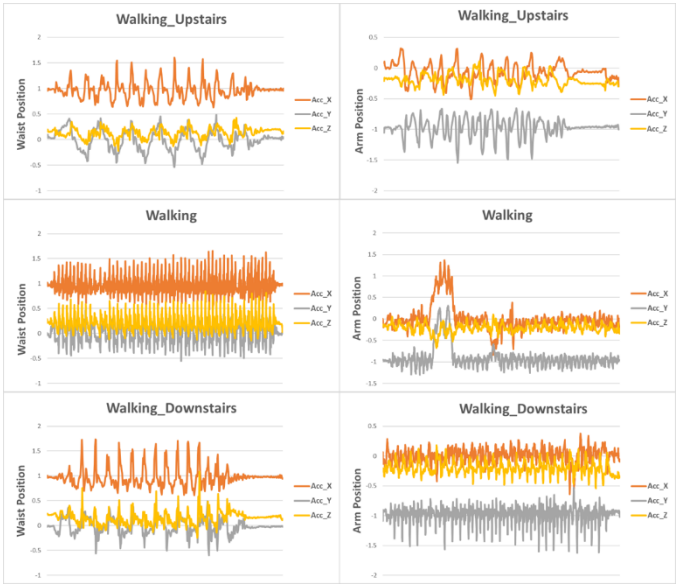

Fig. 2: An example of accelerometer data of three gait patterns

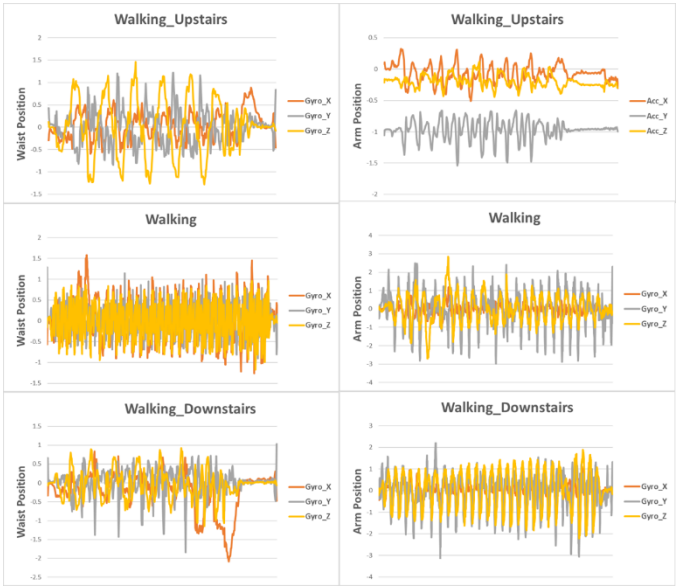

Fig. 3: An example of gyroscope data of three gait patterns

TABLE I: Types of statistical features [4]

Feature	Formula
Mean value	$mean = \frac{1}{N}\sum_{i=1}^{N} S_i$
Standard deviation	$std = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(S_i - mean)^2}$
Median absolute deviation	$mad = median(\lvert S_i - mean(S_t)\rvert)$
Maximum value	$max = MAX(S_t)$
Minimum value	$min = MIN(S_t)$
Signal magnitude	$sma_{xyz} = \frac{1}{3}\left\{\sum_{j=1}^{N}\lvert S_{xi}\rvert + \sum_{j=1}^{N}\lvert S_{yi}\rvert + \sum_{j=1}^{N}\lvert S_{zi}\rvert\right\}$
Energy measure	$energy = \frac{1}{N}\sum_{i=1}^{N} S_i^2$
Interquartile range	$iqt = Q_3(S_t) - Q_1(S_t)$
Correlation between axis	$c_{xy} = \frac{\sum_{i=1}^{N}(S_{xi}-mean(S_x))(S_{yi}-mean(S_y))}{\sqrt{\sum_{i=1}^{N}(S_{xi}-mean(S_x))^2)\sum_{i=1}^{N}(S_{yi}-mean(S_y))^2}}$

derlying patterns which exist by setting one attribute to be the root, and then considering other attributes to be the branches from which the leaves will represent particular concepts, such as the intuitive cognition of other information. A decision tree will be deemed comprehensible if its attributes are rational.

2) Multilayer perceptron (MLP): Neural networks are tools which rely upon virtual intelligence tool to assist the human mind in carrying out analyses and evaluating the outcomes [23]. The multilayer neural network enables the machine learning algorithm to use its capacity for generalization, non-linear mapping, and self-organization to generate reasonable responses when receiving novel inputs which it has never previously experienced.

Its capacity for generalization creates the potential to train the network using example sets comprising acceptable input-output pairs, and to subsequently derive excellent results when the network is trained using exposure to every possible input-output pair.

3) Support Vector Machine (SVM): Support vector machines were first used to address problems of two-class pattern recognition [24]. The underlying principle involves establishing a hyperplane which can distinguish between the positive and negative cases, all the while seeking maximization of the smallest margin. This technique offers two major strengths. Firstly, it is not necessary to employ feature selection, and secondly, the parameters need no fine tuning.

III. Ensemble Learning for Gait Pattern Classification

During the course of this research, experimentation was conducted using each of the various approaches to machine learning. The basic machine learning model was evaluated along with the ensemble machine learning model in terms of their performance in the classification of gait pattern. The basic machine learning models which were used included, the decision tree, the multilayer perceptron and the support vector machine, all of which were created to handle classification of gait pattern. Using a combination of the basic machines allows greater accuracy to be achieved. This approach is better known as ensemble learning. Previous research has shown that ensemble learning models generate improved accuracy when compared to single-approach models [25]. Therefore, this study proposes two different ensemble learning algorithms to address the gait pattern classification problem that are majority voting and stacking. The ensemble methods used involve combining the three basic models described: DT, MLP, and SVM.

1) Majority voting (MV): MV is the most widely used ensemble technique, and offers the advantage of proceeding with no further parameter turing after construction of the basic classifiers [26]. The formula given below is applied to calculate *c(x)* which is linked to an unlabeled gait pattern *x*:

$$c(x) = arg \max_{c_i \in d(y)} \left(\sum_k v(y_k(x), c_i) \right) \tag{1}$$

where

x = the *k*th basic machine learning model,
d(y) = the domain of the class label *y*,
$y_k(x)$ = the class label indicating the gait pattern,
$v(y_k(x), c_i)$ = the indicator function defined as follows:

$$v(y_k(x), c_i) = \begin{cases} 1 & \text{if } y_k(x) = c_i \\ 0 & \text{if } y_k(x) \neq c_i \end{cases} \tag{2}$$

2) Stacking (ST): ST uses a meta-classifier in the ensemble method in order to combine all the classification results which are generated by the various basic classifiers in order to formulate the final classification [27]. The stacking approach is based on a double layered frame structure in which numerous base classifiers are obtained from the training dataset in the layer

designated level-0. The meta-classifier in level-1 then takes all of these individual classifiers to form a decision tree (ST-DT), a multilayer perceptron (ST-MLP), or a support vector machine (ST-SVM). Fig. 4 presents the stacking illustration which shows the double layered structure of the ensemble learning method applied in this study to address the problem of gait pattern classification.

IV. Experimental Results

This research use a WEKA machine learning tool (Waikato Environment for Knowledge Analysis) to assess the ensemble learning approaches. The computer used in working the data analysis was equipped with an i5-8250U CPU, 4 GB memory, and was running Microsoft Windows 10. The experimentation involved the three base classifiers (DT, MLP and SVM) and the four ensemble classifiers (MV, ST-DT, ST-MLP and ST-SVM). The gait pattern dataset is collected from the ten participants indicating their classification performance of the classifiers. Evaluation was performed using a ten-fold cross-validation method. The seven used classifiers, as shown in Table 2 were evaluated. The abbreviations used in the table to represent each classifier are used in the sections which follow.

The accuracy in the experiment can be measured in order to evaluate how well human gait pattern can be classified. The accuracy values can be mathematically computed as follows:

$$Accuracy = \frac{TP + TN}{TP + FP + TN + FN} \tag{3}$$

where

TP = the true positive,
TN = the true negative,
FP = the false positive,
FN = the false negative.

The study used the wearable sensing data from smartphones located at the arm and waist in order to classify each of the three different gait patterns. The classification performance of the gait patterns was evaluated in combination with the seven classifiers in Table II; experimental results were obtained and shown in Table III and Table IV.

Table III summarizes the accuracy levels achieved in classification performance at the waist position. From this table it is seen that ST-SVM has the highest classification performance

TABLE II: Seven classifiers used in this research

Type of Classifiers	WEKA-version	Notation
Decision trees	J48	DT
Neural networks	MulitlayerPerceptron	MLP
Support vector machines	LibSVM	SVM
Majority voting	Vote	MV
Stacking	Stacking with J48	ST-DT
Stacking	Stacking with MLP	ST-MLP
Stacking	Stacking with SVM	ST-SVM

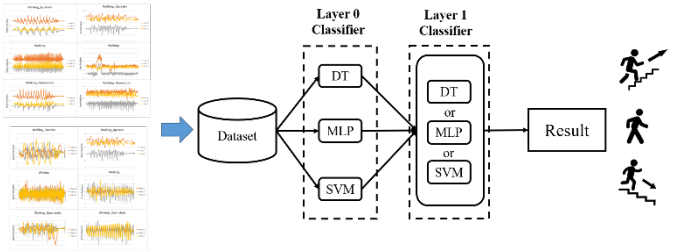

Fig. 4: Two-layer stacking diagram proposed in this work

for using both accelerometer data and gyroscope data with an accuracy of 98.1167 percent.

Table IV summarizes the accuracy of the classifiers using the gait pattern dataset from the smartphone sensors positioned at the arm. It can be seen that the performance is high for all seven classifiers, but the data in the table also reveal where the improvements in performance can be obtained through comparison of the different combinations. It is apparent that ST-SVM offers the optimal classification performance when the data from accelerometer and gyroscope are combined, achieving an accuracy level of 98.5333 percent.

V. Conclusion

This research propose a framework for classification of gait patterns from given wearable sensing data. The wearable sensing data of human movements recorded by smartphones with two different sensors that are an accelerometer and a gyroscope. In addition, the research study examined the use of ensemble learning approaches in order to solve the problem of the gait pattern classification. The experimental results show that the data obtained from the accelerometer and gyroscope via the smartphone are broadly complementary and provide more accurate and reliable classification performance. With sensors at the waist position, the ensemble learning-based approach of ST-SVM achieves classification accuracy of 98.1167 percent with regard to both the accelerometer and the gyroscope data. However, with sensors at the arm position, the ensemble technique of ST-SVM is able to combine data from both the accelerometer and the gyroscope in achieving an accuracy level of 98.5333 percent.

Acknowledgment

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References

[1] C. Wan, L. Wang, and V.V. Phoha, "A survey on gait recognition", ACM Computing Surveys, vol. 51, no. 5, 2018.
[2] M. Hu, Y. Wang, and Z. Zhang, "Gait-Based Gender Classification Using Mixed Conditional Random Field". IEEE transactions on systems, man, and cybernetics. Vol. 41, pp. 1429–1439, 2011.
[3] J. Kwapisz, G. Weiss, and S. Moore, "Activity recognition using cell phone accelerometers", SIGKDD Explorations, vol. 12, no. 2, pp. 74–82, 2010.

TABLE III: Experimental results of classification performance at the waist position

Wearable sensing data	**Accuracy(%) at waist position**						
	Basic classifier			**Ensemble classifier**			
	DT	**MLP**	**SVM**	**MV**	**ST-DT**	**ST-MLP**	**ST-SVM**
Acc. data	94.0000	95.0000	73.2000	94.1000	94.8000	95.3000	**95.4333**
Gyro. data	88.6000	89.4667	87.8500	90.4667	87.5500	89.2333	**90.1500**
Acc. and Gyro. data	95.7167	97.8333	94.3000	97.8500	97.1833	97.5000	**98.1167**

TABLE IV: Experimental results of classification performance at the arm position

Wearable sensing data	**Accuracy(%) at waist position**						
	Basic classifier			**Ensemble classifier**			
	DT	**MLP**	**SVM**	**MV**	**ST-DT**	**ST-MLP**	**ST-SVM**
Acc. data	94.5167	97.5500	90.0645	97.4000	97.8667	98.0135	**98.4167**
Gyro. data	87.5833	91.6333	85.9500	89.7500	88.5333	89.6667	**90.3167**
Acc. and Gyro. data	94.6133	97.9330	90.0667	97.4330	97.9333	98.1167	**98.5333**

[4] N. Hnoohom, A. Jitpattanakul, P. Inluergsri, P. Wongbudsri, and W. Ployput, "Multi-sensor-based fall detection and activity daily living classification by using ensemble learning", in Proceeding of 1st International ECTI Northern Section Conference on Electrical, Electronics, Computer and Telecommunications Engineering (ECTI-NCON 2018), pp. 111–115, 2018.

[5] N. Hnoohom, S. Mekruksavanich, and A. Jitpattanakul, "Human activity recognition using triaxial acceleration data from smartphone and ensemble learning", in Proceeding of 13th International Conference on Signal-Image Technology and Internet-Based Systems (SITIS 2017), pp. 408–412, 2017.

[6] J.R. Kwapisz, G.M. Weiss, and S.A. Moore, "Activity recognition using cell phone accelerometers", *SIGKDD Explorations Newsletter*, vol. 12, no.2, pp. 74–82, 2011.

[7] T. Brezmes, J.L. Gorricho, and J. Cotrina, "Activity recognition from accelerometer data on a mobile phone", *Distributed Computing, Artificial Intelligence, Bioinformatics, Soft Computing, and Ambient Assisted Living*, pp. 796–799, 2009.

[8] W. Wu, S. Dasgupta, E.E. Ramirez, C. Peterson, and G.J. Norman, "Classification accuracies of physical activities using smartphone motion sensors", *Journal of Medical Internet Research*, vol. 14, no.5, 2012.

[9] M.F.A. bin Abdullah, A.F.P. Negara, M.S. Sayeed, D.J. Choi, and K.S.Muthu, "Classification algorithms in human activity recognition using smartphones", *International Journal of Computer and Information Engineering*, vol. 6, pp. 77–84, 2012.

[10] D. Steins, H. Dawes, P. Esser, J. Collett, J., "Wearable accelerometry-based technology capable of assessing functional activities in neurological populations in community settings: a systematic review", *Journal Neuroengineering Rehabilitation*, Vol. 11, no. 36, 2014.

[11] W. Zijlstra, A.L. Hof, "Assessment of spatio-temporal gait parameters from trunk accelerations during human walking", *Gait Posture*, Vol. 18, pp. 1–10, 2003.

[12] L. Bao and S.S. Intille, "Activity recognition from user-annotated acceleration data", In T. Kanade, J. Kittler, J.M. Kleinberg, F. Mattern, J.C. Mitchell, O. Nierstrasz, C. Pandu Rangan, B. Steffen, D. Ter- zopoulos, D. Tygar, M.Y. Vardi, and A. Ferscha, editors, *Pervasive Computing*, 2004, pp. 1-17. 2004.

[13] D. Anguita, A. Ghio, L. Oneto, X. Parra, and J.L. Reyes-Ortiz, "Human activity recognition on smart-phones using a multiclass hardware-friendly support vector machine", *In Proceedings of the International Workshop of Ambient Assisted Living*, 2012.

[14] J.Y. Yang, J.S. Wang, and Y.P. Chen, "Using acceleration measurements for activity recognition: An effective learning algorithm for constructing neural classifiers", *Pattern recognition letters*, vol.29, no.16, pp. 2213-2220, 2008.

[15] D.M. Karantonis, M.R. Narayanan, M. Mathie, N.H. Lovell, and B.G. Celler, "Implementation of a real-time human movement classifier using a triaxial accelerometer for ambulatory monitoring", *IEEE Transactions on Information Technology in Biomedicine*, vol.10, no.1, pp. 156–167, 2006.

[16] G. Brown, J.L. Wyatt, and P. Tino, "Managing diversity in regression ensembles", Journal of Machine Learning Research, Vol.6 pp. 1621–1650, 2005.

[17] E.K. Tang, P.N. Suganthan, and X. Yao, "An analysis diversity in measures", Machine Learning, vol. 65., no.1, pp. 247–271, 2006.

[18] N. Hnoohom, and A. Jitpattanakul, "Comparison of Ensemble Learning Algorithms for Cataract Detection from Fundus Images", in Proceeding of ICSEC 2017 - 21st International Computer Science and Engineering Conference 2017, pp. 144–147, 2017.

[19] S. Mekruksavanich, N. Hnoohom, and A. Jitpattanakul, "Smartwatch-based sitting detection with human activity recognition for office workers syndrome", in Proceeding of 1st International ECTI Northern Section Conference on Electrical, Electronics, Computer and Telecommunications Engineering, ECTI-NCON 2018, pp. 160–164, 2018.

[20] J. R. Kwapisz, G.M. Weiss, and S.A. Moore, "Activity recognition using cell phone accelerometers", ACM SIGKDD Explor. Newskett., vol. 12, no. 2, pp. 74–82, 2010.

[21] P. Siirtola and J. Roning, "Ready-to-use activity recognition for smartphones", in Proceeding of IEEE Symposium of Computing Intelligence and Data Mining (CIDM), Singapore, pp. 59–64, 2013.

[22] P.E. Utgoff, "Incremental induction of decision trees", *Machine learning*, vol.4, no.2, pp. 161–186, 1989.

[23] L. V. Fausett, "Fundamentals of Neural Networks: Architectures, Algorithms, and Applications", Prentice-Hall, 1994.

[24] V.N. Vapnik, "The nature of statistical learning theory", Springer-Verlag New York Inc., USA, 1995.

[25] D. Roggen, A. Calatroni, M. Rossi, T. Holleczek, K. Foŕster, G. Troŝter, P. Lukowicz, D. Bannach, G. Pirkl, and A. Ferscha, "Collecting complex activity data sets in highly rich networked sensor environments", In Proceedings of the 7th International Conference on Networked Sensing Systems 2010, 2010.

[26] L. Rokach, "Ensemble-based classifiers", Artificial Intelligence Review, vol. 33(1-2), pp. 1–39, 2010.

[27] R. Polikar, "Ensemble based systems in decision making", IEEE Circ. Syst. Mag, vol. 6, no.3, pp. 21–45, 2006.

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Educational Data Analytics using Association Rule Mining and Classification

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***Abstract*— The education crisis is now widely spread in global in term of decreasing number of student and decreasing degree requirements for some jobs. Educational data mining (EDM) is recently interested in data mining area to discover useful knowledge in educational data to help educators improve their administration planning and student services. This paper proposes applying of two data mining technics in educational data. First, association rule was applied in admission data to find some knowledge for supporting admission planning. Second, decision tree was applied in course grades and job data of graduated student to predict job after graduated. The results of these studies give good knowledge for admission planning and job prediction.**

Keywords—educational data mining, classification, association rule mining

I. INTRODUCTION

The occurrence of disrupt technology in many areas has conducted the large volume of data in various format and unprecedented speed of generated data. These data phenomenon known in term of big data [1] (volume, various, velocity). The big data required to analyses with appropriate approach for extracting useful knowledge. The data mining aims to discover pattern or useful knowledge from large collection of data [2]. The major functions of data mining are applying various algorithms to discover useful pattern and catch patterns which hidden in data. Educational Data Mining (EDM) is a new research direction in data mining. The focuses of EDM are focus on discovering useful knowledge and mining the helpful patterns from educational data, such as student profile data, student registration data, student job data and other occurrence of student data which can collect during college [3].

There are a lot of objective of EDM depend on data source and educational problem. In 2011, B.K. Baradwaj and S. Pal [4] studied on classification task of student database to predict the student's performance in end semester examination. The student' performance was divided into four stages (first, second, third and fail). It helps earlier in identifying the dropouts and student who need special attention from teacher. In 2015, N. Buniyamin et al. [5] presented the use of Neuro-Fuzzy classification in a student's academic data in an electrical engineering faculty of Malaysian public university. The study showed that the output of system can determine probability of student to achieve excellent grade even if the student achieved weak in certain course or subject. In 2016, A. A. Saa [6] used multiple data mining tasks to create qualitative predictive models to predict the students' grades from educational dataset. Four decision tree algorithms have been implemented and Naïve Bayes algorithm. The results can motivate the university to perform data mining task on their student data, as well as student to improve their performances. In 2017, F. Matsebula and E. Mnkandla [7] proposed an architecture for big data analytics in higher education. The architecture composed of five parts; data gathering device which collected student data from various data source (student's card, social networking and student information system), data storage and management system which consists of bigdata management, data analytics system which process algorithms from data, data visualization which help in decision making process, and action system for providing alerts, warning or guiding to student or administrators.

The main objective of this research is to answer two main questions using data mining algorithms. First, how data mining can help admission working process. Second, how data mining can predict the student's jobs. To answer these questions, we provide two task of data mining with two difference sources of data. First, the association rule mining [8] is used to discover interesting relation between feature in admission data, such as school name, province, region, admission project, faculty. The result of association rule mining could be used to help for admission planning. Second, the ID3 which is a classification algorithm invented by Ross Quinlan [9] used to generate a decision tree from student's course grade dataset which is mapped each student's course grade to their job after graduated. The rule result from ID3 showed that accuracy and precision for student's job prediction.

The rest of this paper organized as follows. Section II provides basic knowledge discovery process. Section III describes a brief of association rules mining and ID3 decision tree. Section IV present the design of experiments while the following section focus on results discussion. Finally, section VI contains conclusion and future works.

II. KNOWLEDGE DISCOVERY IN DATABASE

Knowledge discovery in database (KDD) is a process to identifying valid, novel, useful and understandable pattern from large and complex datasets [8]. The KDD process consist of following step as shown in figure1.

Fig. 1. The KDD process.

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1. Data selections: is the process of retrieving data from multiple source which are relevant to our tasks.
2. Data preparation and transformation: is the process of collecting, cleaning, organizing data, converting data from one complex domain or format into another simple domain or format. Many data preparation and transformation method are applied in this step, such as noise filtering method, handle missing data method, data sampling method, normalization feature construction, etc.
3. Data mining: is the process of discovering useful knowledge from a large amount of data. To discovery useful knowledge data mining algorithms, such as associations rule mining, pattern classification, data clustering, are applied to data.
4. Evaluation: is the process of evaluation or scoring of the discovery pattern or knowledge to confirm useful result.

III. ASSOCIATION RULE MINING AND ID3 DECESION TREE

A. *Association Rule Mining*

Association rule mining is a data mining method to discovery interesting relationship between features. The association rule mining has two important steps. First step, frequent itemset generation, is a process to find frequent itemset which have minimum support and minimum confidence value more than assigned threshold. Second step, rule generation, is a process to generate rules from frequent itemset. The generated rules are evaluated by confidence value. A widely-used algorithm for the association rules mining is the Apriori algorithm [10]. The key success of Apriori algorithm is pruning a lot of unnecessary itemset which lead to reduce computational time. The summary Apriori algorithms shown in figure 1.

```
ProcedureApriori (T, minSup){
//T is dataset and minSup is minimum support value
Ck: Candidate itemset of size k
Lk: frequent itemset of size k
L1 = {frequent itemsets};
for(k=1; Lk != ϕ; k++) do begin
Ck+1 = candidates generated from Lk;
    for each transaction t in dataset do{
        increment the count of all candidates in Ck+1 that are
contained in t
        Lk+1 = candidates in Ck+1 with min_sup
        }
end
return Uk, Lk
```

Fig. 2. Pseudocode of the Apriori algorithm [x]

B. *ID 3 Decision Tree*

ID3 algorithm is a statistical model used for generating decision tree from a dataset. The basic idea of ID3 algorithm is to construct the decision tree by applying a top-down, greedy search through the given sets of training data to test each attribute at every node [x]. The key of decision tree construction is root node selection which using statistical method call information gain.

The information gain can evaluate how well of chosen node that might be generate smallest decision tree. The information gain equation as follows:

$$\text{Gain(S, A)} = \textit{Entropy}(S) - \sum_{v \in \textit{Values}(A)} \frac{|S_v|}{|S|} \textit{Entropy}(S_v)$$

where *Values(A)* is the set of all possible values for attribute *A*, and S_v is the subset of *S* for which the attribute A has value *v*. The *Entropy(S)* is a measure in the information theory, which describes the diversity of an arbitrary collection of data as follows:

$$\text{Entropy(S)} = \sum_{i=1}^{c} -p_i \log_2 p_i$$

where p_i is the probability of S belonging to class *i*. The procedure for decision tree generation as follows:

```
ProcedureBuildTree(S){
//S = set of not null data
repeat
    maxGain ← 0
    split A ← null
    e ← Entropy(Attributes)
        for all Attributes a in S do
            gain ← InformationGain(a, e)
                if gain > maxGain then
                    maxGain ← gain
                    splitA ← a
                end if
        end for
        Partition(S, splitA)
    until all partition processed
}
```

Fig. 3. Pseudocode of the build decision tree in ID3 [x]

IV. EXPERIMATAL DESIGN

We define our two research questions. First, how data mining can help admission working process. Second, how data mining can predict the student's jobs.

A. *Testing problems*

To answer two research questions, we conduct two sets of experiments: admission data set and the mapped student's course grade with job dataset.

a) admission data set: The admission data set used in this research was collected from admission year 2016 and 2017. The size of dataset is 10,342 records. Table 1 describes the attributes of dataset and their possible value

TABLE I. ATTRIBUTES DESCRIPTION OF ADMISSION DATA SET

Attributes	Description	Values
Acadyear	Acadamic year	{2016,2017}
StuCode	Student code	set of 7 number
GFacName	Group of faculty	{Technology science, Health scicence, Social science}
FacName	Faculty	{ICT, Engineering, MIS, …}
ProjName	Admission project	{Project 1, Project 2, …}

Attributes	Description	Values
	name	
EduName	School name	{School1, School2, …}
ProvName	Provice name	{Chiang rai, Phayao, … }
RegName	Region name	{North, South East, South, Central}

b) student's course grade with job dataset: This set of problems was select from student's course grade of schooll of information and communication technology between 2011-2014 which is admission only in 2011 mapped with their job after graduated. The job was collected by manual survey. The size of dataset is 106 records.

TABLE II. ATTRIBUTES DESCRIPTION OF STUDENT'S COURSE GRADE WITH JOB DATASET

Attributes	Description	Values
Gender	Gender	{Male, Female}
GradSubject 1	Grade of course 1	{High(A,B+,B), Medium(C+,C), Low (D+,D)}
GradSubject 2	Grade of course 2	{High(A,B+,B), Medium(C+,C), Low (D+,D)}
…	…	…
GradSubject N	Grade of course N	{High(A,B+,B), Medium(C+,C), Low (D+,D)}
Job	Job of graduated student (Label or Class)	{IT, Non-IT}

B. Experimatal setup

a) Association Rule Mining: In our study we used APRIORI algorithms to analyze all association rule that have support and confidence higher than a given minimal support threshold (minsup=0.01) and a minimal confidence threshold (minconf=0.5)

b) ID 3 algorithm: the following setting used with ID3 operator to produce the decision tree:

- Splitting criterion = information gain ratio
- Minimal size of split = 4
- Minimal leaf size = 2
- Minimal gain = 0.1

V. EXPERIMATAL RESULTS

A. First research question

For the first research question, how data mining can help admission working process. To answer this question, we selected association rule mining as a mining tool to discover interesting relation between features. The threshold of minsup and minconf are configured as above. A snapshot of rules after run on admission data set for each region are shown in Table III.

TABLE III. A SNAPSHOT OF RULES IN EACH REGION

Region	Rules	Support / Confidence
North	1. North, Faculty of Medicals, 10% direct admission => Lampang	5% / 80%
	2. North, Faculty of MIS, 10% direct admission => Phayao	4% / 60%
Central	3. Central, School of education, 10% direct admission => Sukhothai	2% / 80%
	4. Central, Faculty of Medicals, 10% direct admission => Phitsanulok	3% / 60%
South East	5. South East, School of education, 10% direct admission => Udon Thani	5% / 80%
	6. South East, Faculty of Medicals, 10% direct admission => Udon Thani	3% / 50%

After analyzing the generated association rules, it is observed as following rules:

The Rule no.1 means that the students who come from north region and admission from 10% direct project and admission in faculty of medicals have relative with Lampang province with support value 5 % and confidence value 80%.

The Rule no.2 means that the students who come from north region and admission from 10% direct project and admission in faculty of MIS have relative with Phayao province with support value 4 % and confidence value 60%.

The Rule no.3 means that the students who come from central region and admission from 10% direct project and admission in school of education have relative with Sukhothai province with support value 2 % and confidence value 80%.

The Rule no.4 means that the students who come from central region and admission from 10% direct project and admission in faculty of medicals have relative with Phitsanulok province with support value 3 % and confidence value 60%.

The Rule no.5 means that the students who come from south east region and admission from 10% direct project and admission in school of education have relative with Udon Thani province with support value 5 % and confidence value 80%.

The Rule no.6 means that the students who come from south east region and admission from 10% direct project and admission in faculty of medicals have relative with Udon Thani province with support value 4 % and confidence value 60%.

B. Second research question

For the second question, how data mining can predict the student's jobs. To answer this question, we selected ID3 decision tree as a mining tool to predict student's job. The configuration of important parameters is configured as above. After running ID3 decision tree with 5-fold cross validation on student's course grade with job dataset, the confusion matrix of ID3 decision tree was generated as table IV.

TABLE IV. THE CONFUSION MATRIX OF ID3 DECISION TREE

	True IT	*True Non-IT*	*Class Precision (%)*
Prediction IT	45	11	80.35%
Prediction Non-IT	17	33	66.00%
	72.58%	75.00%	

The ID3 decision tree was able to predict both true positive and true negative 78 records out of 106 records. The accuracy of ID3 decision tree is 73.58%.

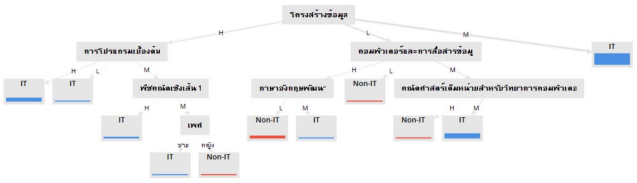

Fig. 4. The decision tree result from ID3 using Rapid Miner Studio Educational 8.1.000

The fig.4 showed the decision tree which generated from ID3 using Rapid Miner Studio. The example of IF-THEN rule could be easier to explain is shown in fig. 5.

IF Data structure = 'M' THEN Job = 'IT'
IF Data structure = 'H' AND Intro. Programming = 'H' THEN Job = 'IT'
IF Data structure = 'H' AND Intro. Programming = 'M' AND Linear Algebra = 'H' THEN Job = 'IT'
IF Data structure = 'H' AND Intro. Programming = 'L' THEN Job = 'IT'
IF Data structure = 'L' AND Data com. = 'L' THEN Job = 'Non-IT'
IF Data structure = 'L' AND Data com. = 'H' AND Dev. Eng. = 'L' THEN Job = 'Non-IT'
IF Data structure = 'L' AND Data com. = 'H' AND Dev. Eng. = 'M' THEN Job = 'IT'

Fig. 5. The example of rule set generated by ID3 decisin tree

VI. Conclusion

In this paper, we applied two data mining algorithms to discover useful knowledge from educational dataset. First, the association rule mining is used on admission dataset to answer the question "how data mining can help admission working process". The result shown the significant relationship between region, admission project name, faculty and province. This result might be help educators who response for admission working process to plan their admission promotion. Second, ID3 decision tree is applied to student's course grade with job dataset to answer the question "how data mining can predict the student's jobs". The result rule show that the significant subject which student should be important for future career.

VII. Future works

Future work will be aimed at collect more career data from graduated student. It would be also applied other classification algorithms such as neural network, SVM, etc. to improve classification accuracy.

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References

[1] N. Elgendy and A. Elragal. Big Data Analytics: A Literature Review Paper, Industrial Conference on Data Mining (ICDM), 2014, pp214-227.

[2] Heikki, Mannila, Data mining: machine learning statistics, and database, IEEE, 1996.

[3] Jiawei Han and Micheline Kamber (2011) Data Mining: Concepts and Techniques. 3 editions. Morgan Kaufmann.

[4] N. Elgendy and A. Elragal. Big Data Analytics: A Literature Review Paper, Industrial Conference on Data Mining (ICDM), 2014, pp214-227.

[5] Heikki, Mannila. Data mining: machine learning statistics, and database, IEEE, 1996.

[6] AlejandroPeña-Ayala. Educational data mining: A survey and a data mining-based analysis of recent works, Expert Systems with Applications, March, 2014, Vol. 41(4).

[7] B.K. Baradwaj, S.Pal. Mining Educatinal Data to analyze Students' Performance, International Journal of Advanced Computer Science and Applications (IJACSA), 2011, Vol. 2(6).

[8] N. Buniyamin, U.B. Mat, P.M. Arshad. Educational data mining for prediction and classification of engineering students achievement, The 7 th International Conference on Engineering Education (ICEED), 2015, Kanazawa, Japan, pp. 49-53.

[9] A. A. Saa., Educational Data Mining & Student's Performance Prediction., International Journaal of Advanced Computer Science and Application (IJACSA), 2016, Vol.7(5).

[10] F. Matsebula, E. Mnkandla., A big data architecture for learning analytics in higher education, IEEE Africon, 2017, pp.951-956.

[11] J. Han, M. Kamber, J. Pei,. Data Mining: Concepts and Techniques, Morgan Kaufmann , 2011.

[12] Quinlan, J. R. Induction of Decision Trees. Mach. Learn. 1, 1 ,Mar. 1986, pp. 81–106.

[13] S. Rao, R. Gupta,. Implementing Improved Algorithm Over APRIORI Data Mining Association Rule Algorithm., International Journal of Computer Science And Technology, Mar. 2012, pp. 489-493.

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A Machine Learning Approach for Detecting Distributed Denial of Service Attacks

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***Abstract*—This research aims to present the method for identifying distributed denial of service (DDoS) attacks. Two benchmark dataset, including KDD CUP 1999 and NSL-KDD, were used. The dataset were checked and deleted duplicate data. After the process, the amount of records of KDD Cup 1999 dataset were decreased from 4,898,431 records to 529,655 records, and the amount of records of NSL-KDD dataset were decreased from 125,373 to only 12,354 records. The reduction of the records always happened because of the characteristics of DDoS attacks which send repeated data to the victims' server. The researchers converted alphabet data to numeric data, then training by K-nearest neighbor (KNN), multi-layer perceptron and support vector machine. The result showed that KNN was the best method to identify the DDoS attacks.**

***Index Terms*—Distributed denial of service (DDoS) attack, K-nearest neighbor (KNN), Multi-layer percetron (MLP), Support vector machine (SVM)**

I. Introduction

Nowadays, security concerns from the use of the internet and computer system is one of problems. The security has been attacked in different ways. Distributed Denial of Service (DDoS) [1] is one of the most common attacks on the internet due to the limitation on the attacked device such as memory or bandwidth. The victims require to open the system to allow users to connect. The cyber attackers use these channels to make the victims' resources reach their peak until they cannot be used. Then, the victim' devices are out of service and cannot serve the users. Classification o f abnormalities in computer network can be classified b y u sing computer network traffic l ogs, w hich i nclude n ormal d ata a nd various network attack data. In each attack features, there are different characteristics which can be used to detect abnormalities when occurring in the system. In [2]–[5] artificial n eural network (ANN) were used in order to classify attack data. The accuracy is higher than 90%.

Related work: In the research [2], researchers specified the numbers of hidden layers of the network from 30-55 layers in order to to classify the DDoS attack data from 4,986 records. Records were classified i nto 4 g roups i ncluding, D NS DDoS attack, CharGen DDoS attack, UDP DDoS attack and Normal. The result found that ANN with total 50 hidden layers can identify the DDoS data with a 95.6% accuracy rate. While Hsieh and Chan [3] used neural network and Apache Spark framework, which has been used to manage large-scale data (Big Data) and work as a cluster for DDos detection. In the experiment of series ARPA 2000 LLDOS 1.0 which has 7 special features including, Number of Packets, Average of Packet Size, Time Interval Variance, Packet Size Variance, Number of Bytes, Packet Rate, and Bit Rate. All data were classified into two categories: normal data and attack data. There were 51,040 normal data and 74,480 attack data. All data samples were separated into 2 parts, 30% for the learning series, and another 70% for the test Data. It was found 94% accuracy rate.

In the research of Devaraju and Ramakrishnan [4] tested three artificial neural networks including 3 methods. There were feed forward neural network (FFNN), probabilistic neural network (PNN) and radial basis neural network (RBNN). The methods has been used to test the effectiveness of the Intrusion Detection System by tested with the KDD Cup 1999 dataset [6], containing 41 special features. There are four types of attacks including, 1) Denial of Service (DoS) containing back, land, neptune, pod, smurf and teardrop, 2) Remote to Local (R2L), containing ftp_write, guess_passwd, imap, multihop, phf, spy, warezclient and warezmaster, 3) User-to-Root (U2R), containing buffer_overflow, loadmodule, perl and rootkit, 4) probing, containing ipsweep, nmap, portsweep and satan. The data were divided into 7 classes. There were normal class, smurf class, neptune class, saint class, mail bomb class, Apache class and satan class. The experiment was divided into training set and test set. Each set contains 700 data. The experimental data showed that the PNN network was the best. The PNN, FFNN and RBNN neural networks performed accuracy rate at 97.5%, 94.3% and 65%, respectively.

Researchers also use different machine learning techniques e.g. In [5], they classified network attack information by using ANN, SVM, and ANN+SVM techniques and using dataset NSL KDD [7] . In this experiment, the attack were divided into 2 classes including, 58,630 attack class and 67,343 normal classes. The accuracy rate were 79.56, 79.27 and 79.71%, respectively.

In [8] offers intrusion detection method by using decision

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tree ID3 in order to reduce the number of special features. From the KDD Cup 1999 dataset which reduced 41 attributes to 18 attributes. The information used in this test were divided into four intrusion categories. There are Denial of Service (DoS), Remote to Local (R2L), User to Root (U2R) and Probe. The 26,167 data sets are divided into two equal parts for training and testing. Special feature information were trained through K-nearest neighbor and genetic algorithm (KNN-GA) techniques in order to categorize the information and compare to KNN methods and support vector machine (SVM). The experiments showed that the KNN-GA method was the most accurate. The accuracy rate was 98%.

In [9] presented a method for improving the detection and classification process using naïve bayes, bayesian networks (NB-Tree) and AD-Tree which tested with NSL-KDD 99 dataset. The test data values were converted to the rage 0-1 by min-max normalization method. Then, the special features were selected from the data by correlation-based feature selection (CFS). The results showed that NB-Tree had the best performance. NB-Tree, AD-Tree and naïve bayes are effective at 99.87%, 98.49% and 90.38%, consequently.

Kushwaha et al. [10] presented a method for selecting the best special features with the Mutual Information (MI) for detecting abnormalities. 10% of KDD Cup 1999 data were tested. The data contains 494,021 training data and 311,029 test data. The data were divided into 2 classes including, attack data and normal data. When using MI, 30 special features were selected and applied to further training with naïve, random forest, OneR, SVM, Adaboost, Bagging, KNN (k=5), KNN (k=10) and SVM+Nave Bayes. The accuracy rates were 92.73%, 99.89%, 95.58%, 99.91%, 95.05%, 99.79%, 99.77%, 99.69%, and 60.40% respectively. The results showed that the SVM performs the best accuracy rate at 99.91%. In [11] presented the method for identifying abnormal data in computer networks. The KDD Cup 1999 and NSD-KDD dataset were tested with J48 graft and naïve bayes method. Cross validation were conducted as an effective evaluator. Given $K = 10$, from the test, the J48 graft method has 99.435% accuracy rate. the J48 got the best effectiveness. The naïve bayes method got 92.715% accuracy rate.

Contribution: This research presents a method for classifying DDoS attack data by using computer network security information with machine learning. The KNN, SVM and MLP method are introduced. The grid search method are used for finding the suitable parameters for the KDD Cup 1999 and NSL-KDD dataset in order to make a performance comparison.

Paper outline: The remaining parts of the paper is organized as follows: In Section II, the machine learning approaches are described. In Section III data processing is presented. In Section IV experimental settings and the results are presented. Finally, a conclusion and future work is given in Section V.

II. Machine Learning Approaches

A. K-Nearest Neighbors Algorithm (KNN)

KNN which is the method to find the nearest member in dataset. It is a technique of machine learning that does not require modeling for data classification, but all data will be calculated to find distance value in order to compare the distance between the data that need to be classified y and all data X_i [12]. Therefore, the data with the smallest distance, the amount of data is k , is taken to be considered. In the total k, if any of members in the group C_i has the highest values of k, that data which needs to be categorized y will be categorized at that group. Therefore, given $k = 3$ means 3 values with minimum distance value will be taken into the account. If three data, containing the distance value, are in the group $d = (C_1, C_1, C_3)$, the data which need to be categorized will be set as C_1 because there are the most appearances. Euclidean distance calculations can be calculated as Eq. 1.

$$d(x, y) = \sqrt{\sum_{i=1}^{N}(x_i - y_i)^2} \tag{1}$$

where N is the number of special features (Dimensions) of the data. x, y is the data in the training set, and y is the data which needs to be classified. Then, calculate all the distance values $d(x, y)$ for voting by majority vote method. Therefore, C_k dataset which most appears is determined as the result of KNN.

B. Support Vector Machine (SVM)

SVM [13], [14] is the powerful and accurate categorization method, so researchers always use in classifcation problems. The SVM algorithm find the optimal hyperplane with the maximum margin between training point and hyperplane. The training point that approach the hyperplane line are called *support vectors*. Initially, SVM was designed to work with the special two-class classification, using a linear equation for segmenting feature vector data (Eq. 2).

$$f(x) = sign(w^T x + b) \tag{2}$$

where w is weight vector and B is bias.

C. Multi-Layer Perceptron (MLP)

MLP is artificial neural network with a multi-layer structure [15]. It consists of an input layer and passes from one layer to another hidden layer. It has a function for calculating when receiving an output from the node in the previous layer. The function called *activation function*. Each layer does not need to be the same function. The function converts incoming data to distinguish using a single line called *linearly separable*. Before the data has been sent to the output layer, it is sometimes necessary to use more than one hidden layer in order to convert the data into Linearly Separable until it reach the output layer.

III. Data Processing

A. Data Analysis

KDD CUP 1999 dataset and NSL-KDD dataset were divided into normal class and 4 features of attack class including,

1) *Denial of Service (DOS)* attacks is an attack that send a large number of packets to the target victims which cause the service to become failed.
2) *Remote to Local (R2L)* attacks is an attempt to access the targeted system without permission to access.
3) *User to Root (U2R)* attacks is an attempt to access unauthorized function in order to reach the Supper-user (root).
4) *Probing* attacks are the data validation on the network.

Then, trying to find the vulnerability of the target in order to use in the attacks. The example of common types are Nmap or port scanning. In the dataset of this research, there are 41 special features which are selected only normal data and DDos attacks.

B. Data Pre-Processing

The KDD CUP 1999 dataset and NSL-KDD dataset are composed of duplicate data, numbers, and alphabets. Before sending the data to machine learning, the data required to be processed as follows.

1) Removed the DDos data which is duplicate data. A lot of duplicate data were sent to the system during attacks. Deleting the duplicate data result as the data could be different in one row. Deleting method is done by diagnosis the duplicate special attributes and classes (Class).
2) Convert the alphabet values of the special feature to numeric values.
3) From normal dataset and DDoS dataset (Total 526,655 record), the dataset were divided into 3 series which different classes as follows:
    a) *Series 1* has 2 classes: normal data and DDoS attack which converted from 6 classes to 1 class which is attacks.
    b) *Series 2* has 6 classes: the dataset that get rid of normal data. The remaining data are DDoS attacks. There are Neptune, Pod, Smurf, Teardrop, Land and Back.
    c) *Series 3* has 7 classes: the dataset contains Neptune, Pod, Smurf, Teardrop, Land, Back and Normal.

IV. Experimental Setting and Results

This research is a research on the security of computer networks for identifying DDoS attacks using the 4,898,431 KDD Cup 1999 dataset and 125,373 NSL-KDD dataset. Those dataset are normal data and computer network intrusion data.

A. Parameter Tuning

Classification on information of machine learning were conducted by modeling both sets of data for DDoS attacks classification and identification. Training data and testing data were divided by cross validation method (given, $k = 2$). Then, both dataset were classified by MLP, SVM and KNN. The Parameter Tuning were as follows:

1) *KNN* is the identification of information by distance detection K position which get majority vote or nearest distance value. Given $K = 1, 3, 5, 7, 9$ to find the parameter for the test that aim to give the highest accuracy.
2) *SVM* [12,13] is a discriminative classifier formally defined by a separating hyperplane. The data classification which presented in this research apply grid search method to find suitable parameter for SVM. The testing parameter were as follows. Kernel function were set as RBF and linear. Gamma γ were set as between $1e-3$ and 1000. C were set as between $1e-3$ and 1000 to calculate the best parameter.
3) *MLP* applying grid search method to find the parameter. The test were set hidden layer as 10, 50, 100, 150, 200, 500, 1000. alpha were set as 1e-05, 1000, ... , 0.0001, 0.00001 and use the same methods as Adam [16] which works great when the data is large.

B. Experimental Results

There are three machine learning methods of classifying DDoS attacks in this research including, 1) K-Nearest Neighbor (KNN), 2) Support Vector Machine (SVM), and 3) Multi-Layer Perceptron (MLP). The accuracy equation [16] is as follows.

$$ACC = \frac{(TP + TN)}{(TP + TN + FP + FN)} \tag{3}$$

where True Positive (TP): refer to predictions is true and confirm that is true.

True Negative (TN): refer to predictions is not true and confirm that is not true.

False Positive (FP): refer to predictions is true and confirm that is not true.

False Negative (FN): refer to predictions is not true and confirm that is true.

TABLE I: Accuracy Results of the KDD Dataset

Methods	Parameters Setting	Accuracy (%)
KDD 2-Class+SVM	rbf kernel, $C = 8, \gamma = 16$	98.946± 0.022
KDD 2-Class+KNN	$K = 3$	**99.983± 0.003**
KDD 2-Class+MLP	Hidden layer = 150	98.833± 0.131
KDD 6-Class+SVM	rbf kernel, $C = 8, \gamma = 32$	98.781± 0.020
KDD 6-Class+KNN	$K = 3$	**99.998± 0.002**
KDD 6-Class+MLP	Hidden layer = 20	99.981± 0.131
KDD 7-Class+SVM	rbf kernel, $C = 4, \gamma = 32$	99.096± 0.027
KDD 7-Class+KNN	$K = 3$	**99.984± 0.002**
KDD 7-Class+MLP	Hidden layer = 500	99.944± 0.019

TABLE II: Accuracy Results of the NSL-KDD Dataset

Methods	Parameters Setting	Accuracy (%)
NSL-KDD 2-Class+SVM	rbf kernel, $C = 1, \gamma = 32$	91.171± 0.194
NSL-KDD 2-Class+KNN	$K = 3$	**99.191± 0.044**
NSL-KDD 2-Class+MLP	Hidden layer = 200	98.091± 0.265
NSL-KDD 6-Class+SVM	rbf kernel, $C = 4, \gamma = 16$	95.364± 0.603
NSL-KDD 6-Class+KNN	$K = 3$	**99.951± 0.026**
NSL-KDD 6-Class+MLP	Hidden layer = 150	98.730± 1.200
NSL-KDD 7-Class+SVM	rbf kernel, $C = 1, \gamma = 16$	91.182± 0.183
NSL-KDD 7-Class+KNN	$K = 3$	**99.087± 0.076**
NSL-KDD 7-Class+MLP	Hidden layer = 100	98.066± 0.137

The accuracy results of the DDoS attack classification test with KDD CUP 1999 dataset and NSL-KDD dataset are showed at Table I and Table II, respectively.

In this paper, the data divided by cross validation method. The data were divided into two parts ($k = 2$) and tested 10 iterations. Starting with the KDD CUP 1999 dataset, the results found KNN had the best performance for all three subsets (2 Classes, 6 Classes, and 7 Classes). The accuracy rate were 99.98%, 99.99% and 99.98%, respectively which is very effective when compared to SVM and MLP. Then, testing with the NSL-KDD dataset which were also divided into three subsets. The results found that the KNN method had better performance than MLP and SVM with the three subsets data. The accuracy rate were 99.19% for NSL-KDD (2 Classes), 99.95% for NSL-KDD (6 Classes), and 99.08% for NSL-KDD (7 Classes).

V. Conclusion

In this research, machine Learning including; KNN, MLP and SVM were used to identify DDoS attacks. Two benchmark dataset which is 529,655 records of KDD CUP 1999 dataset and 12,354 records of NSL-KDD dataset. Those two dataset were divided into three subordinate dataset. There are 2, 6 and 7 classes for accuracy test of classification of DDoS attacks. When testing were conducted for 10 iterations, the result showed that KKN method obtained the best performance when compare with MLP and SVM with the accuracy rate 99.99%. In the future, researchers have planned to find a special feature that could possible to reduce the number of features. At the same time, it must not reduce the accuracy rate. Then, experiment with other types of attacks.

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References

[1] F. Lau, S. H. Rubin, M. H. Smith, and L. Trajkovic, "Distributed denial of service attacks," in *Systems, Man, and Cybernetics (ICSMC), IEEE International Conference on*, vol. 3, Oct 2000, pp. 2275–2280 vol.3.

[2] D. Peraković, M. Periša, I. Cvitić, and S. Husnjak, "Artificial neuron network implementation in detection and classification of DDoS traffic," in *24th Telecommunications Forum (TELFOR)*, Nov 2016, pp. 1–4.

[3] C. Hsieh and T. Chan, "Detection DDoS attacks based on neural-network using apache spark," in *Applied System Innovation (ICASI), International Conference on*, May 2016, pp. 1–4.

[4] S. Devaraju and S. Ramakrishnan, "Performance analysis of intrusion detection system using various neural network classifiers," in *Recent Trends in Information Technology (ICRTIT, International Conference on)*, Jun 2011, pp. 1033–1038.

[5] T. Omrani, A. Dallali, B. C. Rhaimi, and J. Fattahi, "Fusion of ANN and SVM classifiers for network attack detection," *CoRR*, vol. abs/1801.02746, pp. 1–5, Jan 2018. [Online]. Available: http://arxiv.org/abs/1801.02746

[6] Information and Computer Science, "KDD cup 1999 data," Oct 1999. [Online]. Available: http://kdd.ics.uci.edu/databases/kddcup99/kddcup99.html

[7] S. Yuanyuan, W. Yongming, G. Lili, M. Zhongsong, and J. Shan, "The comparison of optimizing SVM by GA and grid search," in *Electronic Measurement Instruments (ICEMI), 13th IEEE International Conference on*, Oct 2017, pp. 354–360.

[8] P. Singh and A. Tiwari, "An efficient approach for intrusion detection in reduced features of KDD99 using ID3 and classification with KNNGA," in *Advances in Computing and Communication Engineering ICACCE, 2nd International Conference on*, May 2015, pp. 445–452.

[9] D. H. Deshmukh, T. Ghorpade, and P. Padiya, "Intrusion detection system by improved preprocessing methods and naïve bayes classifier using NSL-KDD 99 dataset," in *Electronics and Communication Systems (ICECS), International Conference on*, Feb 2014, pp. 1–7.

[10] P. Kushwaha, H. Buckchash, and B. Raman, "Anomaly based intrusion detection using filter based feature selection on KDD-CUP 99," in *IEEE Region 10 Conference TENCON*, Nov 2017, pp. 839–844.

[11] G. Meena and R. R. Choudhary, "A review paper on IDS classification using KDD 99 and NSL KDD dataset in WEKA," in *Computer, Communications and Electronics (Comptelix), International Conference on*, Jul 2017, pp. 553–558.

[12] O. Surinta, M. F. Karaaba, L. R. Schomaker, and M. A. Wiering, "Recognition of handwritten characters using local gradient feature descriptors," *Engineering Applications of Artificial Intelligence*, vol. 45, pp. 405 – 414, 2015.

[13] V. N. Vapnik, *Statistical Learning Theory*. Wiley, 1998.

[14] A. G. Gedam and S. G. Shikalpure, "Direct kernel method for machine learning with support vector machine," in *Intelligent Computing, Instrumentation and Control Technologies (ICICICT), International Conference on*, Jul 2017, pp. 1772–1775.

[15] J. Wu, X. Wang, X. Lee, and B. Yan, "Detecting DDoS attack towards DNS server using a neural network classifier," in *Artificial Neural Networks (ICANN), 20th International Conference on*, K. Diamantaras, W. Duch, and L. S. Iliadis, Eds. Berlin, Heidelberg: Springer Berlin Heidelberg, 2010, pp. 118–123.

[16] J. Han, M. Kamber, and J. Pei, *Data Mining: Concepts and Techniques*. Elsevier, 2011.

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Recognizing Pornographic Images using Deep Convolutional Neural Networks

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***Abstract*—In this paper, we propose to use deep convolutional neural network (CNN) architectures, namely the deep residual networks (ResNet), the GoogLeNet, the AlexNet, and the AlexNet architectures, for pornographic image dataset. Also, the local descriptors, namely the local binary patterns (LBP), the histogram of oriented gradients, and the scale invariant feature transform (SIFT) combined with a support vector machine (SVM), a multi-layer perceptron (MLP), or a K-nearest neighbor (KNN) techniques are proposed. Additionally, a bag of visual words (BOW) and the BOW using extracted HOG features (HOG-BOW) are compared. To classify the pornographic images, we compare the CNN architectures to well-known local descriptor techniques combined with the SVM, the MLP, and the MLP methods. Experimental results indicate that the ResNet architecture yields higher accuracies than all other approaches.**

***Index Terms*—pornographic classification, d eep convolutional neural network, deep residual networks, local descriptor technique, bag of visual words**

I. Introduction

Most research in image classification has focused on applications such as a face, object, scene, plant, animal, character, and even pornographic recognition [1]–[3]. In pornographic image recognition, image processing and machine learning techniques are proposed to use. Due to the image processing techniques, most of the pornographic image recognition researches, the human skin, called a region of interest (ROI), is first extracted from the whole image. In this process, the RGB color space is converted into HSV and YCbCr color spaces to extract the skin color [4]–[6]. In [4], the ratio value between the ROI and the whole image region calculated and decided as the pornographic image when the ratio is more than the threshold value. The threshold set to 50% and the accuracy result of the YCbCr and the HSV color space achieved a 76.25% and 77.5%, respectively. Wijaya et al. [7] presented a fusion of scale variant descriptor to extract the ROI, and a principal component analysis is used to reduce the feature vector. Then, matching the ROI with the training set using the nearest neighbor approach. This technique obtained an accuracy of 80%.

As for the machine learning technique, in [5], the color image is converted into YCbCr color space. Two feature extraction techniques including color-based and texture-based features are extracted a feature vector from the ROI. Hence, the results show that the combination of color- and texture-based features combined with a support vector machine (SVM) technique obtain more than 96%.

Contribution: In this paper, we evaluate the performance of 16 different techniques on a TI-UNRAM pornographic image dataset [7], [8]. The use of existing deep convolutional neural network (CNN) architectures (ResNet, GoogLeNet, and AlexNet) and a bag of visual words method are presented. In addition, this paper is combining three well-known local descriptor methods, called the local binary pattern (LBP) [9], the histogram of oriented gradients (HOG) [10], and the scale invariant feature transform (SIFT) [11] with three machine learning techniques include the SVM [12] using RBF kernel, multi-layer perceptron (MLP), and k-nearest neighbor (KNN). In deep learning, the results have shown that the ResNet architecture [13] are competitive when compared to the other deep CNN architectures. Furthermore, the results also show that the local binary pattern (LBP) when combined with the SVM using the RBF kernel, has obtained an accuracy of 87.80%, which is slightly lower than the ResNet architecture.

Paper outline: The remaining parts of the paper is organized as follows: In Section II, the pornographic image recognition approaches are described. In Section III, experimental settings and the results are presented. Finally, a conclusion and future work is given in Section IV.

II. Pornographic Image Recognition Methods

We will explain in this section the deep residual networks (ResNet) [13] and the local binary patterns (LBP) [9] with support vector machine (SVM) [12], which are used as image recognition methods.

A. Deep Residual Networks (ResNet)

ResNet architecture has very deep network [13]. It has shown good performance in many image recognition such as Hanja Chinese character [14], gastric pathology image [15].

He et al. [13] proposed a novel architecture called *shortcut connections*, the shortcut directly uses the input of the previous layer to the next output and sum the output in ReLu activation function. In [13], the deep ResNet architecture is proposed

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with a depth of 18, 34, 50, 101, and 152 layers on the ImageNet dataset. The ResNet-152 architecture is deeper 22 and 7 times than AlexNet [16] and GoogLeNet [17] architectures, respectively. The results on the ImageNet dataset show that the top-5 error rate decrease from 15.3% [16] to 3.6%.

Actually, the plain network (see Fig. 1(a)) uses in may deep learning such as VGGNet [18]. This network, however, the error increases when adding more layers. In the ResNet architecture, a building block as shown in Fig. 1(b) is proposed to due with the deeper layers.

B. Local Binary Pattern with Support Vector Machine (LBP-SVM)

Local Binary Patterns (LBP) is a non-parametric feature method and first proposed by Wang and He [19] for texture classification. In [19], a *texture specturm method* computed 8 neighbor pixels in a 3×3 neighborhood. Consequently, in [9] improved the performance of the LBP by use a two-level of the LBP. This method decreased the possible number of the texture units (TU) into $2^8 = 256$ TU. In the first level, the 8 neighbor pixels around the center pixel value are convert into 0 and 1 according to the threshold T. In this case, the center pixel value is defined as the T. The pixel value is assianed to 1 if the pixel more than T, otherwise, it assigns to 0. In the second level, thus, the 8 neighbor pixels are multiplied by the weights $(2^n, n = 0, 1, ..., 7)$ that given to the corresponding pixels. As a result, the values of the 8 neighbor pixels are summed and use as the texture unit. Nowaday, the LBP is applied to many applications such as face recognition [20] and character recognition [3].

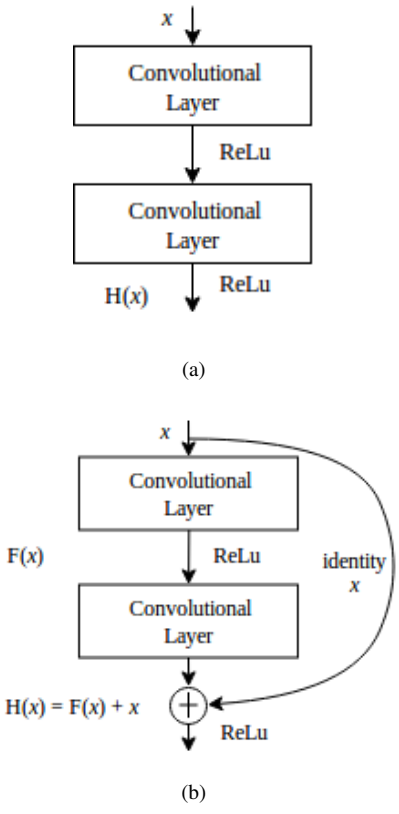


Fig. 1: Illustration of the residual learning between (a) plain network and (b) a residual network.

Support Vector Machine (SVM) algorithm [12] has been applied to many image recognition problems. The SVM algorithm finds the maximizing margin between the separating hyperplane and the training data, called *the optimal separating hyperplane*. The training set is $(\mathbf{x}_i, y_i), i = 1, ..., l$, where $\mathbf{x}_i \in \mathbf{R}^n$ with corresponding labels $y_i \in \{1, -1\}$. It can be split by the hyperplane $\mathbf{w}^T\mathbf{x} + b = 0$, where $\mathbf{w}$ is the weight vector and b is the bias. The optimal separating hyperplane obtains the largest distance to the closest positives $\mathbf{w}^T\mathbf{x} + b = +1$ and negatives $\mathbf{w}^T\mathbf{x} + b = -1$.

In this paper, we chose the radial basis function (RBF) kernel as a non-linear similarity function. The RBF kernel is defined by:

$$K(\mathbf{x}_i, \mathbf{x}_j) = exp(-\gamma \left\| \mathbf{x}_i - \mathbf{x}_j \right\|)^2 \quad (1)$$

The hyperparameters that need to be tuned in the SVM with the RBF kernel include the cost parameter C and the gamma γ. The C parameter has a significant effect on the decision boundary. It controls the with of the margin. The γ parameter directly affects overfitting. This cause large γ values to increase the number of support vectors.

III. Experimental Settings and Results

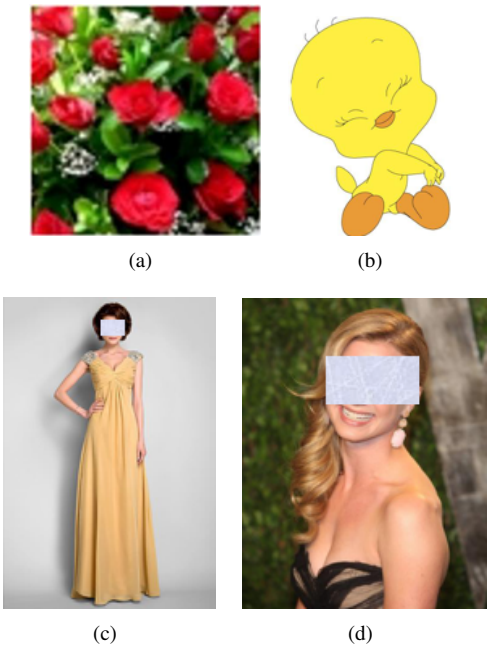
In this section, we first briefly explain the pornographic image dataset and the experimental setups used for the dataset. After that the results are presented and discussed.

A. The TI-UNRAM Pornographic Image Dataset

In this research, we evaluate the deep CNN methods and compare with the other methods including local feature descriptors combined with machine learning technique and bag of visual words on pornographic image dataset called *TI-UNRAM* [7], [8].

The TI-UNRAM dataset was introduced in [7], [8] to evaluate pornographic recognition algorithm. This dataset includes two classes (pornographic and non-pornographic), the dataset is randomly divided 50% of the whole dataset into training and test set. In the non-pornographic images include random objects such as flower, cartoon, bridge, planet, animal, plant, natural scene, and even food. Some examples of non-pornographic images are shown in Fig 2. The dataset contains 685 pornographic and 715 non-pornographic images, in total 1,400 images. These images are also collected from the Internet using a download tool. Then, images collected in numerous pixel resolutions. All images in the dataset are in RGB color space. Some of the pornographic images that show in the challenge dataset comprise single, couple, and even triple persons. An overview of the TI-UNRAM pornographic image dataset and the number of image training data are described in Table I.

In this dataset, mostly female appears in pornographic images. However, there is error occurred with this dataset.



(a) (b) (c) (d)

Fig. 2: Some examples of non-pornographic images, (a) flower image, (b) cartoon image, (c) and (d) woman images of the TI-UNRAM dataset.

TABLE I: Overview of the TI-UNRAM pornographic image dataset.

Dataset	Color format	Number of images			
		Total	Porn	Non-porn	Train/Test
TI-UNRAM [7], [8]	Color	1,400	685	715	700

Here, some of non-pornographic men images (see Fig. 3(a)) labeled as the pornographic class. Although, some of the pornographic women images are not the pornographic image, however, it labeled as the pornographic class, see Fig. 3(d)

B. Experimental Setup

In the experiments, we used 2-fold cross validation according to [7], [8] to evaluate the performance of the different methods. We compute the average and standard deviation for evaluating the test performance of the deep convolutional neural network (CNN) architectures and the variants of local descriptors combined with the machine learning methods, and a Bag of visual words (BOW) technique on the TI-UNRAM pornographic image dataset. For the local descriptors and the BOW methods, the images are resized to 90 $\times$ 90 pixel resolution, and 256 $\times$ 256 pixels for the deep CNN architectures.

C. Experimental Results

In this section, we compare the deep CNN architectures, local descriptors combined with machine learning methods, and the BOW technique for the pornographic image dataset.

As mentioned in many research studies [1], [2], [21], the deep CNN approaches are always obtained a high accuracy performance when a transfer learning and data augmentation are applied. To compare the deep CNN with the other methods, in our experiments, we decided not to use the transfer learning and data augmentation.

TABLE II: Recognition results (accuracy and standard deviation) using deep CNN methods for the TI-UNRAM pornographic image dataset.

Deep CNN Methods	Layer	Test Accuracy (%)
ResNet	50	**88.00± 0.37**
GoogLeNet	22	87.20± 0.18
AlexNet	8	86.10± 0.35
LeNet	5	85.90± 0.04

TABLE III: Recognition results using different local descriptors and machine learning techniques for the TI-UNRAM pornographic image dataset.

Methods	Test Accuracy (%)
LBP+SVM	**87.80± 0.13**
HOG+SVM	78.00± 0.02
SIFT+SVM	78.00± 0.01
LBP+MLP	85.80± 0.30
HOG+MLP	75.87± 0.01
SIFT+MLP	74.28± 0.02
HOG+BOW	80.71± 0.34
BOW	79.00± 0.21
LBP+KNN	73.50± 0.12
HOG+KNN	70.00± 0.01
SIFT+KNN	66.43± 0.02
FD+YCbCr [7]	83.97

The recognition results using deep CNN methods include accuracy and standard deviation are shown in Table II. According to the experimental results, if compare only the deep CNNs, the ResNet architecture outperforms the other deep CNN architectures. This approach has obtained an accuracy of 88% which is the best performance on the TI-UNRAM pornographic image dataset. Furthermore, the ResNet slightly better than the GoogLeNet. The ResNet architecture and other deep CNNs, however, takes a massive amount of time for computing for which the use of GPUs is necessary. We note that all deep CNNs experiments were carried out using the Keras with TensorFlow backend platform on a GeForce GTX 1050 Ti 4G GPU model.

Table III the experiments show when the local descriptors combined with the machine learning techniques; support vector machine (SVM), multi-layer perceptron (MLP), and K-nearest neighbor (KNN). The local binary pattern (LBP) outperforms the scale invariant feature transform (SIFT) and the histogram of oriented gradients (HOG) methods. Consequently, the LBP combined with the SVM (LBP+SVM) obtain an accuracy of 87.80% which is the highest result when the local descriptor combined with the machine learning technique. Also, in [7] proposed a fusion descriptor on YCbCr color space (FD+YCbCr) method and obtained a recognition rate of 83.97% on the TI-UNRAM dataset. It is clear, that when compared the FC+YCbCr and the LBP+SVM methods,

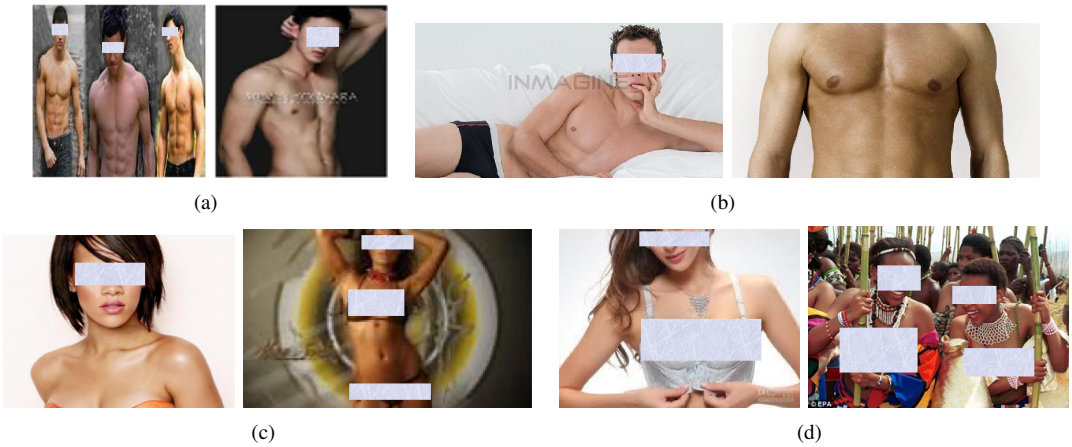


Fig. 3: Illustration of the complex images between (a), (c) non-pornographic and (b), (d) pornographic images of the TI-UNRAM dataset.

the LBP+SVM method has obtained more accurately.

IV. Conclusion

In this paper, we have presented a comparative study of local feature descriptors combined with machine learning techniques and a bag of visual words (BOW) to deep convolutional neural networks (CNNs) on the TI-UNRAM pornographic image dataset.

First, we proposed to use the local binary pattern (LBP), the histogram of oriented gradients, and the scale invariant feature transform as for the local descriptor methods. We combined these methods with three machine learning techniques; support vector machine (SVM), multi-layer perceptron, and K-nearest neighbor. The results show that the combination between the LBP and the SVM, called *LBP+SVM* outperforms the other combinations. The LBP+SVM method also gives a better result than the BOW method.

Second, three deep CNN architectures include the ResNet, GoogLeNet, and AlexNet architectures are compared. However, In many researches show that a transfer learning and a data augmentation obtained the highest results on the image classification. For this reason, to make a fair comparison, the transfer learning and the data augmentation are not performed on the deep CNN experiments. The deep CNN results have also shown that the best recognition accuracy is the ResNet, GoogLeNet, and AlexNet, respectively. The results show that the ResNet architecture obtains the best results. Finally, the ResNet architecture which is the best result in our experiment, also slightly higher than the LBP+SVM.

In future work we want to improve the result of the deep convolutional neural network (CNN) by using transfer learning [21] and data augmentation [1], [22]. We also consider the deep learning approach that requires less memory usage and a decrease in training computing time.

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References

[1] P. Pawara, E. Okafor, L. Schomaker, and M. Wiering, "Data augmentation for plant classification," in *Advanced Concepts for Intelligent Vision Systems*, J. Blanc-Talon, R. Penne, W. Philips, D. Popescu, and P. Scheunders, Eds. Cham: Springer International Publishing, 2017, pp. 615–626.

[2] E. Okafor, L. Schomaker, and M. A. Wiering, "An analysis of rotation matrix and colour constancy data augmentation in classifying images of animals," *Journal of Information and Telecommunication*, vol. 2, no. 4, pp. 465–491, 2018.

[3] L. Liu, H. Zhang, A. Feng, X. Wan, and J. Guo, "Simplified local binary pattern descriptor for character recognition of vehicle license plate," in *Computer Graphics, Imaging and Visualization, Seventh International Conference on*, Aug 2010, pp. 157–161.

[4] J. A. Marcial-Basilio, G. Aguilar-Torres, G. Sánchez-Pérez, L. K. Toscano-Medina, and H. M. Pérez-Meana, "Detection of pornographic digital images," *International Journal of Computers*, vol. 5, no. 2, pp. 298–305, Sep 2011.

[5] C. Santos, E. M. dos Santos, and E. Souto, "Nudity detection based on image zoning," in *Information Science, Signal Processing and their Applications (ISSPA), 11th International Conference on*, Jul 2012, pp. 1098–1103.

[6] S. Karavarsamis, N. Ntarmos, K. Blekas, and I. Pitas, "Detection of pornographic digital images," *International Journal of Digital Crime and Forensics*, vol. 5, no. 1, pp. 39–51, Mar 2013.

[7] I. G. P. S. Wijaya, I. B. K. Widiartha, K. Uchimura, and G. Koutaki, "Phonographic image recognition using fusion of scale invariant descriptor," in *Frontiers of Computer Vision (FCV), 21st Korea-Japan Joint Workshop on*, Jan 2015, pp. 1–5.

[8] I. G. P. S. Wijaya, I. B. K. Widiartha, and S. E. Arjarwani, "Pornographic image recognition based on skin probability and Eigenporn of skin ROIs images," *TELEKOMNIKA, Telecommunication, Computing, Electronics and Control*, vol. 13, no. 3, pp. 985–995, Sep 2015.

[9] T. Ojala and M. Pietik "A comparative study of texture measures with classification based on featured distributions," *Pattern Recognition*, vol. 29, no. 1, pp. 51 – 59, 1996.

[10] N. Dalal and B. Triggs, "Histograms of oriented gradients for human detection," in *Computer Vision and Pattern Recognition (CVPR), IEEE Computer Society Conference on*, vol. 1, Jun 2005, pp. 886–893.

[11] D. G. Lowe, "Distinctive image features from scale-invariant keypoints," *International Journal of Computer Vision*, vol. 60, no. 2, pp. 91–110, Nov 2004.

[12] V. N. Vapnik, *Statistical Learning Theory*. Wiley, 1998.

[13] K. He, X. Zhang, S. Ren, and J. Sun, "Deep residual learning for image recognition," in *Computer Vision and Pattern Recognition (CVPR), IEEE Conference on*, Jun 2016, pp. 770–778.

[14] S. Lee and G. Jang, "Recognition model based on residual networks for cursive hanja recognition," in *2017 International Conference on*

Information and Communication Technology Convergence (ICTC), Oct 2017, pp. 579–583.

[15] B. Liu, K. Yao, M. Huang, J. Zhang, Y. Li, and R. Li, "Gastric pathology image recognition based on deep residual networks," in *IEEE 42nd Annual Computer Software and Applications Conference (COMPSAC)*, vol. 02, Jul 2018, pp. 408–412.

[16] A. Krizhevsky, I. Sutskever, and G. E. Hinton, "Imagenet classification with deep convolutional neural networks," in *Neural Information Processing Systems, the 25th International Conference on*, ser. NIPS'12. USA: Curran Associates Inc., 2012, pp. 1097–1105.

[17] C. Szegedy, W. Liu, Y. Jia, P. Sermanet, S. Reed, D. Anguelov, D. Erhan, V. Vanhoucke, and A. Rabinovich, "Going deeper with convolutions," in *Computer Vision and Pattern Recognition (CVPR), IEEE Conference on*, Jun 2015, pp. 1–9.

[18] K. Simonyan and A. Zisserman, "Very deep convolutional networks for large-scale image recognition," in *Learning Representations (ICLR), International Conference on*, 2015, pp. 1–14.

[19] L. Wang and D.-C. He, "Texture classification using texture spectrum," *Pattern Recognition*, vol. 23, no. 8, pp. 905 – 910, 1990.

[20] I. L. Kambi Beli and C. Guo, "Enhancing face identification using local binary patterns and k-nearest neighbors," *Journal of Imaging*, vol. 3, no. 3, 2017. [Online]. Available: http://www.mdpi.com/2313-433X/3/3/37

[21] M. M. Ghazi, B. Yanikoglu, and E. Aptoula, "Plant identification using deep neural networks via optimization of transfer learning parameters," *Neurocomputing*, vol. 235, pp. 228 – 235, 2017.

[22] E. Okafor, R. Smit, L. Schomaker, and M. Wiering, "Operational data augmentation in classifying single aerial images of animals," in *IEEE International Conference on INnovations in Intelligent SysTems and Applications (INISTA)*, July 2017, pp. 354–360.

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Production plan scheduling on electronic factory

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***Abstract*— Production scheduling is essential in the modern manufacturing system. ARENA simulation software is generally used in the industrial practice to simulate discrete events for production.**

This paper aims to optimise the production sequence for the electronic assembly factory. In this study, we proposed an approach that enables collaboration between the software simulation and the optimisation theory. The structure is designed based on the hierarchical approach which divides the system into two layers: ARENA simulation software is used for simulating the production events while five optimisation algorithms consisting of Palmer, Gupta, CDS, FMECA and genetic algorithms are employed as the optimiser. The advantage of the proposed approach is that developers can program the algorithms to explore the optimal solution with the existing high reliable simulated model created by the planner/manager.

A comparison of the performance between different algorithms with a real case study for the benchmark revealed that the GA explored a superior solution with minimising operational time or makespan compared to its rival techniques regarding for production. (167 words)

Keywords—job scheduling, genetic algorithm, styling, insert

I. INTRODUCTION

In Asian countries, one of the important industries is the electronics industry which is rapidly evolving in the coming decades. In 2016, Thailand has become one of the leading suppliers of electronics especially assembling ICs and PCBs in the world with a massive value over USD 33 billion[1].

The improved reliability of the factory can be achieved by providing better production scheduling. Consequently, the production scheduling is the most critical issue in the modern manufacturing system especially when dealing with unexpected circumstances such as high demand. In general, the production scheduling relates to the management and allocation which requires a strong focus on the availability of the resources such as the number of employees, working time, the size of raw materials and the due date of delivering products to customers. Most leading manufacturing companies apply software simulation to design and reproduce the effect of the production line/event. The planners/managers are leveraging the simulated model to customise and verify the model before the real operation begins. In general, the solution of the production schedule can be categorised into two extreme directions: 1) modelling the problem to mathematical formulations and address the optimal solution using optimisation techniques and 2) employing simulation software to simulate the production line. This approach is widely used in industrial practice which does not require high skills in mathematics for modelling the problem and it is convenient for explanation, visualisation and communication in organisations.

ARENA Simulation[2] is one of the simulation software tools generally used in industries and is applied in various fields such as job shop environment[3] and healthcare[4]. The software provides primitive/advanced process modules for a simulation environment. The model of the production line can be created using a connection between process modules before setting parameters for each process. Also, ARENA allows users/developers to program script and control/change the components and the parameters for the simulated model which is more convenient in the real operational situation.

In this study, we investigate a case study of an electronics company located in the northern region industrial estate, Thailand. The company has been in operation for more than ten years and employs around 4,000 people, operates seven days a week, 24 hours a day to produce a wide range of flexible cable circuits which are the main components of the memory in the computer and telecommunication systems. In manufacturing, the process relates to many factors such as the number and types of orders, the number of workers, the number of raw materials, the capacity of machines and maintaining time products that can be done under a time slot. Thus, an effective production schedule whilst minimising operational time or makespan is necessary.

This paper provides an applied method for exploring the optimal production based on simulation technique. The designed structure integrates the optimisation algorithms and ARENA for developing a reliable and practical solution to the simulated production line. The approach is built upon two hierarchical process layers: a low and a high level. The lower level employs ARENA to generate a simulated model under constraints acquired from records/notes in practice to estimate a set of conditions and distributions for operation. The high level is responsible for optimising the simulated model using optimisation algorithms consisting of Palmer[5], Gupta[6], CDS[7], HFMECA[8] and genetic algorithms[9]. To be convenient for implementation, the optimisation algorithms are programmed on the ARENA which does not requires any plugin or other components. With the proposed approach, it guarantees that the existing simulated model generated by staff in the factory can be used in practice without any requirements.

The remaining part of this paper is laid out as follows. Section-2 presents the production line and problem. Section-3 explains the proposed techniques and approach are. Section-4 provides the experimental results for all scenarios. Section-5 presents the conclusion and the direction for future works.

II. THE PRODUCTION LINE

In this study, an electronic factory produces a wide range of products, however most of the orders mainly focus on seven products J, D, F, L, M, I and K which are the primary circuit parts of electronic products. The products are exported to various countries around the world for the final process of assembly. Thus, the due date for delivery is prioritised for the business to guarantee the products are distributed to customers on time. The schedulers/managers who face this issue of planning the sequence of production are able to get a decision on the production.

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The production system of the factory is set to be flexible and practical for adjusting all of the products. The process to produce each product consists of many sub-processes which can be summarised to 7 major stations as shown in **fig.1**.

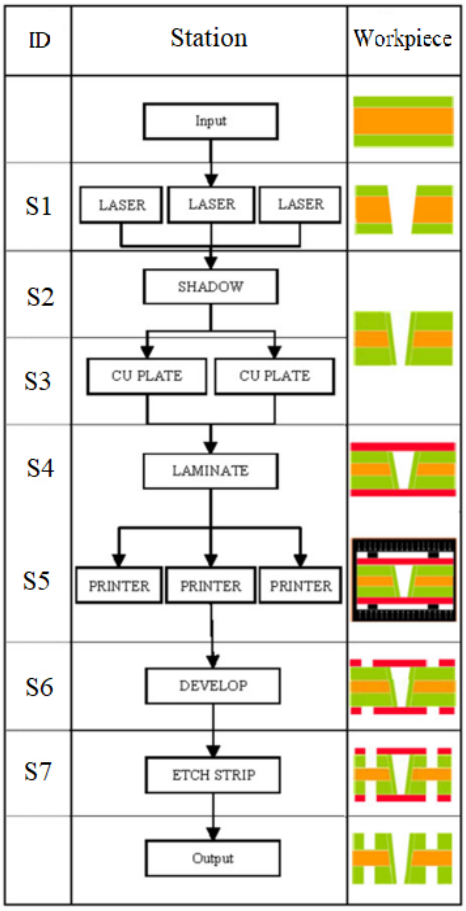

Fig. 1. The production process.

The production process of the printed circuit board: PCB begins by a station of laser cutting dependent on the character of each product type. The workpiece through this station will be sent to the next station. At the SHADOW station, the workpiece is firstly coated and coated again at the CU Plate station to make sure that all layers of the circuit board are connected. Then, the workpiece is the coat with specifying chemical material. The workpiece is sent to the Printer station to printing the line of PCB on both sides of the workpiece. The Develop station and the ETCH STRIP station make the radiation to eliminate the undesirable area of the workpiece in a different layer of the workpiece. Finally, the printed circuit board is created.

Note that each product type requires different conditions/setups for production such as operational times, lead time and the number of workpiece that each machine can produce per lot. For example, at station *S1*, product *J* requires operational time with (9, 11 and 14) in triangular distribution on the machine for laser cutting where 9 is the minimum time, 11 is the average time and 14 is the maximum time that is recorded from the real operation. The product of *S1* takes 5 minutes in average for delivery to the station *S2*. Also, the laser cutting machine can produce three-workpiece per an operation time.

In the factory, each station can consist of a single or multiple machines on the production line. **Fig. 2** shows the animation view of the real production line. It can be seen that the maximum number of machines are up to 4 and the minimum number is one. Also, the efficiency and maintenance time of each machine varies depending on each machine, for example, the station *S3* consists of two machines: *S3a* and *S3b*. The *S3a*–a new machine can be run 72 hours continually before maintenance while the S3a requires maintenance every 48 hours.

Fig.3 provides the simulated model of the production line using ARENA in flowchart mode. All of the processes and constraints for production are included inside a simulated model. The model is also verified in the actual operation to confirm that it can be used in the simulation for generating highly accurate production.

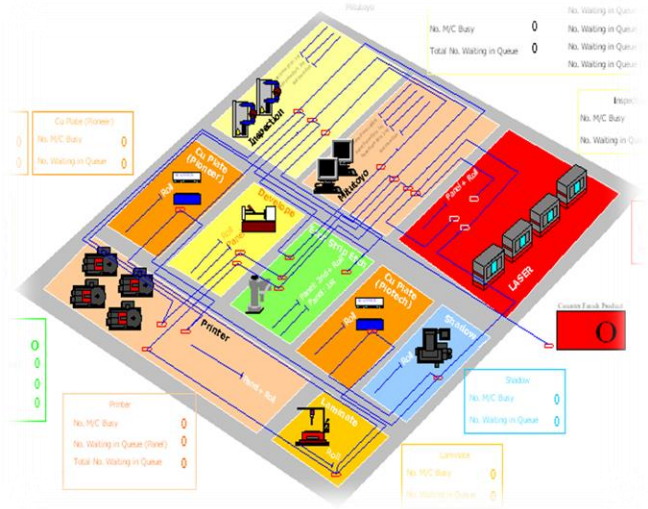

Fig. 2. The simulated production line using ARENA simulation in animation mode.

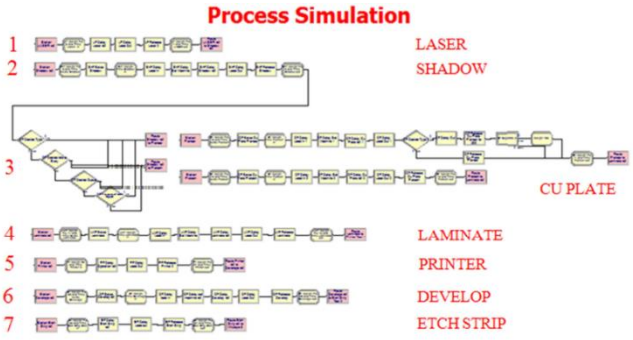

Fig. 3. The simulated production line using ARENA in flowchart mode.

III. Proposed Approach

A. *Proposed approach*

The proposed approach is based on the hierarchical approach which divides the system into two layers: a low and a high level. The low level is a response for a simulated model of the production line using ARENA. This model includes all constraints and conditions for the production such as the efficiency of each machine and workers depending on working time and types of the products. With the advantage of ARENA that allows users/developers to write script to control the model, the structure of the high level contains the scripts of optimisation algorithms consisting of palmers, Gupta, CDS, HFMECA and GA. The parameter/setting of each algorithm is passed from a higher level to the model and

then activates the model to get the output of simulation at a low level. The output of the simulation is sent back to the high level again to generate a new parameter for the next generation until the optimal solution is found. Finally, the optimal solution is approved by the senior manager and used for the actual production. Also, we benefit the high reliable existing model conducting to the simulated solution which is close to the actual production with this proposed approach. **Fig. 4** illustrates the proposed structure for optimisation on the production line.

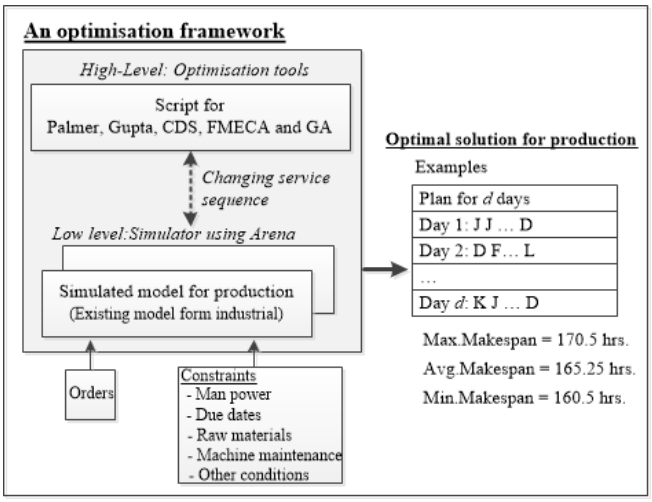

Fig. 4. The proposed approach for solving the production plan scheduling

The following sections provide the optimisation algorithms in use at the high level in this study.

Algorithm 1 – Palmer

Palmer proposed a heuristic method based on the priority of a tendency of the job in the production line. The processing time of each product is converted to the tendency and then ranked on a descending priority. A job with the highest slope index (Sj) of the tendency is firstly executed. The slope index can be mathematically formulated as follows:

$$S_j = (m-1)t_{j,m} + (m-3)t_{j,m-1} + (m-5)t_{j,m-2} + \ldots - (m-3)t_{j,2} - (m-1)t \quad (1)$$

Let m be the number of stage and $t_{j,m}$ be the operating time of job j at stage m. The slope index (S_j) is ordered from large to small that show as follows:

$$S[1] \geq S[2] \geq \ldots \geq S[n] \quad (2)$$

Algorithm 2 – Gupta

Gupta introduced an algorithm for production with the concept similar to Palmer. A slope index (S_j) of Gupta can be formed as follows:

$$S_j = \frac{e_j}{\min_{1 \leq k \leq m-1}\{t_{j,k} + t_{j,k+1}\}} \quad (3)$$

Let $e_j = 1$ when $t_{j,1} < t_{j,m}$ and $e_j = -1$ when $t_{j,1} \geq t_{j,m}$. After calculating S_j for all jobs, the jobs are subsequently ranked in an ascending order of the slope indices.

Algorithm 3 – CDS

CDS presented an improved algorithm based on Johnson's algorithm. This starts by generating $m-1$ stages and then partition m original stages into two virtual stages before solving the generated two stage problem by using Johnson's rule.

Algorithm 4 – HFMECA

HFMECA is a modified algorithm of the Shortest Processing Time Rule (SPT Rule). Firstly, all jobs are separated into two groups. The constraints are divided into two group: a constraint that can be done in a specific machine, and a non-constrained job that requires multiple machines for production. A group of the constrained job is scheduled firstly, and the non-constrained job is planned later.

Algorithm 5 – Genetic algorithm (GA)

Since its introduction by Holland, and the seminal done by Goldberg, genetic algorithm (GA) has been widely used to address problems in different applications. The GA-based approach is one of the most popular optimisation tools in use. **Fig. 5** shows the GA mechanism. The GA procedure starts with an initial set of randomly selected trial solutions, namely **population**. Each individual in the population is **encrypted** and referred to as a chromosome which represents a possible solution to the optimization problem. The chromosomes evolve through successive iterations, called generations. In each generation, the fitness of each chromosome is **evaluated**. The fitness of each chromosome reflects the potential to be the optimal solution. Each chromosome is reproduced according to its fitness value. Fitter chromosomes have higher probabilities to be selected for reproduction using crossover methods. The chromosome **selection** and reproduction are carried out in a reproduction process. The chromosomes resulting from the reproduction process form a **mating pool** and are collectively referred to as offspring. The offspring later undergo **genetic operations** consisting of crossover and mutation. The exploration of search space is carried out through the genetic operations where genetic operators are applied to existing chromosomes and transform them into new chromosomes. The genetic operators-derived chromosomes represent new trial solutions in the search space. The resulting chromosomes then form the new generation of population. The GA mechanism repeats until the optimal solution is reached.

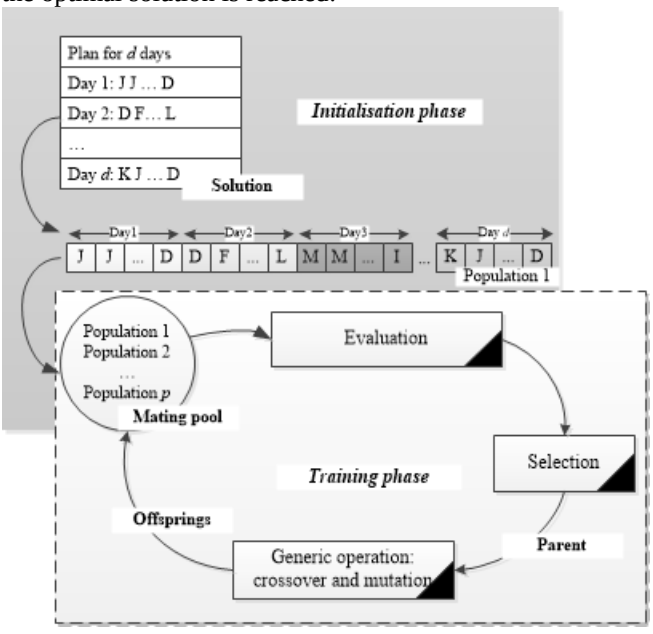

Fig. 5. The machanisim of GA.

IV. A CASE STUDY

The problem description given below is derived from the operation which aims to minimise the sum of makespan time while all constraints are satisfied. The experiment covers 13 weeks for the production, and the factory produces 7 types of products: J, D, F, L, M, I and K. The real orders from customers are used for the experiment.

The model of an objective function can take the form:

$$Min \sum_{w=1}^{W} \sum_{p=1}^{P} \sum_{i=1}^{I} makespan_{p,i}^{w}$$

Where W: the number of weeks
P: types of product
I: the number of order of each product

Fig. 6 shows the comparative performance graphs of all optimisation techniques over 13 weeks. The line graphs of the GA (red line) show the best pattern with minimising the sum of makespan.

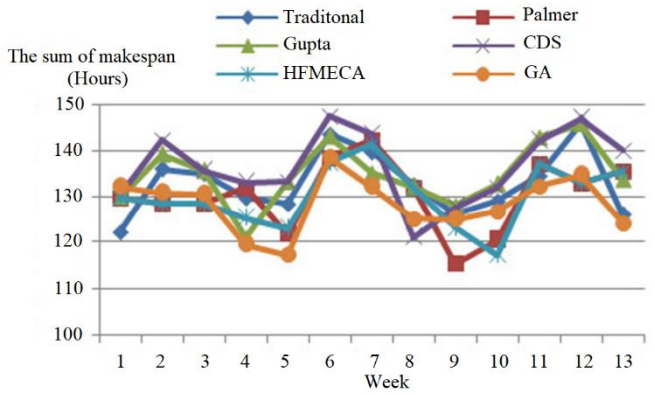

Fig. 6. The machanisim of GA.

As the idea behind a simulation model is to validate the real system, any simulation model must be accurately described in the actual system. In this study, statistical hypothesis testing using t-Test is employed to determine statistically difference between two sample means: the actual and the simulated makespan. A null hypothesis (***H0s***) is a stated assumption that there is no significant difference between the average of the actual makespan and the average of the simulated makespan for station *s*. The hypotheses are:

$$\boldsymbol{H0s}: \bar{X}_{s(Actual)} = \bar{X}_{s(sim)}$$
$$\boldsymbol{H1s}: \bar{X}_{s(Actual)} \neq \bar{X}_{s(sim)}$$

Based on the results of the t-test, the hypothesis H0 of all datasets are accepted and we can conclude that there is no significant difference between the means of the actual and simulated makespan for all stations as shown in table 1.

TABLE I THE HYPOTHESIS TEST OF THE MAKESPAN

Station	$\bar{X}_{Actual}$	$\bar{X}_{sim}$	***P***	***Result***
1) Laser	58.67	58.57	0.971	Accept H0 for each station $\bar{X}_{s,Actual} = \bar{X}_{s,sim}$ Where *s* is a station number from 1 to 8
2) Shadow	61.26	60.78	0.861	
3) Cu Plate	66.49	65.89	0.814	
4) Laminate	69.52	68.89	0.825	
5) Printer	129.06	126.16	0.320	
6) Develop	130.93	127.47	0.229	
7) Etch Strip	134.40	130.55	0.186	
8) Inspection	137.25	132.81	0.130	

V. CONCLUSION

The primary objective of this study is to present a production scheduling approach that incorporates the concept of optimisation algorithms and simulation techniques for exploring the optimal solution with minimising the sum of makespan for the production in an electronics company. Five optimisation algorithms consisting of palmers, Gupta, CDS, HFMECA and GA are programmed to control the simulation model using ARENA simulation software. Our simulated experimental results revealed that the GA is capable of generating the optimal schedule for the production line compared to the traditional method. The planned solution is verified with the actual production times. The statistical results using T-test shows that there is no significant difference between the simulated makespan and actual makespan in the production line.

REFERENCES

[1] T. B. o. I. o. Thailand(BOI), "Thailand's Smart Electronics," The Board of Investment of Thailand, 2016.
[2] W. D. Kelton, *Simulation with ARENA*: McGraw-hill, 2002.
[3] R. S. Edis, and A. Ornek, "Simulation analysis of lot streaming in job shops with transportation queue disciplines," *Simulation Modelling Practice and Theory*, vol. 17, no. 2, pp. 442-453, 2009.
[4] S. R. Chakravarthy, "Reliability, health care, and simulation," *Simulation Modelling Practice and Theory*, vol. 29, pp. 44-51, 2012.
[5] D. Palmer, "Sequencing jobs through a multi-stage process in the minimum total time—a quick method of obtaining a near optimum," *Journal of the Operational Research Society*, vol. 16, no. 1, pp. 101-107, 1965.
[6] J. N. Gupta, "A functional heuristic algorithm for the flowshop scheduling problem," *Journal of the Operational Research Society*, vol. 22, no. 1, pp. 39-47, 1971.
[7] H. G. Campbell, R. A. Dudek, and M. L. Smith, "A heuristic algorithm for the n job, m machine sequencing problem," *Management science*, vol. 16, no. 10, pp. B-630-B-637, 1970.
[8] A. P. K. Sethanun, K. Tipayasri, and N. Weerakornpimol, "Scheduling Hybrid Flowshops under Machine Eligibility Constraints," *Engineering and Applied Science Research*, vol. 31, no. 3, pp. 239-256, 2004.
[9] D. E. Goldberg, *Genetic Algorithms in Search, Optimization and Machine Learning*: Addison-Wesley Longman Publishing Co., Inc., 1989.

Using Geographical Information System and Multi-Criteria Analysis for Travelling Routing Design from Phayao Province to Luang Prabang

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***Abstract*— Tourism is the national agenda of Thailand. Phayao is the province in the north part of Thailand contains several attractive natural areas and cultural treasures. This paper presents a procedure to design an effective traveling route from Phayao province, Thailand to Luang Prabang province, Laos. In this paper, traveling data trips have been collected in the survey project and then the traveling database was constructed by secondary data and the survey data. After that, the potential traveling route has been considered by the expert, Thai government agencies and private tourism businesses. In this work, the Geographical Information System (GIS) function and the Multi-Criteria analysis were employed to identify appropriate routes. It found that the results from this project are very encouraging.**

Keywords—tourism planning, traveling route, geographical information system, route construction

I. INTRODUCTION

Tourism is one of the world's largest and most rapidly expanding industries, contributing with over ten percent to global GDP and generating employment for 200 million people, according to annual research by the World Travel & Tourism Council (WTTC) [1]. Technology plays a vital enabling role in tourism and is crucial to the expansion of the industry.

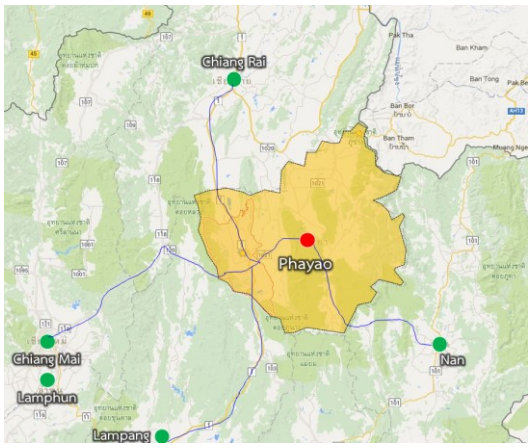

Fig. 1. The border connected between Phayao province and others.

Phayao is the province in the north part of Thailand contains several attractive natural areas and variety of cultures. Virtually enveloped by mountains and valleys, Phayao is a peaceful province. With only modest facilities and conveniences, it is an enchanting community with delightful natural beauty and fascinating religious sites. The province border is connected with many famous provinces such as Chiang Mai, Chiang Rai, Lampang, and Nan. It also connected to Laos which contains the beautiful natural areas and attractive traditional festival (see Fig.1).

Fig. 2. The border crossing points between Phayao and Laos [2].

In Fig. 2, the border crossing points between Phayao province and Laos demonstrated. These border crossing points including Chiang Khong - Huayxai, Ban Huak - Ban Pangmon, Huay Kon – Muang Ngeun, Tha Li - Kenethao, and the first Thai–Lao friendship bridge. It should be noted for travelers that, the passport is required when people want to pass these crossing points.

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Today, information technologies and tourism are two of the most dynamic motivators of the emerging global economy. Both tourism and IT increasingly provide strategic opportunities and powerful tools for economic growth, redistribution of wealth and development of equity around the globe. Many effective techniques such as [3][4][5][6][7][8] have been brought to provide effective routes to business and organizations in order to minimize cost. For the tourist, maps are a natural means of indexing and presenting tourism related information. Travelers are using maps to navigate during their travels and for preparing their routes. Moreover, maps exploit the two-dimensional capabilities of human vision and present the information in a compact and "easy to read" way. Because the GIS is one of an effective tool to provide routing maps to present information [6], therefore, it was chosen to evaluate the tourism database in this work.

In this paper, the traveling routes have been surveyed. The purpose is to collect the transportation data and produce effective route by the geographical analysis. The immediate objective is to overcome methodological issues in modeling a huge number of travel routes. To survey the traveling routes in Phayao province, Mueang Phayao, Dok Khamtai, Chun, Chiang Kham, and Phusang districts are investigated. After that, the possible routes are designed and reported. The rest of this paper including tourism route planning, methodology, the results and conclusion illustrated in section 2, 3, 4 and 5 respectively.

II. Tourism Route Planning

In the literature, the concepts of accessibility (the ease with which destinations are reached) and mobility (the ease of moving) have assumed heightened importance in this debate [9][10]. Tourism planning refers to the integrated planning of attraction (i.e., natural, cultural, man-made), service (e.g., accommodation, restaurants, shops, visitor information, tour and travel operations, money exchange, medical facilities, postal services etc.), and transportation facilities (i.e., both material infrastructure and transportation services). Tourism planning requires more spatial data collecting and processing, as all locations and their interrelations should be defined and analyzed within a spatial context. For this purpose, GIS can describe and identify tourism infrastructure elements geometrically, thematically and topologically. Moreover, GIS can deal with both object data (e.g., visitor centers, trails) as well as field data (e.g., humidity, altitude) of which both types can be represented in either grid or vector data format.

To construct tourist maps, vector graphic shapes (e.g., paths consisting of straight lines and curves), textual information, and images must be integrated. Each object is assigned to a thematic layer. Each layer combines related objects. To integrate tourism data the traditional layer model with layers like roads, buildings, watercourses, etc., must be widened with additional tourism layers like hotels, restaurants, sights and further infrastructure layers [10].

The process of tourism logistics model from [11] was examined in this work (see Fig. 3).

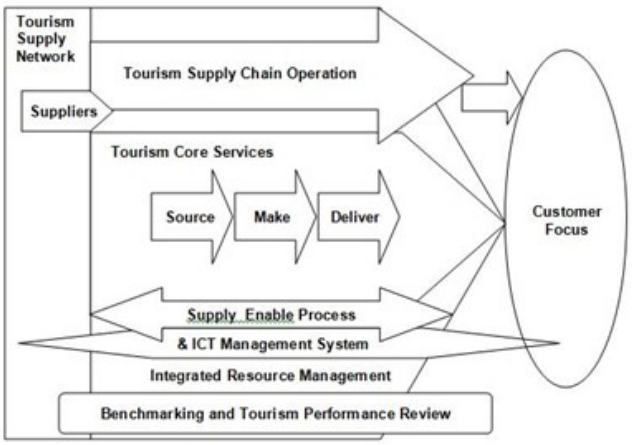

Fig. 3. Tourism logistics model [11].

III. Methodology

The strategy of this work is to develop an integrated framework for land use and transport development so that participation in activities by all sections of the community is promoted. The strategy proposes that spatial development will take place in the main towns of Phayao province and Laos. The main process to construct the travel routes is shown in the following figure.

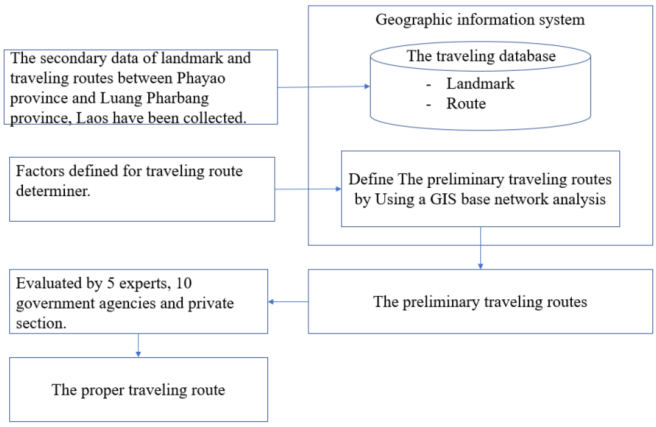

Fig. 4. The main process of the construction of the traveling route.

In Fig. 4, the secondary data of landmark and traveling routes between Phayao province and Luang Prabang province, Laos were collected. After that, the traveling database was constructed by the collected data and the spatial data. The traveling map between Phayao province and Luang Prabang province was created from the database by the GIS. Five experts and ten relating people from government and private sections were discussed and analyzed relating factors in the constructed routes by using the Multi-Criteria analysis.

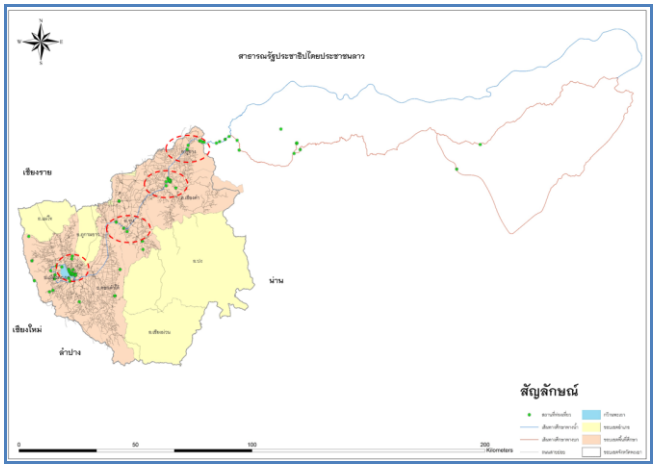

Fig. 5. The traveling landmark in Phayao province.

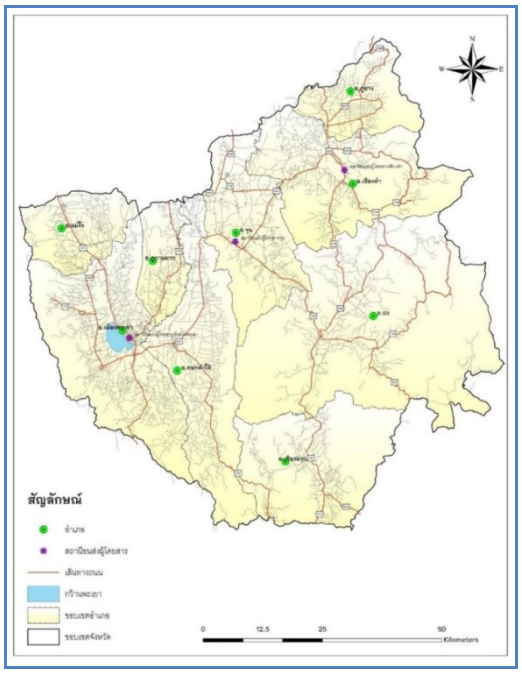

Fig. 6. The public transportation routes in Phayao province.

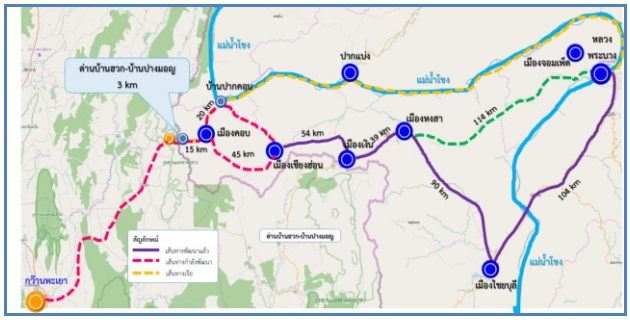

Fig. 7. The traveling routes by road from Phayao province to Luang Prabang province.

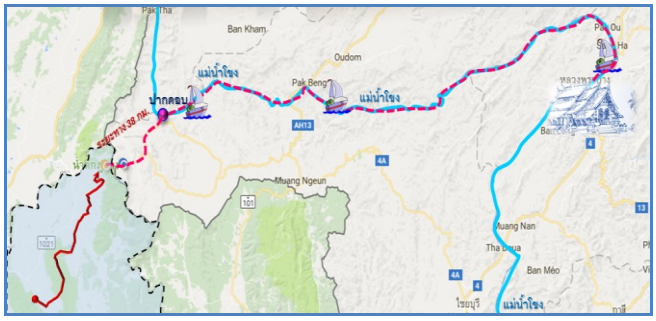

Fig. 8. The traveling routes by watercourses from Phayao province to Luang Prabang province.

Fig. 9. The public transportation routes from Phayao province to Luang Prabang province.

The geographical data can be seen in Fig. 5 to Fig 9. The secondary data of the landmark map is shown in Fig. 5 while the public transportation routes in Phayao province is shown in Fig. 6. The traveling routes by road and watercourses from Phayao province to Luang Prabang province are demonstrated in Fig. 7 and Fig. 8 respectively. Finally, the public transportation routes from Phayao province to Luang Prabang province are surveyed and shown in Fig. 9. The GIS was applied in the analytical process to transform the data into useful information. Spatial Analysis helps in creating new relationships from the data, viewing complex relationships between data, and making better decisions. The analysis functions use the spatial and non-spatial attributes in the database to answer questions about the real data and thus make new information available. These results can be achieved by queries in GIS Design and Application in this work. After the routes were produced, 4 factors which are (1) facilities/public utilities (2) transportation/ logistics (3) economic and (4) architecture were evaluated by the Multi-Criteria analysis (MCA). The results are shown in the next section.

IV. RESULTS

In this work, the GIS Design and Application recommends six best routes from the database as follows:

Route 1: The first watercourses traveling route from Kwan Phayao, city-state to Luang Prabang. It takes one day and one night in Phayao and then travel along the Mekong River to Luang Prabang.

Route 2: The first road traveling route from Kwan Phayao, city-state to Luang Prabang. The route takes one day and one night in Phayao and then go to Luang Prabang by road.

Route 3: The second watercourses traveling route from Kwan Phayao, city-state to Luang Prabang. This route suggests traveling in Phayao for two days and two nights and then travel to Luang Prabang by watercourses.

Route 4: The second road traveling route from Kwan Phayao, city-state to Louang Phrabang. The 4th route is the same as the 3rd route but travel to Luang Prabang by road.

Route 5: The third watercourses traveling route from Kwan Phayao-Jun-Chiang Kham-Pusang to Luang Prabang.

Route 6: The third road traveling route from Kwan Phayao - Jun-Chiang Kham-Pusang to Luang Prabang.

From these suggestion routes, the experts mention relating factors which should be the focus along the traveling routes including facilities/public utilities, transportation/ logistics, economic and architecture. The Multi-Criteria analysis (MCA) was applied to evaluate these factors and the results are shown in the following table.

Table 1 Weighting factor score

Factors	1	2	3	4	Total	Weighting Score
1	0	2.6	3	2.4	8	0.33
2	1.4	0	2.8	2.2	6.4	0.27
3	1	1.2	0	1.4	3.6	0.15
4	1.6	1.8	2.6	0	6	0.25
				Total	**24**	

In Table 1, factor number 1, 2, 3, and 4 refers to facilities/ public utilities, transportation/ logistics, economic, and architecture respectively. The score from Table 1 shows that the factors for the produced traveling route running from high to low level were facilities/ public utilities, transportation/ logistics, architecture, and economic successively. The results could help to develop more effective routes from Phayao to Luang Prabang in the future.

Next, each route was evaluated by the weighting score from Table 1 to find the most appropriate route. The results shown in Table 2 illustrates that the most effective route is route number 5. However, route 1 and route 3 are also recommended to travel.

V. CONCLUSION

The success of tourism in any country depends on the ability of that country to sufficiently develop, manage and market the tourism facilities and activities in that country. Most developing countries depend mainly on tourism for economic growth and diversity. In Thailand, tourism is one of the national agenda. This study was carried out in tourist destination Phayao province Thailand and Laos, which have a lot of tourist resources, facilities, products, and offers. In the study of the tourist potential of Phayao province in Thailand and Luang Prabang (Laos), the GIS was consistently used in the sense of concept and technology. At the same time, the GIS was used as an analytical tool for establishing arrangement and density of tourist objects in that area, as well as their characteristics, such as type, category, name, quality, and others. To provide efficient traveling information to tourists, this work performs the traveling database from the secondary data and the surveying data. Traveling routes between Phayao province and Luang Prabang province were created from the database by the GIS and then evaluated by 5 experts, 10 government agencies and private sections. The Multi-Criteria analysis (MCA) was applied to evaluate appropriate factors of each route. It found that the effective traveling routes provided by the GIS evaluation are satisfied. It points that the most effective route is route number 5.

REFERENCES

[1] D. Ake, "GIS and the tourism industry", SEDA – Council of Governments, Lewisburg, 2001.

[2] Department of Public Works and Town and Country Planning, Phayao

[3] K. Kantawong and R. Chaisrichareoun, "A hybrid ABC algorithm for vehicle routing problem with time window" AROB 20th 2015 International Symposium on Artificial Life and Robotics By Science and International Affairs Bureau, Ministry of Education, Culture, Sports, Science and Technology, Japanese Government".

[4] K. Kantawong and R. Chaisrichareoun, "An Improving ABC Algorithm for Long-haul Time Dependent Vehicle Routing Problem". the International Conference on Digital Arts, Media and Technology (ICDAMT) which was formed by Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology Association of Thailand (ECTI Thailand).

[5] K. Kantawong and R. Chaisrichareoun, "The New Methodology for Vehicular Network". Global Wireless Summit-2016, pp. 334-338. Aarhus University, Denmark.

[6] K. Kantawong, "Multi-phase Method for Geographical Transportation". International Journal of Geoinformatics, 13(3), 2017.

[7] K. Kantawong and R. Chaisrichareoun, "An Improving ABC Algorithm for Time Dependent Transportation Problem". International Journal of Applied Engineering Research ISSN 0973-4562 Volume 13, Number 5 (2018) pp. 2809-2813.

[8] K. Kantawong and R. Chaisrichareoun, "The New Methodology for Vehicular Network with Fuzzy Time Windows". Malaysian Journal of Computer Science.

[9] Moseley, M.A., 1979. Accessibility: The Rural Challenge. Methuen, London.

[10] Preston, J., Rajé, F., 2007. Accessibility, mobility and transport-related social exclusion. Journal of Transport Geography 15 (3), 151–160.

[11] Mingsap Kaosa-ard and Komsan Suriya, 2008. An analysis of Tourism Logistics in Tourism City. Integrated Development of Sustainable Tourism in the Mekong Region 3. Chiang Mai: Social Research Institute, Chiang Mai University.

Table 2 Score and weighting score of each route.

Factors	Weighting Score	Route 1		Route 2		Route 3		Route 4		Route 5		Route 6	
		score	result	score	result	score	result	score	result	score	result	score	result
1	0.33	4.30	1.43	4.30	1.43	3.78	1.26	3.50	1.17	4.70	1.57	4.50	1.50
2	0.27	4.20	1.12	3.00	0.80	3.40	0.91	3.60	0.96	3.60	0.96	2.70	0.72
3	0.15	4.20	0.63	2.60	0.39	4.20	0.63	2.60	0.39	4.20	0.63	2.80	0.42
4	0.25	4.30	1.08	4.40	1.10	4.10	1.03	4.30	1.08	4.50	1.13	4.40	1.10
Total			**4.26**		**3.72**		**3.82**		**3.59**		**4.28**		**3.74**
Rank			**2***		**5**		**3***		**6**		**1***		**4**

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Developing the Evaluation System of the Thai Dance Training Tool

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***Abstract*—The Thai traditional dance training tool was created with the objective to develop the technologies for supporting the learning of Thai traditional dance, which still has been transferred orally from generation to generation. The tool collects the dataset of dance movements from traditional Thai dance experts using motion capture system and it uses them to show a demonstration for the user, then it gives the user a stage to perform and record their movement data using the Microsoft Kinect sensor. The movement data obtained will be evaluated and a score is generated to provide feedback for the user at the end. The project also tests the performance of the evaluation by comparing the score generated by the tool with the score generated by a traditional Thai dance teacher from the College of Dramatic Arts to calculate the inverted pair and the displacement in order to see the difference. The project tries to test the evaluation method that uses the formula to calculate the similarity percentage between the user's movement and the expert's movement. This testing method gives 17.7% inverted pair and 53% displacement. The project and also tries many evaluation methods using different regression algorithms in machine learning from which the best results are from the Random Forest Classifier that gives 7.89% inverted pair and 48% displacement, and from the Decision Tree Regressor that gives 15.79% inverted pair and 44% displacement.**

Keywords— Thai traditional dance; Microsoft Kinect sensor; evaluation; Thai Dance Training Tool;

I. INTRODUCTION

Thailand is one of the richest cultural heritage countries. Thai tradition and culture, which has grown along with the lifestyle of Thai people for a long time, contribute to the invention of many cultural arts. One of the most valuable ones is Thai Dramatic Art, the dance performance that has played an important role in the history of culture. From rituals to celebrations, it penetrated all the important dimensions of the past.

To preserve this intangible cultural heritage, the government intends to make the new generation familiar with the Thai dance by implementing basic Thai dance lessons into the basic education core curriculum of the Thai education system. Besides, they also established the College of Dramatic Arts which uses a specific curriculum focused on teaching Thai Dramatic Arts, especially for students who are interested in Dramatic Arts and want to make a career in this field. Recently, technology has been introduced to manage the traditional Thai dance knowledge. Y Tongpaeng developed a tool for storing the traditional Thai dance movements. [1] His projects aim to translate Thai dance notation using Labanotation to digital data [2] and convert them into 3D animation to represent it to the user [3]. However, up until now, there are not too many tools or technology provided to support practical learning. Thai dance knowledge is still transferred to the next generation orally because the movement is delicate, complex and has a lot of details. The process of learning starts from watching the demonstration from the teacher to observe how to pose and move, then the students perform them following the demonstration while the teacher thoroughly corrects the students' movements along their performances. Moreover, students also need to regularly practice by themselves to improve their movements more precisely.

In 2012, João presented the prototype of the system called "Super Mirror" for assisting the ballet learners to practice their skills. This system compares the captured live motion with the recorded ballet movements to show the difference and provide real-time instructional feedback for the user [4]. In 2015, S. Chernbumroong proposed a research about Gamification in the classroom, his studies showed that gamification elements can encourage the motivation in learning [5], Based on the ideas of the practical dance learning tool and the gamification tool, we present the development of the Thai dance training tool, the tool for practicing the traditional Thai dance by evaluating the user's movements and giving users the useful feedback. By following the steps of the traditional Thai dance learning, the tool will give users the demonstration in 3d animation which is an appropriate way for learning inputs [6]. Next, the tool will let users perform to evaluate their movements. This paper focuses on developing the evaluation method and improving the evaluation performance to be equivalent to the standard evaluation of the College of Dramatic Arts.

The paper is organized as follows : Section II is the description of the system structure of the tool and the evaluation method using the formula, section III describes the performance testing and the results, section IV describes the experiment of machine learning as an evaluation method and the testing results. Finally, section V contains the conclusions of the experiment results.

II. STATE OF THE ART DANCE TRAINING TOOLS

In 2016, Ob-orm developed a prototype for the Thai dance training tool. The prototype has a function for evaluating the accuracy of a real-time traditional Thai dance movement form

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the user by obtaining the dance movement from the Kinect sensor and then comparing it with the traditional Thai dance movement collected from an expert in the database. The process is to compare the angle of the bones which is composed from the connection of the joints from the 3D models that contain the movements from 2 sources. The prototype calculates an average percentage and grade in the end. [7]

Yootthapong proposed the work titled Evaluating Real-Time Thai Dance Using Thai Dance Training Tool for assisting the traditional Thai dance students by correcting the accuracy of their dance movements. The work uses a similar model to Ob-orm's focusing on designing a system and developing an evaluation method. [8]

Based on Yootthapong's work, this paper continues to develop the evaluation method focusing on improving the performance of the evaluation. Below is a description of the training tool:

A. System Overview

The Thai Dance Training Tool compares the real-time traditional Thai dance movement of the user with the traditional Thai dance expert's movements to evaluate the accuracy of the user's dance movements and to give the user a feedback in the form of similarity percentage. The system diagram of the tool is shown in Figure 1. Traditional Thai dance movement data from the expert is collected using the optical motion capture system. This motion data is applied to the skeleton of the 3D human model and then stored in the form of a 3D animation in the database of the tool to be used in the comparison process as a criteria. The tool is installed on a computer which is connected to a Microsoft Kinect sensor. When the user performs the dance in front of it, the tool can obtain the dance movement from the user. The dance movement from the user is also applied to the skeleton of another model that has the same characteristics as the model that the movements ofthe expert had been applied to, in real-time. The comparison method uses data from the joints ,which are the sub-units of the skeleton that control each body part of the model, to calculate the differences.

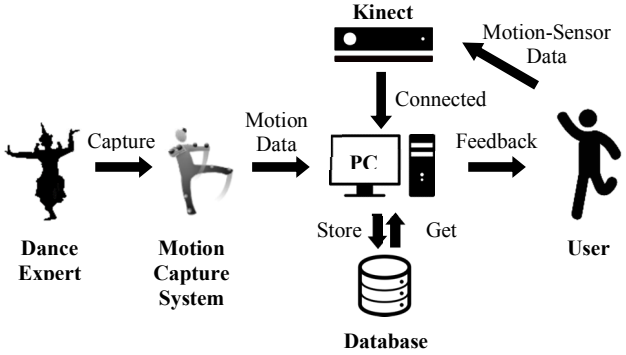

Fig. 1. The system diagram.

B. System Prototype

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- Menu stage - The menu stage offersthe dance choices allowing the user to choose the dance that they want to practice.
- Play stage - After the user selects a dance. After selecting the dance, a video of the dance is shown to let the user know how to move before practicing based on observation. When the video ends, a countdown shows the user how much time he or she has to prepare. The user can start performing immediately when the countdown ends, the screen shows an animation of the user's movements from Kinect and also an animation of the expert's dance beside. In the meantime, the system starts processing the comparison.
- Result stage - This stage gives the user the similarity percentage between the user's dance and the expert's dance to provide feedback on accuracy.

C. Comparison method

As mentioned above, the tool uses data from the joints to compare the movements of the user and the expert.

Jacky C.P. Chan proposed a dance training system using the motion capture. To find the best measurement method for evaluating the dance performance, he made an experiment to compare three different measurement methods including joint position, joint velocity, and joint angle. The result shows that joint position is the best measurement method. The second and the third are angle and velocity, respectively. [9]

The comparison process compares the position data and the rotation data of each joint one by one in every frame, then calculates the result in a form of a similarity percentage.

For the position comparison, the difference is calculated using the Euclidean distance between joints based on the following formula:

$$Distance = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2}$$

To find the position similarity percentage, the maximum threshold, which is the value for defining the range the user accuracy is measured in, are set in Unity units, then it is used to calculate the percentage as the following formula:

$$Position\ similarity\ percentage = 100 - \left(\frac{Distance}{Threshold} * 100\right)$$

For the rotation comparison, 3D Unity units provide a function called *Quaternion.Angle*. By using this function, the rotation differences can be obtained as an angle between two rotations in degrees. After that, the rotation similarity percentage is calculated by following the same method as the position accuracy but the threshold would be fixed to 360 degrees.

$$Rotation\ similarity\ percentage = 100 - \left(\frac{Angle\ between\ two\ rotation}{360} * 100\right)$$

Then the tool calculates the averages of the Position Similarity Percentage and the Rotation Similarity Percentage as a final percentage of each joint.

For the result, the tool provides the similarity percentage between the user's dance and the expert's dance which is the average of the similarity percentages of all joint types.

III. The Evaluation Method Relevant for Scoring the Dances

In order to get a good performance evaluation system, the evaluation system needs to be able to rate in accordance with the standard scoring from the College of Dramatic Arts. Thus, the result from our comparison method are analyzed along with the score from a traditional Thai dance teacher from the College of Dramatic Arts to see if they are relevant or not.

Ravi Kumar describes the methods for measuring the distance between ranking [10] that could be used to analyze the score to identify the correlation of the scores from a program evaluation and a standard scoring. There are 2 methods that has been chosen for analysis in this work as follows:

A. Kendall's Tau

This method provides a total number of inversions which is counted from pairs of elements i and j from the teacher's rank and the tool's rank σ such that $i < j$ and $\sigma(i) > \sigma(j)$ as the following formula:

$$K(\sigma) = \sum_{i>j} 1_{\sigma(i)<\sigma(j)}$$

B. Spearman's Footrule

This method gives a total displacement which is calculated from the distance an element i moved due to $\sigma = |i - \sigma(i)|$ as the following formula:

$$F(\sigma) = \sum_{i} |i - \sigma(i)|$$

The dance data is collected from the sample group of people with scores from the tool and scores from the traditional Thai dance teacher. Then the scores from these 2 sources are ranked generating the traditional Thai dance teacher's rank and the tool's to be applied to the measurement method.

The dance data from 20 people were analyzed using the methods that were mentioned above, the result is provided in table I. The score analysis shows that as regards the example gesture the scoring between the tool and the teacher has 33 inverted pairs which is 17.7% of the result, and the total number of displacements are 106 which is 53%. The results show that the scorings don't correlate well.

TABLE I. The Result from Scores Analysis

No.	Score		Rank		K(σ)	F(σ)
	Expert	Computer	Expert	Computer		
1	80	49	3	16	8	13
2	80	50	3	7.5	2	4.5
3	80	49	3	16	8	13
4	80	59	3	1	0	2
5	80	50	3	7.5	2	4.5
6	70	50	6	7.5	2	1.5
7	60	50	7	7.5	2	0.5
8	50	49	12	16	1	4
9	50	49	12	16	1	4
10	50	50	12	7.5	1	4.5
11	50	51	12	3	1	9
12	50	49	12	16	1	4
13	50	50	12	7.5	1	4.5
14	50	50	12	7.5	1	4.5
15	50	50	12	7.5	1	4.5
16	50	49	12	16	1	4
17	40	54	18.5	2	0	16.5
18	40	49	18.5	16	0	2.5
19	40	49	18.5	16	0	2.5
20	40	49	18.5	16	0	2.5
Sum					33	106

IV. Machine Learning Approach for Dance Training Scoring

Since the evaluation system that has been developed can't evaluate as good as expected, the experiment needs to find another method that can provide more relevant results to improve the tool performance. Regression algorithms in machine learning provide a method for such an approach. By putting an amount of dance movement data from the user with the rating from the teacher for each movement data into the tool, the program automatically learns how the teacher rates the scores from the movement-score pairs as inputs, then the program can evaluate the dance based on that dataset.

A. Dataset Structure

To teach the machine, the dataset files are prepared as inputs for the learning process, one file for one dance gesture. The files contain lines of data we extract from the dance movement animation files, one line for one case. Each line consists of a user movement data plus expert movement data, which is the position data and the rotation data of each joint from every frame of movement, and ends with a score that the expert gives for the user movement of that line.

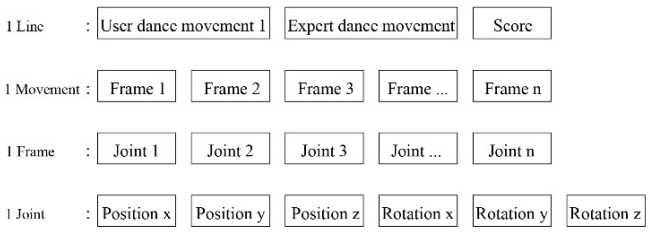

Fig. 2. Dataset Structure

B. Using Regression Algorithm to Predict The Scores

We extracted the significant features from our tool including positions and rotations of each joint of body parts.

Particularly, there are six selected features to express each joint (position x, position y, position z, rotation x, rotation y, rotation z). Therefore, we represented one movement data being a feature vector with at least 294360 extracted features. The same 20 movement data of the traditional Thai Dances that we used in the evaluation system in section 3 are used for training and testing. With a large dimension extracted from each movement data and a few items/vectors (20 videos), we use several regression algorithms to predict the score such as SVR (Support Vector Regression), Linear Regression, Lasso, Decision Tree Regression, Decision Tree Classifier for testing using many different parameters.

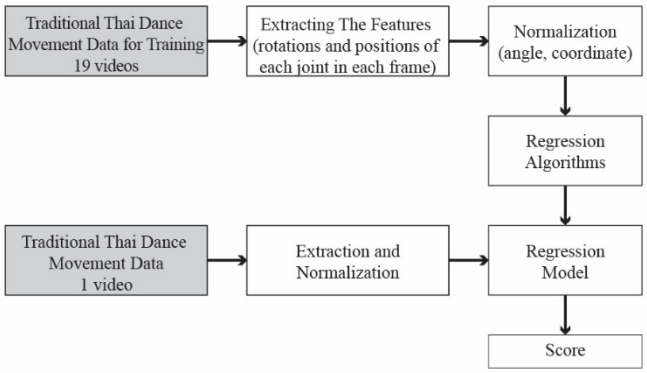

Fig. 3. Regression Framework

For the experiment, we created the leave-one-out training sets, we employed the procedure to create n independent replicates of the original data set where n is the number of the Thai dance videos (n=20 videos). Each set (replicate) is identified by a value i where i = 1, …, n. Individual observations are systematically removed from each of the sets, creating a training set i training and testing set i test. We accomplished this by creating a second id for each movement data based on observation number in the original dataset, then deleting if the second id equals i. These steps simply create the indicator variable for whether the data for a certain individual will be used in that particular training set or as the testing set.

The experimental result is represented in the table below:

TABLE II. SCORE FROM MACHINE LEARNING METHOD

No.	Machine Learning Score										
	Linear Regression	SVR (1)	SVR (2)	SVR (3)	SVR (4)	Lasso	LassoLars	Random Forest Classifier	Decision Tree Regressor	Random Forest Regression (1)	Random Forest Regression (2)
1	58	55	58	57	58	56	70	50	80	63	57
2	62	58	62	61	62	56	56	50	50	48	57
3	64	56	64	63	64	56	52	80	50	67	60
4	52	50	52	52	52	56	59	80	50	57	54
5	61	53	60	60	60	56	49	50	50	61	52
6	63	58	63	63	63	57	65	80	50	62	64
7	56	54	56	57	56	57	59	50	70	64	61
8	39	40	39	41	39	57	56	50	50	50	48
9	53	50	53	53	53	57	59	50	50	50	54
10	54	51	54	54	54	57	48	50	50	56	54
11	60	53	60	59	60	57	57	80	80	66	59
12	70	61	70	69	70	57	63	50	50	56	61
13	64	63	64	64	64	57	63	50	50	64	62
14	62	55	62	61	62	57	55	50	50	59	56
15	62	59	62	61	62	57	71	80	50	56	63
16	57	55	57	57	57	57	58	80	80	58	65
17	62	56	62	62	62	58	63	50	40	59	63
18	56	57	56	57	56	58	60	50	50	61	58
19	46	46	46	47	46	58	67	50	80	58	55
20	47	48	47	48	47	58	52	50	40	58	55

Using the same method as the analysis of the program evaluation, the result from all machine learning algorithms that are used in the experiment is analyzed as shown in the following tables:

TABLE III. INVERTED PAIRS

No.	K(σ) - Inverted Pairs											
		Machine Learning										
	Program Evaluation	Linear Regression	SVR (1)	SVR (2)	SVR (3)	SVR (4)	Lasso	LassoLars	Random Forest Classifier	Decision Tree Regressor	Random Forest Regression (1)	Random Forest Regression (2)
1	8	7	6	7	7	7	15	1	4	0	3	9
2	2	3	3	3	4	3	15	11	4	4	15	9
3	8	1	5	1	2	1	15	13	0	4	0	7
4	0	12	11	12	12	12	15	7	0	4	10	12
5	2	6	9	6	6	6	15	14	4	4	4	14
6	2	2	3	2	2	2	4	2	0	4	3	1
7	2	7	7	7	6	7	4	6	3	3	1	4
8	1	4	4	4	4	4	4	3	0	1	4	4
9	1	2	2	2	2	2	4	3	0	1	4	4
10	1	2	2	2	2	2	4	4	0	1	4	4
11	1	1	2	1	1	1	4	3	0	0	0	1
12	1	0	0	0	0	0	4	1	0	1	4	1
13	1	0	0	0	0	0	4	1	0	1	0	1
14	1	0	2	0	1	0	4	3	0	1	1	2
15	1	0	0	0	1	0	4	0	0	1	4	0
16	1	1	2	1	1	1	4	3	0	0	2	0
17	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
Sum	33	48	58	48	51	48	119	75	15	30	59	73

TABLE IV. TOTAL DISPLACEMENT

No.	F(σ) - Total Displacement											
		Machine Learning										
	Program Evaluation	Linear Regression	SVR (1)	SVR (2)	SVR (3)	SVR (4)	Lasso	LassoLars	Random Forest Classifier	Decision Tree Regressor	Random Forest Regression (1)	Random Forest Regression (2)
1	13	8	7	8	9.5	8	15	1	10.5	0.5	2	8.5
2	4.5	3.5	1.5	3.5	4	3.5	15	11.5	10.5	9	17	8.5
3	13	0.5	4.5	0.5	0.5	0.5	15	14.5	0.5	9	2	5
4	2	14	13.5	14	14	14	15	7	0.5	9	11	14
5	4.5	6	10.5	6.5	6	6.5	15	16	10.5	9	4.5	16
6	1.5	2	1.5	2	2.5	2	4	2	2.5	6	0	4
7	0.5	6.5	5	6.5	5.5	6.5	3	3	6.5	2	3.5	0.5
8	4	8	8	8	8	8	2	2.5	1.5	0	6.5	8
9	4	4	4.5	4	4	4	2	2	1.5	0	6.5	5
10	4.5	3	3	3	3	3	2	8	1.5	0	4	5
11	9	2	1.5	2.5	2	2.5	2	1	8.5	9.5	10	3
12	4	11	10	11	11	11	2	6	1.5	0	4	5.5
13	4.5	9.5	11	9.5	10	9.5	2	6	1.5	0	8.5	7
14	4.5	5.5	2	5.5	5	5.5	2	4	1.5	0	2.5	1
15	4.5	5.5	9	5.5	5	5.5	2	11	8.5	0	4	8.5
16	4	0	2	0	0.5	0	2	0	8.5	9.5	0	11
17	16.5	12	11	12	13.5	12	16	12.5	5	1	9	15
18	2.5	5	12.5	5	6	5	16	10.5	5	6.5	11	8.5
19	2.5	0.5	0.5	0.5	0.5	0.5	16	15.5	5	16	6.5	4
20	2.5	0.5	0.5	0.5	0.5	0.5	16	1	5	1	6.5	4
Sum	106	107	119	108	111	108	164	135	96	88	119	142

From the score analysis result, there are 2 algorithms that give the number of inverted pairs and the total displacement less than the program evaluation which is Random Forest Classifier (7.89% inverted pair and 48% displacement) and Decision Tree Regressor (15.79% inverted pair and 44% displacement)

However, the analysis shows that the result from the program evaluation compared to the result from machine learning algorithms are not very different from and are not correlated with the scores from the traditional Thai dance teacher as it was expected.

V. Conclusion

In conclusion, this work reports the development and testing result of Thai traditional dance evaluation system for the Thai dance training tool project.

The evaluation method, at first, uses the formula to calculate the similarity percentage between user's movement and expert's movement. To test the performance, the scores from the evaluation method are collected and their rank is compared with the rank of scores given by the traditional Thai dance teacher from the College of Dramatic Arts by calculating the inverted pair and the displacement. This testing method gives 17.7% inverted pair and 53% displacement.

The results were not as good as expected, so the regression algorithms in machine learning were implemented to be used for evaluation instead of using the formula for calculation. After trying several regression algorithms, the results show that there are 2 algorithms that give better results than the formula calculated which are Random Forest Classifier that has 7.89% inverted pair and 48% displacement, and Decision Tree Regressor that has 15.79% inverted pair and 44% displacement.

Acknowledgment

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References

[1] Y. Tongpaeng., M. Rattanakhum, P. Sureephon., S. Wicha. "Implementing A Tool for Translating Dance Notation to Display in 3D Animation: A Case Study of Traditional Thai Dance" In: Benferhat S., Tabia K., Ali M. (eds) Advances in Artificial Intelligence: From Theory to Practice. IEA/AIE 2017. Lecture Notes in Computer Science, vol 10351. Springer, Cham

[2] Y Tongpaeng, K Nantapatsaran, P Sureephong, "Interpreting Thai Laban Notation into ThaiDanceXML" International Conference on Digital Arts, Media and Technology 2018 (ICDAMT 2018), page 173-178, IEEE, 2018

[3] Y Tongpaeng, T Somyawakath, P Sureephong, "Translation Process of ThaiDanceXML into a 3D Animation Representation" International Conference on Digital Arts, Media and Technology 2018 (ICDAMT 2018), page 179-184, IEEE, 2018

[4] João B., Sebastian K. "SuperMirror : A Kinect Interface for Ballet Dancers". Retrieve December 11, 2017

[5] S. Chernbumroong, P. Sureephong, "Gamification in classroom, effect of categorization of extrinsic reward to motivate student learning performance", In Proceedings of the international Convention on Rehabilitation Engineering & Assistive Technology, Singapore Therapeutic, Assistive & Rehabilitative Technologies (START) Centre, November 2015, Article No. 16

[6] Chernbumroong, S., Suereephong, P. and Puritat, K., 2017. Massive Open Online Course Related Learning Style and Technology Usage Patterns of Thai Tourism Professionals. International Journal of Emerging Technologies in Learning (iJET), 12(11), pp.98-120.

[7] O. Muangmoon, P. Sureephong, K. T abia "Dance Training Tool using Kinect-based Skeleton Tracking and Evaluating Dancer's Performance" Retrieve October 11, 2017

[8] Y. Tongpaeng, P. Sribunthankul, P. Sureephong, "Evaluating Real-Time Thai Dance Using Thai Dance Training Tool" International Conference on Digital Arts, Media and Technology 2018 (ICDAMT 2018), page 185-189, IEEE, 2018

[9] Jacky C. P. C., Howard L., Jeff K. T. T., Taku K. "A visual Reality Dance Training System Using Motion Capture" Retrieve December 20, 2017

[10] I. S. Jacobs and C. P. Bean, "Fine particles, thin films and exchange anisotropy," in Magnetism, vol. III, G. T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271–350.

Improving ThaiLabanXML Standard for the Automatic Thai Laban Drag & Drop System

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***Abstract*—Thai dance has a long history in Southeast Asia. Preserving Intangible Cultural Heritage is a challenging task that requires the use of a combination of technologies to record and represent the dance as a three-dimensional human figure. The Labanotation System had been used to record many kinds of dances such as the Thai dance. To represent the Thai dance as a 3D animation based on Thai Laban Scores, the first version of ThaiDanceXML standard was developed to convert the data manually from Human-Readable data to Machine-Readable data. There are some issues occurred such as the human error regarding reading Thai Laban scores and writing ThaiLabanXML. Hence, a Thai Laban Drag & Drop system has been created to reduce such issues and to assist the notator to write Laban scores by displaying the movements in a 3D human figure animation. Therefore, a new version of the ThaiLabanXML standard must be improved to support the Thai Laban Drag & Drop system. This paper is focusing on improving the ThaiLabanXML standard to support the automatic Thai Laban Drag & Drop system in order to write Thai Laban scores and represent the Thai dance movement in 3D animation.**

Keywords—Thai dance, Intangible Cultural Heritage, Labanotation System, ThaiLabanXML standard, Thai Laban Drag & Drop system,

I. Introduction

A nation with a long history, Thailand has preserved its unique identity and traditions over the centuries. Intangible Culture Heritage is passed on from generations to generations. Arts and Dramatic Arts have always been important elements of this country's civilization due to their valuable emotional impacts. Thai dance is part of the dramatic arts and is performed with musical instruments, divided into upper class performances such as Khon, Lakhon and Fon which all have movement as their key element [1]. However, the influence of other cultures affects the Thai dance movements from time to time. Therefore, traditional Thai performance is at a risk of transforming and disappearing from the living cultural heritage [2].

In many counties, the dance movement is recoded by using dance notation systems such as the Labanotation system which is used worldwide to record and analyze dance movements. The Ohio State Department of Dance had been developed the system to recode the movement digitally as called "LabanWriter". In this system, user can edit the abstract symbol on the system [3]. Previously, a few systems were able to translate the abstract symbols into 3D animation such as the LabanDancer, GenLaban [4] [5] however, these programs do not support the newer versions of operating systems.

To represent the Thai dance movement in three dimensions, the ThaiDanceXML was created step by step manually to interpret the abstract symbols of the Labanotation system in the ThaiDanceXML language and translate it into 3D in the Unity 3D program. Consequently, an automatic system had been created to translate the ThaiDanceXML into 3D animation called "Drag&Drop system". Hence, this paper is focusing on developing the ThaiDanceXML standard based on the previous version [6]. The new version of the ThaiLabanXML standard must be compatible with the automatic drag & drop transformation system using the Unity 3D program.

II. Literature Review

A. Labanotation

Labanotation also known as Kinetography Laban system is a dance notation system for recording the movement of the human body. It is a great and popular way to represent and share the knowledge on dance scores among choreographers, originally created by Rudolf Laban in the 1920's. Rudolf von Laban studied architecture, was attentive towards arts, and was very interested in analyzing and studying dance movement [7].

It proposes two innovations: a vertical staff to present the body movement, which allows the correct interpretation of the right and left sides of the body as well as a continuity in indicating the flow of movement.

In 1977, Ann Hutchinson Guest and other researchers at the Dance Notation Bureau, New York improved the Labanotation system to be used in the contemporary dance and developed some information, and edited the way to write Laban scores.

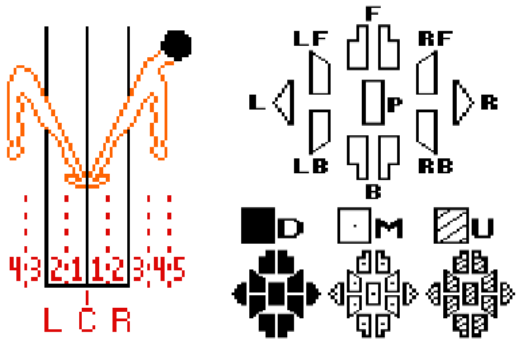

Fig. 1. The columns of the parts of body and horizontal direction symbols.

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In 2013, Dr. Chommanard introduced the Labanotation System in Thailand. He had been having experience in learning and teaching Thai performing arts since he was young. Later Dr. Chommanard also had the chance to study and get trained using the Labanotation system so it became an opportunity for research and to concentrate on using Labanotation to teach and learn Thai performing arts. As a next step, Labanotation was used by Dr. Chommanard to archive and record Thai dance performances with special attention tohand and finger movements as key elements of the traditional Thai dance [8]. In learning Thai dance, Chernbumrong et al. mentions that the combination of Thai dance and game-based learning could provide an interesting and challenging learning environment for the users [9]. Developing Thai laban XML standard will facilitate transfering intangible knowledge to Thai-dance student since they are keen with digital technology [10]

B. Extensible Markup Language (XML)

XML, which is a software and hardware independent tool for storing and transporting data, stands for eXtensible Markup Language. It was designed to be self-descriptive and XML is actually simple and easy-to-use. It simplifies data sharing, gets along with other platforms and is also compatible with most applications,therefor XML is not predefined so you can define tags, and new data can be added or removed [11].

Thus, the user can define any tags which are suitable for certain projects. And when assigning data there is no need to predefine the structure to store the data. Because of the extensibility of XML, XML functions similarly like the internet where different systems and platforms are supported. [12].

1) LabanXML Standard: Minako Nakamura and Kosaburo Hachimura, found that the Principles of Labanotation resembles both staff notation and music notes. Thus, they created LabanXML based on the principles of MusicXML [11]. In XML, Laban score is presented in the root element of LabanXML which is the <laban> element. The <laban> element includes:

The <attribute> and <notation> elements. The <attribute> element contains the<time> element. The <time> element contains the <beat> and <beat-type> elements. The main part of LabanXML is represented by the <notation> element. The notation element contains the <repeat> element ,which explains repetition, and contains the <measure> element [2].

For the Thai Dance movement, the beat of the song is always changing in the same song. Nevertheless, the beat of the song in LabanXML is defined strictly and cannot be changed. Thus, LabanXML is inapplicable to be translated from the Thai Dance Laban Score. Elements in LabanXML such as the <repeat> element are unavailable attributes and parameters for the support of the translation. Accordingly, LabanXML has its restrictions when it comes to Thai Dance [2].

2) MovementXML Standard: The Structure of the MovementXML is a representation of the human movement similar to LabanXML based on Labanotation but MovementXML had been developed from LabanXML, so it is more flexible than LabanXML [13]. The structure of MovementXML begins with elements. The Movement Element is also assigned to a <measure> element and it has parameters that are assigned to the measure number, beat, beat-type, beat-duration and meter (beats per minute). The measure includes two elements, <support> and <gesture> which explain the performance of the body parts. The <description> element found in both <support> and <gesture> explains how the body part moves and each includes element such as <direction> and<level> to assign the movement and performance. MovementXML also has a <repeat> element that includes parameters that define how to repeat the movement. And so forth, <repeat count = “4” repeat-type = “exact” exclude-path= “false the movement is more elastic because the movement is repeated 4 times [2].

However there are quiet some limitations when come to Thai Dance movement even through MovementXML is more flexible than LabanXML.

As regards the Thai dance movements, hands and feet terminologies are quite complicated and specific. The Lorkaew terminology for instance focuses on the figure movement where the whole body is executing harmonized moves at the same time and the performance is based on the beat of the song. Hence, it is difficult to translate the large amount of information in MovementXML. In contrast, the advantage of MovementXML is that the elements and time duration can be explained effectively.

3) ThaiDanceXML Standard: In 2018, researchers developed the way to create ThaiDanceXML standard that translates the Thai dance Laban Score [2]. The core determination of ThaiDanceXML is to store a representation of the Laban Notation System. Advantages of the standards of both LabanXML and MovementXML structures were analyzed to understand and find common points in order to create the ThaiDanceXML standard for the archiving the Thai dance movement performance as Human-Readable information and to be able to transfer that into Machine-Readable information [2]. Therefore, the method of writing ThaiDanceXML is to represent the parameter of the dance movement. ThaiDanceXML adapts from both LabanXML and MovementXML.

ThaiDanceXML data uses machine readable information that represent the Thai dance performances in 3D animation. First of all, the ThaiDanceXML can describe some of the Thai dance movements by 3D Unity but when you run ThaiDanceXML it cannot be read because it has more than 1 attribute in the parameter so that it confuses the machine. Therefore, a second version of ThaiLabanXML has been improved to support the Thai Laban Drag & Drop system.

III. METHODOLOGY

This paper is focusing on developing ThaiLabanXML standard by using the Labanotation system as Human-Readable Information changing it into Machine-Readable information. It also auto-generates ThaiLabanXML to ThaiLabanXML. There are two standards to be used for translating Laban notation scores to 3D human figure animation. ThaiDanceXML stores a representation of the Laban Notation system. The main purpose is to archive the Thai dance movements using Laban notation systems as Human-readable data transferring it into Machine-readable

data. Then, Machine-readable data is analyzed and submitted to be represented in the 3D Unity program.

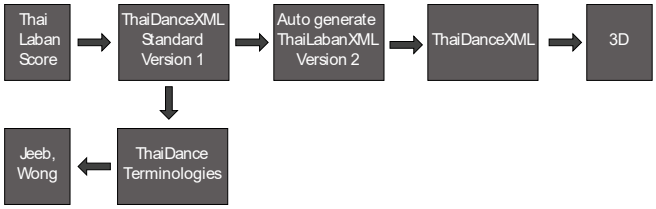

Fig. 2. Interpreting Thai Notation Score to ThaiLabanXML diagram.

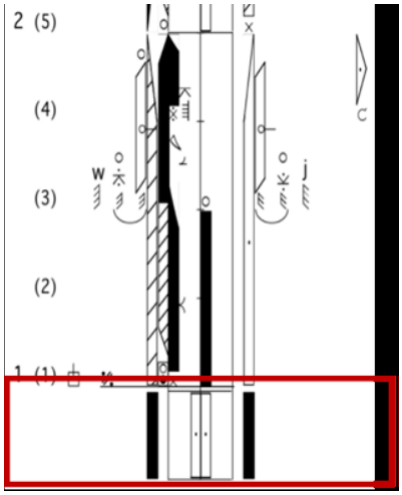

Fig. 3. Thai Dance Notation Score on Krai-Mue terminology

Thai Laban Notation Score (red box) translated into ThaiDanceXML in figure 4 and ThaiLabanXMLin figure 5.

A. Comparison of the First and Second Version

1) First Version

ThaiDanceXML is an Extensible Markup Language that was created based on LabanXML and MovementXML using Labanotation Systems for the interpretation of the Thai dance movement. The structure of the ThaiDanceXML starts with the creation of a name. <ThaiDanceXML> contains all elements of the score. <The main purpose of XML in ThaiDanceXML is to store a representation of the Laban Notation System. Therefore, the way of writing ThaiDanceXML is to represent the parameter of the dance movement. ThaiDanceXML adapts elements from both LabanXML and MovementXML. The structure of ThaiDanceXML begins with <Laban> As the root of each element, the <Laban> element contains the <Notation> element. The <Notation> element contains the <attribute> element. The <attribute> element signifies the beat count of a measure. The <attribute> element contains the <Measure> element. The <Measure> element includes the number parameter, and the <Beat>, <Beat-type>, <support>, <leg>, <body>, <arm>, <hand> and <head> elements. The maintenance, leg, body, arm, hand and head elements probably include the <Level>, <Direction>, <Speed>, <Hold>, <Sign>, <Degree>, <Contact>, <Rotate>, <Rpin>, <Relationship>, <Bodypart> and <Terminology> elements. However, the Thai dance hand sign has its own <Direction>, <Level> etc. [2].

```
<Laban>
  <Notation>
    <attribute>

      <Measure num="0">
        <Beat-Type>4</Beat-Type>

        <Support side ="Left">
          <Level>M</Level>
          <Direction>Place</Direction>
        </Support>

        <Support side ="Right">
          <Level>M</Level>
          <Direction>Place</Direction>
        </Support>

        <Arm side ="Left">
          <Level>L</Level>
          <Direction>Place</Direction>
        </Arm>

        <Arm side ="Right">
          <Level>L</Level>
          <Direction>Place</Direction>
        </Arm>
      </Measure>
    </attribute>
  </Notation>
</Laban>
```

Fig. 4. Frist Version: ThaiDanceXML (Krai-Mue)

2) Second Version

The main purpose of XML in ThaiLabanXML is to translate data using the translation program Drag & Drop system. The ThaiLabanXML is adapted from ThaiDanceXML and has a similar purpose. Its Machine-Readable information is analyzed and exported into the 3D unity to represent the Thai dance performance in VDO. The information in VDO can be transferred back into ThaiLabanXML form.

The structure of ThaiLabanXML starts with the <ThaiLabanXML> root element containing all data. The </ThaiLabanXML> element contains the <Attribute>element. The<Attribute>element includes the beat count of a measure. The <Measure> element stores the number of each room <room> and the count of beats in each room <beat>. The <Measure> element contains the<Body> element. The <Body>element includes the body part <part>, and the time of body part moves counted from the <start>. The <start>parameter refers to the time when the body part starts to move. The <end>parameter shows when the body stops moving. The <Body>element contains <Direction>, <Level>, <Turn> and each body part's performance. The <Direction> includes thebody movement positions such as <place>, <forward>, <backward>, <left> and <right>. The <Level> includes the position against the Y-axis like <low>, <middle> and <high>.

```
<ThaiLabanXML>
  <Attribute>

    <Measure room="0" beat="1">

      <Body part="left_support" start="0" end="1">
        <Direction>place</Direction>
        <Level>middle</Level>
      </Body>

      <Body part="right_support" start="0" end="1">
        <Direction>place</Direction>
        <Level>middle</Level>
      </Body>

      <Body part="left_arm" start="0" end="1">
        <Direction>place</Direction>
        <Level>low</Level>
      </Body>

      <Body part="right_arm" start="0" end="1">
        <Direction>place</Direction>
        <Level>low</Level>
      </Body>

    </Measure>
  </Attribute>
</ThaiLabanXML>
```

Fig. 5. Second Version: ThaiDanceXML (Krai-Mue)

B. *Process to write ThaiLabanXML*

First of all, to write ThaiLabanXML, it is needed to know all the structure and tags in ThaiLabanXML as shown in figure 6, and the tags of ThaiLabanXML, that are taken from the ThaiDanceXML version using the Drag & Drop system.

TABLE I. STRUCTURE AND TAGS IN THAILABANXML

Tags	Descriptions
<ThaiLabanXML>	This tag is used for indicating the start of the Laban score record
<Attribute>	Identity that the element data within is recorded from the notation
<Measure>	The counter tag for room and beat
room	Variable defining the number of rooms in staff In Thai dance 1 room = 2 or 4 beats
beat	Variable counting the number in each room
start, end	Variable defining the time from when the body starts to perform until the end in each body part in score
<Body>	It is used when the writer wants to be more specific about the part of the body mentioned.
part	Variable defining a specific part of body (leg, arm etc.)
<Direction>	Identifies the direction of the mentioned body part according to Laban notation.
<Level>	Identifies the height of movement of the mentioned body part according to the Laban notation.
<Turn rpin>	Defines the rotation action of a body part clockwise and anti-clockwise.
<Space>	Defines a specific action of a body part (fold, wide, narrow)
degree	Variable defining the number of quantity sign levels
<Contact>	Indicates the part of the foot that is in contact with the floor.
<Hold>	Addresses the action of keeping a dance move at its position.
<Gesture>	Indicates extended option for appropriate Thai dance is Jeeb and Wong.

C. *ThaiLabanXML Standard*

1) It Begins to record the lowest Labanotation score moving up beat by beat.

2) Within a staff count by beat from the support, it records the left side first until finishing 1 row in y-axis, followed by the right side and moving on to the legs and other body parts etc.

3) Starting channel record to record in staff is prepared-posture and Up-beat score before start perform predefine 2 beat in this room.

4) Counter beat in each room by the measure tag.

IV. RESULT

A. *Developing the ThaiLabanXML standard for Thai Laban Drag&Drop system*

The ThaiLabanXML is developed from ThaiDanceXML to be automatically translated in the Thai Laban Drag and Drop. Thus, the Labanotation system has too many elements and some of them have to be defined more specifically so we have to improve the structure and the way of utilizing the old version.

The beat count in the starting channel needs to be defined before performing. This Prepare-posture and Up-beat input data of the program can be read, and the beat can continue similarly to an actor performing in real, as shown in figure 6 (red box).

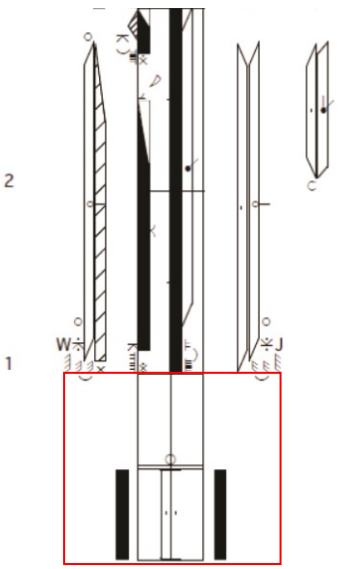

Fig. 6. Thai Laban Score on Krai-Mue

B. *Export ThaiLabanXML from Drag&Drop system*

Thai Laban Drag and Drop system was developed from the LabanWriter to export the XML file when Draw score on program similar expert Laban writing in the old way in program Laban Writer. Therefore, the ThaiLabanXML Standard was created to support the Drag and Drop system because the Draw element of the program can be immediately translated to an XML file and be transferred to the 3D unity program where it can be represented on the user interface. This way, it is not necessary to write an XML file anymore. This can be helpful to represent generated data in 3D unity.

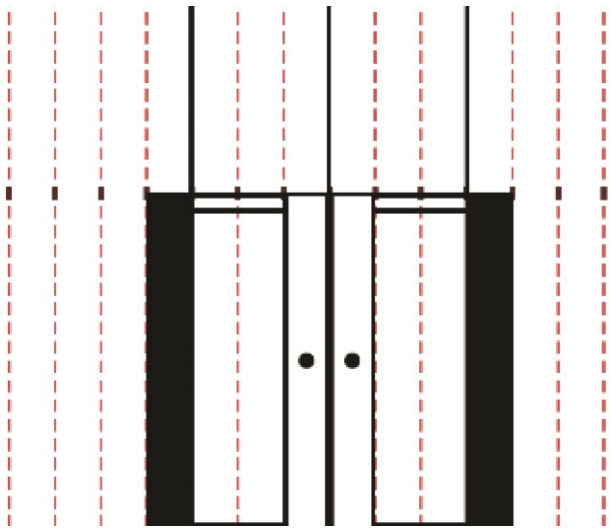

Fig. 7. Thai Laban score in Drag & Drop system

Formatted XML

```
<ThaiLabanXML>
    <Attribute>
        <Measure room="0" beat="2">
            <Body start="0" end="0.5" index="-1">
                <Level>middle</Level>
                <Direction>Place</Direction>
            </Body>
            <Body start="0" end="0.5" index="1">
                <Level>middle</Level>
                <Direction>Place</Direction>
            </Body>
            <Body start="0" end="0.5" index="-4">
                <Level>low</Level>
                <Direction>Place</Direction>
            </Body>
            <Body start="0" end="0.5" index="4">
                <Level>low</Level>
                <Direction>Place</Direction>
            </Body>
        </Measure>
    </Attribute>
</ThaiLabanXML>
```

Fig. 8. Export file ThaiLabanXML from Drag & Drop system.

V. Conclusion

Thai performing arts such as Khon is disappearing from the living cultural heritage. To preserve such knowledge, the Labanotation system is used to record the delicate dance movements. Nevertheless, to represent the movement from Thai Laban scores as 3D animation, a standard must be developed to convert Human-Readable Information to Machine-Readable Information. The ThaiDanceXML standard was created to manually write and insert the ThaiDanceXML file into the Unity 3D program to create 3D human figure movements. The second version of the ThaiLabanXML standard was developed to support the automatic generation of the ThaiLabanXML file from the Thai Laban Drag & Drop system to reduce the human error related issues and to generate an accurate ThaiLabanXML file for the system to represent the proper 3D animation gesture. The comparison of the first and second versions of the ThaiLabanXML standards showed a process of improvement and also the limitations of the standard. Possible related future work could be the improvement of the ThaiLabanXML standard on Thai Laban syntax, more complex movements, and enhanced compatibility with the Thai Laban Drag & Drop system.

Acknowledgment

This study would never be successful without the kind support of the Knowledge and Innovation Research Laboratory (KIRLY), College of Arts, Media and Technology, Chiang Mai University, Thailand. In addition, special thanks to Research and Innovation Staff Exchange (RISE) called H2020-MSCA-RISE-2015 in the project called “High Dimensional Heterogeneous Data based Animation Techniques for Southeast Asian Intangible Cultural Heritage Digital Content” or “AniAge Project” for supporting us with mobility funds [EU H2020 project-AniAge (691215)]. Last, this study would never be successful without the kind support of Bournemouth University (BU), Bournemouth, England.

References

[1] College and Academy website teaching all about dance also Thai dance http://bangkokdanceacademy.com/class

[2] Y Tongpaeng, K Nantapatsaran, P Sureephong, “Interpreting Thai Laban Notation into ThaiDanceXML” International Conference on Digital Arts, Media and Technology 2018 (ICDAMT 2018), page 173-178, IEEE, 2018

[3] Department of Dance, The Ohio State University. “LabanWrier” Retrieved May 25, 2016. https://dance.osu.edu/research/dnb/laban-writer

[4] Lars W. Tom C. Rhonda R. “From Dance Notation to Human Animation - The LabanDancer Project”. Retrieved May 8, 2016. http://www.sfu.ca/ ~tom/Papers/LabanDancer1.pdf

[5] Worawat C. Minako N. Kozaburo H. “GenLaban: A tool for generating Labanotation from motion capture data”. Retrieved May 9, 2016. ftp://www.infomus.org/pub/AestheticsPapers/GenLaban-2014.pdf

[6] Y Tongpaeng, K Nantapatsaran, P Sureephong, “Interpreting Thai Laban Notation into ThaiDanceXML” International Conference on Digital Arts, Media and Technology 2018 (ICDAMT 2018), page 173-178, IEEE, 2018

[7] Ann Hutchinson Guest “Labanotation Dance Notation” https://www.britannica.com/art/labanotation

[8] Worawat C. Kingkarn S. Chommanad K. Kozaburo H. “Desirability of a Teaching and Learning Tool for Thai Dance Body Motion”. Retrieved January 8, 2016. http://link.springer.com/chapter/10.1007/978-3-642-39241-2_20

[9] Chernbumroong, S., Sureephong, P., Tabia, K. and Khemlani, Y.D., 2018, February. Thai dance training game-based model. In Digital Arts, Media and Technology (ICDAMT), 2018 International Conference on (pp. 194-197). IEEE.

[10] Chernbumroong, S., Sureephong, P., Tabia, K. and Ho, H., 2018, February. Technology usage of Thai dance student. In

Digital Arts, Media and Technology (ICDAMT), 2018 International Conference on (pp. 276-279). IEEE.

[11] Javatpoint - The Best Portal to Learn Technologies https://www.javatpoint.com/xml-tutorial

[12] M.Rouse. “XML (Extensible Markup Language)”.Reieved November 23,2017.http://searchmicroservices.techtarget.com/definition/XML-Extensible-Markup-Language.

[13] J.Hotol. “MovementXML:A Representation of Semantics Of Human Movent Based on Labanotation”. Retrieved July 15 ,2017. summit.sfu.ca/system/files/iritems1/2741/etd2344.

The 4th International Conference on Digital Arts, Media and Technology
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Comparing the Thai Dance Labanotation Recording Results with an Expert

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***Abstract*—Thai Dance is a unique performative form of art based on complex movements with rhythm. The performer requires expertise to move every part of the body, especially hands and fingers to harmonize and balance the body control. Thus, it is challenging to pass on such a tacit knowledge to the next generation. Currently, the drop in the number of experts is dramatic and the chance of archiving the dance knowledge as explicit knowledge is very low. To archive the Thai dance knowledge, the use of a system like the Labanotation System is necessary to record the complex movements as abstract symbols. This system allows to record dance movements, but it cannot provide their three-dimensional representation. Therefore, to automatically generate 3D animation from the Thai Laban Scores, the Thai Laban Drag & Drop system was developed. Nevertheless, the results of the Thai Laban Drag & Drop system development must be verified. This Paper focuses the autogenerated output of the Thai Laban Drag & Drop system, comparing Video Recoding and 3D Animation, the Thai Laban Scores from an expert and Thai Laban Scores from the system, the ThaiLabanXML and the regenerated ThaiLabanXML from the system.**

Keywords—Thai Dance, Labanotation System, Thai Laban Scores, ThaiLabanXML, 3D Animation

I. Introduction

Thai Dance is a performative art that enhances the mental and emotional aesthetics of people in the society and influences people in such a way that they can reflect on their activities and the way of their living. UNESCO would like to preserve such cultural elements called "Intangible Cultural Heritage" also known as "ICH" for future generations. Knowledge archiving is the way to preserve the knowledge as explicit knowledge by transferring such knowledge in the form of writing, drawing or symbols. The lack of unity in such languages is a problem to be mentioned here [1]. Nowadays, Thai Dance knowledge is challenging to be passed on to the next generation. There are people who attempt to conserve this tradition, although there are many obstacles including complexity and the accuracy of recording the movements. One way of recording the movements is to use a camera to record as a video but then the video is not covering all the details and the complexity of the movement, especially the movements of the hand and fingers. Thus, making a video recording for teaching and learning is not sufficient. Previously, Labanotation System has been used to assist in recording the body movements by written abstract shapes representing commands and organs on the staff, representing the rhythm. Labanotation is a human-readable information system that can be converted to computer-readable information. Thus, Thai Dance can be recorded in motion by the Labanotation System and can be converted into computer-readable data in the form of Extensible Markup Language (XML) files. However, the Extensible Markup Language Standard created to support the Labanotation System is incapable of recording specific details of the Thai dance movements such as hand, arm, foot and body gestures. According to our studies and findings, the Laban Thai Dance XML is a standard that has the advantages and disadvantages of each written standards [2].

The ThaiLabanXML standard was developed to support the Thai Laban scores in the Unity 3D program to display a three-dimensional animation. Moreover, the standard covers basic movements of the Thai Dance and includes specific rhythms. However, coding XML may cause errors at some point due to human errors and it is also time-consuming. Moreover, there may be further loopholes of the standard when recording more complex dance movements.

The Thai Laban Drag & Drop system is a Thai Dance Labanotation program which allows to store, edit and export the data as XML, .PDF and .JPEG. It provides the abstract symbols of Labanotation symbols and the Thai Laban scores created by Dr. Chommanard [3], who had great experience in Thai performing arts and Labanotation research. Finally, it can be displayed in three-dimensions so that the notator will be able to visualize the movements of the body through the characters within an environment. However, the results from this program, namely the Thai Laban Score, the ThaiLabanXML and the 3D Animation haven't been recognized as accurate by Thai dance experts. Therefore, this paper focuses on the comparison of 3 inputs: the Thai dance experts demonstration, the Thai Laban Scores, and the ThaiLabanXML standard and the 3 outputs of Thai Laban Drag & Drop system.

II. Literature Review

A. Labanotation

Labanotation or Kinetography Laban is a notation system for recording and analyzing the human movement. The system by Rudolf von Laban, also first published in 1928, offers two innovation: 1. the vertical staff to present the body, which allows the correct representation of the right and left sides of the body as well as continuity in indicating movement flow; 2. Elongated movement symbols, by their length, indicating the exact duration of each action. His analysis of movement, based on spatial and dynamic principles, was flexible and can be applied to all forms of movement [4].

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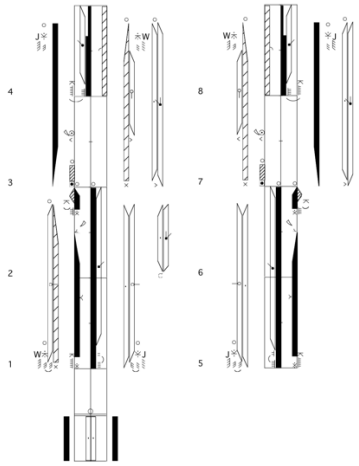


Fig. 1. Example of a Labanotation Score for Kaii-Mue (Thai Dance)

B. Thai Laban XML Standard

The Labanotation system uses the Thai dance movement as human-readable information and makes it convertible to computer-readable information. Thereby, the ThaiLabanXML standard is used for transferring Laban notation scores as human-readable information into Extensible Markup Language as machine-readable information. ThaiLabanXML is a standard that has advantages and disadvantages when creating the appropriate movements. LabanXML allows the creation of the sematic representation of human movements [5] and MovementXML is a semantic representation of the human movement which is also more flexible and more extensible [6]. Moreover, the ThaiLabanXML includes Thai dance gestures such as Jeeb and Wong in order to be able to support the Thai dance properly.

The Recording of the Thai Laban XML starts with recording from the bottom then moving up through the Labanotation scores and startsfrom the inside of staff to the outside, left side first and switching to the right. This standard starts off with the root <Laban> element including the<Notation> and <attribute> elements. The <attribute> element collects the beat count of measure and includes the <Measure> element inside. The <Measure> element collects the parameter, <Beat-Type> and the element that collects the body parts. Each element of the body parts comprises a <Level>, <Direction>, <Speed> and other elements.

```
<Laban>
  <Notation>
    <attribute>

      <Measure num ="0">
        <Beat-Type>4</Beat-Type>

        <Support side ="Left">
          <Level>M</Level>
          <Direction>Place</Direction>
        </Support>

        <Support side ="Right">
          <Level>M</Level>
          <Direction>Place</Direction>
        </Support>

        <Arm side ="Left">
          <Level>L</Level>
          <Direction>Place</Direction>
        </Arm>

        <Arm side = "Right">
          <Level>L</Level>
          <Direction>Place</Direction>
        </Arm>

      </Measure>
```

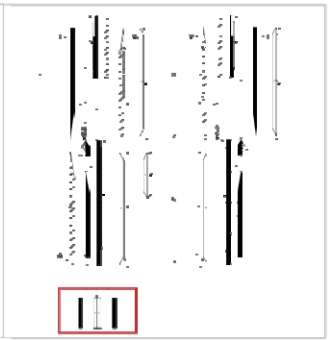


Fig. 2. ThaiDanceXML for Kaii-Mue in the initial part of the Thai Dance Score

C. Thai Laban XML Standard

In 2002, Kojima Kazuya et al. have researched the way to improve 3D CG animation for the Labanotation system in the LabanEditor program. LabanEditor is an interactive graphic editor program for editing Labanotation scores and rendering the 3D CG character animation [7]. They added features to allow users give input, edit, describe and reproduce scores. The score can be rendered in animation immediately and naturally. Moreover, when rendering in a 3D Animation window, users can change the perspective in the 3D scene against all three axes. Finally, this research group achieved to show the description and reproduction of Noh which is the most well-known and characteristic traditional Japanese performance.

In 2018, Yootthapong et al. researched on the process of transferring the ThaiDanceXML into the Unity3D program in order to display the movement as a 3D Animation [8]. They have developed a system of five processes that results in creating an animation. The process steps are: ThaiLabanXML file transferred into Unity 3D, Model preparation, 3D character transformation and 3D animation presentation.

Fig. 3. Translating Process from ThaiDanceXML to 3D Animation

XML and Thai Dance Techniques have been adopted to generate a ThaiDanceXML standard. After that C# language was used to connect the data of XML files with the Unity 3D program. The preparation of the 3D character model is based on a 3D mesh using Autodesk Maya. The polygon must be cleaned, and the name of the joints should be defined to get the structure of the human body as defined in the ThaiDanceXML standard to make the 3D transformation possible. Finally, the Unity 3D Program can interpret and collect the data from the ThaiLabanXML file. Most of all, the Thai dance knowledge could transfer knowledge using game-based learning method which provide an interesting and exciting learning environment [9].

D. Comparison

In 2018, Yootthapong et al. researched the creation of a tool to check the accuracy of a Thai Dance expert compared to the Real-Time Dance movement by Microsoft Kinect. The first step was to obtain the data of the Thai dance movements that were recorded by an expert using the Motion capture system applied to the skeleton of a 3D character model and also the dance movements from a user were collected by the Microsoft Kinect sensors to be applied to another 3D skeleton model. Then these were compared using the joints of the skeleton. Finally, this research shows that the two models were quite different as regards the joints because of the limitations of the Kinect sensor, as it couldn't capture all the complex Thai Dance movements clearly [10].

III. METHODOLOGY

Thai Laban Drag & Drop system generates the output according to the Laban scores as input such as direction, and degree of the abstract symbols. First of all, archiving data from an expert is quite essential. Therefore, it has been collected through video recording from a Thai dance expert, the movement was

recorded by an expert having the experiment. To convert the human readable information of the Thai Laban scores into machine readable information, the Thai Laban XML standard was developed and translated into a ThaiLabanXML file. In the Unity 3D program, the ThaiLabanXML file is separately loaded into the GameObject on each part of the 3D model as Container & Loader script to be displayed as movement.

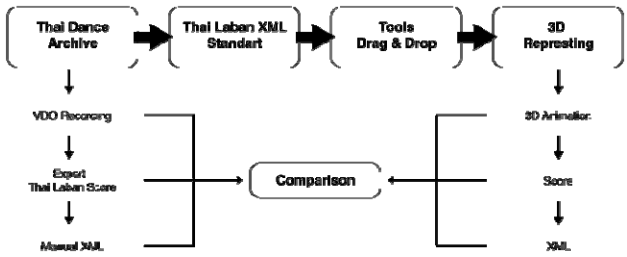


Fig. 4. The process of comparison between Thai dance archive and Drag&Drop results

A. *Expert: Thai Laban Score and System: Thai Laban Score*

First of all, the Thai Laban score is uploaded into the Thai Laban Drag & Drop system to start the process. The system allows the user to select the abstract symbol just like in the LabanWriter system [11]. After the writing of the Thai Laban Scores is finished, the system provides the function to export the written Thai Laban score as .PDF and .JPEG. Both input and the output image can be compared to see the limitation of the Thai Laban Drag & Drop system on writing Laban scores.

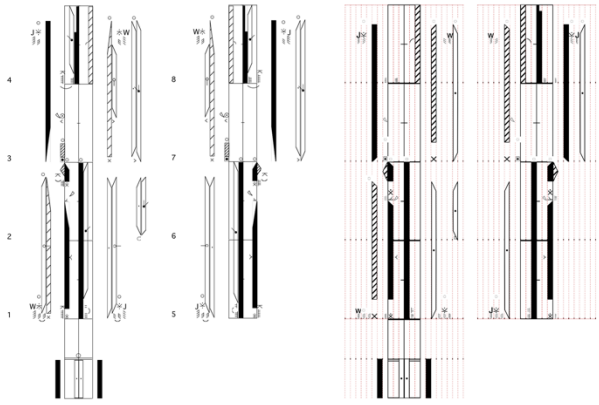
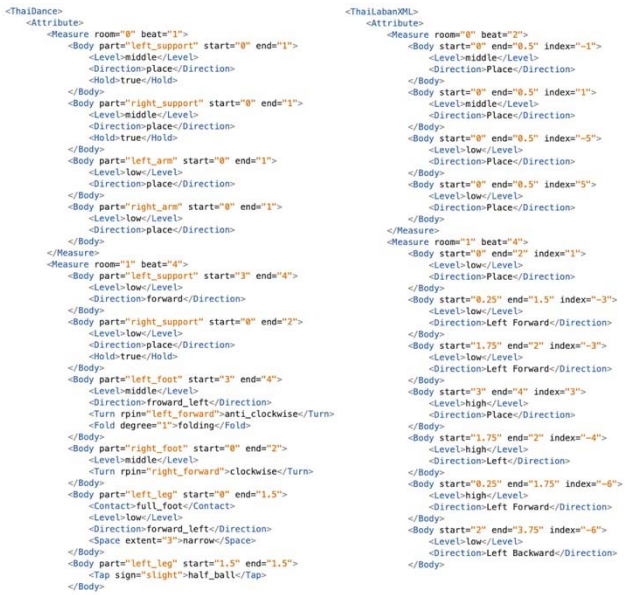


Fig. 5. The way to compare the Thai Laban Score from an expert (left) with the Thai Laban Drag&Drop system (right)

B. *Manual: ThaiLabanXML and System: ThaiLabanXML*

ThaiLabanXML was manually written according to the ThaiLabanXML Standard to translate the Thai Laban Scores into a ThaiLabanXML file. Now, the Thai Laban Drag & Drop system provides the XML file by dragging the symbol and dropping it into the score to generate the ThaiLabanXML file. In addition, the system provides the export function to export the .XML file format. Both XMLs can be compared line by line to see the differences.



```
<ThaiDance>
  <Attribute>
    <Measure room="0" beat="1">
      <Body part="left_support" start="0" end="1">
        <Level>middle</Level>
        <Direction>place</Direction>
        <Hold>true</Hold>
      </Body>
      <Body part="right_support" start="0" end="1">
        <Level>middle</Level>
        <Direction>place</Direction>
        <Hold>true</Hold>
      </Body>
      <Body part="left_arm" start="0" end="1">
        <Level>low</Level>
        <Direction>place</Direction>
      </Body>
      <Body part="right_arm" start="0" end="1">
        <Level>low</Level>
        <Direction>place</Direction>
      </Body>
    </Measure>
    <Measure room="1" beat="4">
      <Body part="left_support" start="3" end="4">
        <Level>low</Level>
        <Direction>forward</Direction>
      </Body>
      <Body part="right_support" start="0" end="2">
        <Level>low</Level>
        <Direction>place</Direction>
        <Hold>true</Hold>
      </Body>
      <Body part="left_foot" start="3" end="4">
        <Level>middle</Level>
        <Direction>froward_left</Direction>
        <Turn rpin="left_forward">anti_clockwise</Turn>
        <Fold degree="1">folding</Fold>
      </Body>
      <Body part="right_foot" start="0" end="2">
        <Level>middle</Level>
        <Turn rpin="right_forward">clockwise</Turn>
      </Body>
      <Body part="left_leg" start="0" end="1.5">
        <Contact>full_foot</Contact>
        <Level>low</Level>
        <Direction>forward_left</Direction>
        <Space extent="3">narrow</Space>
      </Body>
      <Body part="left_leg" start="1.5" end="1.5">
        <Tap sign="slight">half_ball</Tap>
      </Body>
```

```
<ThaiLabanXML>
  <Attribute>
    <Measure room="0" beat="2">
      <Body start="0" end="0.5" index="-1">
        <Level>middle</Level>
        <Direction>Place</Direction>
      </Body>
      <Body start="0" end="0.5" index="1">
        <Level>middle</Level>
        <Direction>Place</Direction>
      </Body>
      <Body start="0" end="0.5" index="-5">
        <Level>low</Level>
        <Direction>Place</Direction>
      </Body>
      <Body start="0" end="0.5" index="5">
        <Level>low</Level>
        <Direction>Place</Direction>
      </Body>
    </Measure>
    <Measure room="1" beat="4">
      <Body start="0" end="2" index="1">
        <Level>low</Level>
        <Direction>Place</Direction>
      </Body>
      <Body start="0.25" end="1.5" index="-3">
        <Level>low</Level>
        <Direction>Left Forward</Direction>
      </Body>
      <Body start="1.75" end="2" index="-3">
        <Level>low</Level>
        <Direction>Left Forward</Direction>
      </Body>
      <Body start="2" end="4" index="3">
        <Level>high</Level>
        <Direction>Place</Direction>
      </Body>
      <Body start="1.75" end="2" index="-4">
        <Level>high</Level>
        <Direction>Left</Direction>
      </Body>
      <Body start="0.25" end="1.75" index="-6">
        <Level>high</Level>
        <Direction>Left Forward</Direction>
      </Body>
      <Body start="2" end="3.75" index="-6">
        <Level>low</Level>
        <Direction>Left Backward</Direction>
      </Body>
```

Fig. 6. The way to compare XML from an expert (left) with the Thai Laban Drag&Drop system (right)

C. *Video Recording and 3D Animation*

Recording the Thai dance score using the Thai Laban Drag & Drop system, 3D animation can be represented in a front view of the character. The system provides the play and pause buttons to play and stop the movement. The animation can be exported in .mov file format. After that, both video files are compared by placing them in the Adobe After Effect program onto different layers. Adjustment of the starting dance position is necessary because the video recording of the expert has a delay time while the 3D Animation can start immediately. Theexpert video recording is the back layer (lower layer) and the 3D Animation is the front layer (top layer). After that, the opacity of the 3D Animation layer should be reduced to around 50% so that both videos can be seen at the same time.

Fig. 7. The way to compare the movement of the expert (back layer) and the Thai Laban Drag&Drop system (front layer)

IV. RESULT

The result of comparing 3 inputs and 3 outputs shows us the limitation of the Thai Laban Drag & Drop system due to various symbols, time and the compatibility of the ThaiLabanXML standard with the Unity3D program. However, the system could provide a quite accurate animation based on the input of the Thai Laban Score.

A. *Expert: Thai Laban Score and System: Thai Laban Score*

After comparing both Thai Laban Scores according to Fig.5, it demonstrated clear differences. The Thai Laban Score created by an expert has 144 symbols and the Thai Laban Score from the Thai Laban Drag & Drop system has 100 symbols due to the limitation of the system, the Thai Laban Score from the system isn't as comprehensive as the Thai Laban Score from an expert. The Thai Laban Drag & Drop system can record an average score of 69.4% based on an expert comparison because the system is unable to record many complexities such as organ rotation, symbols of continuity of movement and organs, etc.

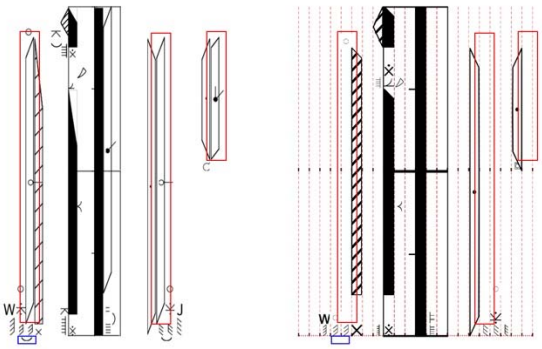


Fig. 8. The symbol of organ rotation in red boxes and the symbol of continuity of organs in blue box

B. *Manual: ThaiLabanXML and System: ThaiLabanXML*

Fig.6, shows that both ThaiLabanXMLs contain the same structure which starts off with the root <ThaiDance> element and includes the <Attribute> elements. The <Attribute> element contains the <Measure> element inside and the <Measure> element contains the <Body> element listing the parts of the body.

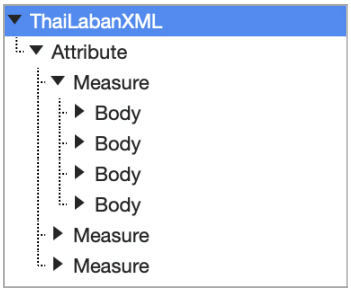


Fig. 9. The Structure of ThaiLabanXML from the Thai Laban Drag&Drop system

Currently, both ThaiLabanXML results are still disparate due to the limitations of the Thai Laban Drag & Drop system, that only shows the <Level> and <Direction> elements. As a result, the system is not able to display the value covering all the movements following Fig.10. Moreover, the system is not able to identify the organ directly with the Thai Laban Score because the Thai Laban Drag & Drop system uses the numbers instead of each column. In fact, some organs are able to move the column, so the parameter named index in the <Body> element is unable to identify an organ.

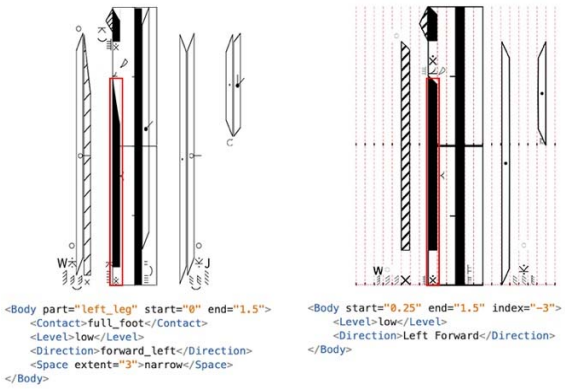


Fig. 10. The comparison of ThaiLabanXMLs - manual ThaiLabanXML and output of the Thai Laban Drag&Drop system - <Body> element of left leg from Kraii Thai dance

C. *Video Recording and 3D Animation*

With the limitations of the system, 3D animation exported from the Thai Laban Drag & Drop system can be played, yet the movement is different compared to the video recording from the expert. The timing of the Thai Laban Scores is still different from the timing of the system. Also, the continuity of the movements is not currently compatible with the Thai Laban Drag & Drop system. This can be improved by changing the beats per minute (bpm) according to the Thai dance movement, which is 60 bpm.

V. Conclusion

In conclusion, the result of the comparison of 3 inputs and 3 outputs provides us a new perspective to improve the Thai Laban Drag & Drop system. Regarding expert: Thai Laban Score and system: for the Thai Laban Score, more symbol is needed to be added to the system in order to be able to interpret more XML files. Regarding manual: ThaiLabanXML and system: ThaiLabanXML, the ThaiLabanXML standard should be made compatible with the system, more symbols are needed to translate more movement. Regarding video recording and 3D animation, timing must be in the same track, to move each part of the character together with the Thai dance expert. As regards the future works, the ThaiLabanXML standard needs to be improved and coding needs to be simultaneously developed to represent the Thai dance movement in the Thai Laban Drag & Drop system.

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This study would never be successful without the kind support of the Knowledge and Innovation Research Laboratory (KIRLY), College of Arts, Media and Technology, Chiang Mai University, Thailand. In addition, special thanks to Research and Innovation Staff Exchange (RISE) called H2020-MSCA-RISE-2015 in the project called "High Dimensional Heterogeneous Data based Animation Techniques for Southeast Asian Intangible Cultural Heritage Digital Content" or "AniAge Project" for supporting us with mobility funds [EU H2020 project-AniAge (691215)]. Last, this study would never be successful without the kind support of Bournemouth University (BU), Bournemouth, England.

REFERENCES

[1] D. Chandnasaro, "Labanotation: The Development of Western Dance Notation by Using Symbol", Retrieved November 15,2016

[2] Y. Tongpaeng, K. Nantapatsaran, P.Sureephong, "Interpreting Thai Laban Notation into ThaiDanceXML", 2018

[3] W. Choensawat, K. Sookhanaphibarn, C. Kijkhun, K Hachimura, "Desirability of a Teaching and Learning Tool for Thai Dance Body Motion", 2013

[4] Ann Hutchinson Guest, "Labanotation: The System of Analyzing and Recording Movement", Revised fourth edition published in 2005 by Routledge

[5] M. Nakamura, K. Hachimura, "An XML Representation of Labanotation, LabanXML, and its imprementation on the notation editor labanEditor2", 2006

[6] J. Hatol, "MovementXML: a representation of semantics of human movement based on Labanotation", 2006

[7] K. Kojima, K. Hachimura, M. Nakamura, "LabanEditor: Graphical editor for dance notation", Robot and Human Interactive Communication, 2002. Proceedings, 11th IEEE International Workshop, 2002

[8] J. Hatol, "MovementXML: a representation of semantics of human movement based on Labanotation", 2006

[9] Chernbumroong, S., Sureephong, P., Tabia, K. and Khemlani, Y.D., 2018, February. Thai dance training game-based model. In Digital Arts, Media and Technology (ICDAMT), 2018 International Conference on (pp. 194-197). IEEE.

[10] Y. Tongpaeng, P.Sribunthankul, M.Rattanakhum, "Evaluating Real-Time Thai Dance Using Thai Dance Training Tool", 2018

[11] Department of Dance, The Ohio State University. "LabanWrier" Retrieved June 20, 2017. https://dance.osu.edu/research/dnb/laban-writer

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The Gamification Element Selection Method

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***Abstract*—The Massive Open Online Course (MOOC) is considered as a new education platform which supports learners in accessing information anytime anywhere. However, the high dropout rate is still a crucial problem for MOOCs which is linked to the uncertainties of learner motivation. Thus, gamification can be a potential concept which promotes motivation and engagement for learners. Previously, many researchers already implemented game elements such as points, badges, or leaderboard in online learning contexts. The adaptation of different game elements provides different results. It seems that there is no empirical method which provides a guideline or suggestions on how to select such gamification elements. This paper provides a game element selection method for developers.**

Keywords—MOOCs, Gamification, Game element

I. Introduction

The Massive Open Online Course (MOOC) is a learning innovation platform that has the potential to allow learners to gain access to education. Many organizations have already adopted this platform as a core training platform for improving their staff's knowledge and skills [1]. 195 HR and teaching professionals reported that 72 percent of them see the value in implementing MOOCs into their knowledge and skills programs [2]. However, the high dropout rate in MOOCs suggests that learner engagement and progression in the courses are problematic. High dropout rate related issues in MOOCs cast doubt on whether or not MOOCs can potentially increase access to higher education, since not all MOOC students throughout the courses [3]. engagement patterns of students may have different motives for learning and not are interested in completing the whole course. For example, training and learning materials which are appropriate for an adult learning style in Thailand are visuals (i.e. picture, 3D graphics, diagrams, and demonstrations) and active styles (i.e. discussions, brainstorming, experimenting, testing) [4]. Moreover, learning in poorly designed MOOCs for students [5]. Therefore, gamification can be adopted as the main concept with the potential to increase learner motivation.

Gamification is now highly adopted in education. This concept is potentially increasing given its capacity to capture and sustain learners' attention, which is crucial for learners' success in educational environments [6]. Generally, gamification can be defined as the use of game elements in non-gaming contexts to improve user experience and user engagement, loyalty, entertainment and fun. Many researchers have applied this concept to their work for fostering motivation [7]. However, the implementation of gamification has shown different results. For example, Domínguez et al. (2013) applied gamification elements such as badges, trophy, and leaderboard in Backboard program. The result showed that the attention rate and practical assignments were greater in the experimental group, but performance on written assignments suffered [8]. Goehle, G. et al. (2013) used gamification in WeB-WorK (home-work app) and found that at least half of the students who completed 90% of the homework put in extra effort to obtain achievements [9]. However, the researcher could not conclude what effect, if any, gamification had on the performance of students in the course. Chernbumroong et al. implemented leaderboard as a gamification element for fostering motivation and performance of Thai students. Their result indicated that different kind of leaderboards provides a different kind of outcomes [10]. As mentioned, since gamification elements contain a diversity of game element types such as points, leaderboards, badges, levels, stories, goals, feedback, rewards, or progress bar, the method for selecting the right game elements is still missing. The game element selection method should support the game developer and should suggest when and how to implement game elements in MOOC contexts. Therefore, the aim of this paper is to develop a game element selection method.

II. Literature Review

A. Gamification Generic Framework

In the past decade, gamification framework has been developed by several researchers in different dimensions. The overview of generic gamification frameworks has been reviewed by Alberto Mora et al. (2015) in his article [11]. For example, the framework for Success has been defined by Di Tomasso (2011) which is influenced by the Self-Determination Ryan and Deci(2000). In this method, he proposed the following steps: discover the reason to gamify (stakeholders and business objectives), identify players' profiles and motivational drivers, set up goals and objectives, describe skills, track and measure, define lenses of interest, desired outcomes and play-test, and polish [12][6]. Meanwhile, Werbach and Hunter (2012) have developed a well-known framework which is presented in Six Steps to Gamification [13]. This framework starts from a definition of business objectives and then proceeds to target the expected behaviors, describes the players, devises the activity forgetting the fun, and finally, deploys the gamification system with the appropriate tools. On the other hand, The guidelines or step to gamification has also been proposed by De Paz (2013) which can basically be applied to any type of project. The overview of this framework seems to be highly influenced by Werbach and Hunter's Six Steps to Gamification [14]. The into three phases: the setting up of the business goals (preparation), the determination and the use of game elements. the system and running it. This approach also recommends the use of metrics. Versteeg (2013) also defines a simplified framework for moral persuasive gamification design [15]. This combines a normative ethical framework with the most relevant issues of the following methodologies. It is based moral design framework by Berdichevsky and Erik Neuenschwander (1999) and golden rules that a designer should never exceed [16]. Furthermore, it incorporates a methodology for

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analyzing the ethics of persuasive proposed by Fogg (2002) [17]. The steps are: definition of moral principles and values, conceptual investigation, the involvement of the stakeholders, and evaluation and iteration.

TABLE I. COMPARISON OF GAMIFICATION FRAMEWORKS

The Step to Gamification	Generic Gamification Framework			
	Framework for Success. Di Tommasso (2011)	***Six steps to Gamification. Werbach and Hunter (2012)***	***Steps to Gamification. De Paz (2013)***	***A moral framework for taking responsibility. Versteeg (2013)***
Identify objective	X	X	X	X
Identify type of player profiles and motivation	X	X		
Identify behavior and measurement	X	X	X	X
Identify activity		X	X	X
Design game element	X	X	X	
Tracking and testing	X			X
Implementation with tool		X	X	

According to the generic gamification framework review, most of the gamification framework has been overlapping in term of a process of qualifying. However, frameworks do not mention how to select the game element. Thus, before the game elements are selected, we decided to follow the step to gamification as the baseline. In our study, the step to gamification is listed as follow; 1. Identify objective, 2. Identify behavior and measurement 3. Identify activity, and 4. select gamification element.

B. Classification of Game Elements

According to the above-listed frameworks, most of the researchers still do not mention game element selection methods. The frameworks only provide the steps which are able to turn non-game situations to gamification contexts. We proposed that the gamification framework needs to deal with the selection of elements. Previously, there existed methods or concepts that provide systematic accounts or frameworks which are helpful. However, these don't seem to be concrete enough. For example, the MDA framework (Mechanics, Dynamics, and Aesthetics) which is presented by Hunicke et al is designed to facilitate game designers in understanding how to create an engaging experience by typing mechanics to the dynamics that afford the appropriate aesthetics for the game [18]. However, the mechanics are not itemized and classified. Meanwhile, Yee offers a framework for gameplay motivation, based on a factor analysis of a large survey of player motivations [19]. However, this does not extend to the gamification features that satisfy motivations. Deterding et al also provide a sophisticated definition of gamification, which places gamification elements in a model of multiple levels of design abstraction, but their objective is not to provide the concrete examples of gamification elements themselves [20]. Dignan presents a 'game frame,' which is a conceptual framework or template comprising ten building blocks which he argues make up a "behavioral game" (a gamified activity) and presents specific examples of "building blocks" of gamified experiences, which is exactly what we are looking for, but it is not organized concisely within a taxonomic structure with guidance on what level of commitment they are best suited to [21].

The framework which is nearly suited to our work is the taxonomy of gamification elements by D. Robinson and V. Bellotti (2013) [22]. This framework has provided a clear each of game elements which are classified in differences categories. In their proposed work, the six major categories of gamification elements were established.

TABLE II. THE CATEGORIES OF GAMIFICATION ELEMENTS

Categories	Description
General Framing	This category provides context and motivation for participation.
General Rules and Performance Framing	Explains in general what is expected such as operating an avatar in combat or scoring as high as possible on a test of health knowledge.
Social Features	Permit the user to interact with others, at the very least outside the experience.
Incentives	The element which motivate user to do something, these may be intrinsic or extrinsic motivation.
Resources and Constraints	are the bounds within which the user must operate to participate.
Feedback and Status Information	Allow the user to understand what is going on, what they must do next, what they have done recently and perhaps over the entire course of their engagement.

The game element can be designed into the experience, designed for the experience, or it may provide a context for an experience. All of the gamification elements that we were able to identify from related works or from articles online were able to be placed into the following set of top-level categories at a first subcategory or second subcategory level. Therefore, the taxonomy of gamification elements has been adapted to our work as a selection method since it provides a clear categorization of game elements.

Since the steps of the gamification framework have been adopted to our work, the gamification elements selection method needs to follow every step. Therefore, the category and element of gamification have been changed from the original.

TABLE III. PROPOSED STEPS TO GAMIFICATION AND GAME CATEGORY

Step to Gamification	Category	Description	Game Element
Identify objective	General Framing	Provides motivation content for participation	Context
			Background
			Narrative
Identify behavior and measurement	General Rules and Performance Framing	Explains how to achieve the objectives or how to evaluate one's own performance	Guidance
			Objectives/ targets*
			Renewal/regeneration
			Template/set for completion
			Normative
Identify activity	Constraints	The bounds within which the user must operate to participate.	Game accomplishments*
			Specific Rules
			Limited of resources
			Limited of time
			Level of difficulty

Step to Gamification	Category	Description	Game Element
	Incentive	Psychologically motivated anticipated real-world outcomes.	Intrinsic
			Extrinsic
	Social Features	Permit the user to interact with others.	Relationships
			Interaction Modes
Select gamification element	Feedback and Status Information	Allow the user to understand what is going on, what they must do next, what they have done recently and perhaps over the entire course of their engagement.	Rescores
			Progress
			Social

III. Proposed Method

Next, we would like to explain the proposed methodology of this study. We tried to develop a method which provides steps and a selection method of the game elements. Therefore, the 4 steps to gamification have been taken from the generic gamification framework by other researchers. Meanwhile, the gamification categories and elements have been taken from the taxonomy of gamification elements by D. Robinson and V. Bellotti (2013). Our game element selection method can be divided into 4 steps.

A. Identifying Objective

The early step is to identify the objective of the user. The objective is basically the desired outcome which we expect from the user to achieve at the end of the activity, such as completing all online exercises, weekly login, or watching new VDO in MOOCs. Furthermore, the objective should be clear to understand. The game category for this step is a general framing, which is a motivational content for participation. The developer has to select only 1 game element to create the content matching the objective.

- Context: the content of objective is based on a real situation, such as a workplace environment.
- Background: the content provides objectives and motivational information such as the introduction and the background of objective and why the user needs to participate.
- Narrative: the content of the object can be fictional or non-fictional information.

Thus, the first step is to list down all the objectives. Then, the game element for the content should be selected and a clear objective needs to be explained.

B. Identify behavior and measurement

The second step is to identify behavior and measurement for the user. This step is related to the General Rules and Performance Framing which describes in general what the expected user behavior is, such as watching all VDO or passing the test. Moreover, the developer needs to determine the normative of user performance for example 80 scores achieved is “good” or below 50 scores is “bad”. The developer needs to select the game element following the steps listed below;

- Guidance: guideline, instructions, explanations for the user how to perform a particular task.
- Objective/targets*: the exact action for user. (select only 1 game element);
    - Correct answers
    - Choices
    - Task executions
    - Missions or quests
    - Beat other players
    - Etc.
- Renewal/regeneration: the chance to play again or defining how many times the user can repeat the test.
- Template/set for completion: for example answering all questions.
- Normative: definition of good or bad performance, for example the average score is 50, the high score is 80.

C. Identifying the activity

Since the developer had already defined the objective as an outcome and the expected behavior, the third step is to identify the activity. The game categories which are used to gamify a non-game activity are constraints, incentives, and social features. Constraints are the bounds within which the user needs to act and participate. The developer can select game elements from the lists depending on their purposes.

- Game accomplishments: the exact activity that the user needs to follow. (select only 1 game element)
    - Collect
    - Find
    - Create
    - Combine
    - Etc.
- Specific rule: required actions to accomplish objectives, for example, the user must complete all tasks within a specific duration.
- Limit of resource: for example only 100 points are provided.
- Limit of time: determining the duration of the activity, for example the activity must be completed within 30 days.
- Level of difficulty: the activity difficulty can be dynamic such as linear, or exponential, or it can be unpredictable to maintain user attention.

The incentive is a thing that motivates or encourages the user to participate or do something. The developer can provide appropriate incentives for the users when they achieve a certain activity.

- Intrinsic incentive: psychologically motivating, anticipated real-world outcomes.
    - Personal returns from gamified behaviors (e.g. wealth, health, longevity,

achievements, avoidance of negative personal consequence)
    - Social reward/peer pressure
    - Societal returns from gamified behaviors
- Extrinsic (Material)
    - Deals or discounts
    - Financial
    - Goods/services
    - Beak time/Holiday
    - Lottery/draw/bet
    - Etc.
- Extrinsic (Virtual)
    - Currency
    - Virtual Goods
    - Powers or abilities
    - Etc.

Social feature is an element which allows the user to interact with others, at the very least outside the experience.

- Relationships (select only 1 game element)
    - Friend feature
    - Team and guild
- Interaction Mode (select only 1 game element)
    - Commerce
    - Gift giving
    - Commendations, voting
    - Collaboration/helping
    - Competition

D. Game element selection

The final step is to select the game element which is used in the activity. The purpose of the game element category is to provide feedback and status for the user. Thus, the users are able to see their progress and can track information. The categories of game elements: the developer can select only 1 game element from each of the following types:

- Rescores (select only 1 game element)
    - Point
    - Score
    - Coin
    - Etc.
- Progress (select only 1 game element)
    - Badges or trophies
    - Progress bar
    - Level
    - Status
    - Avatar
    - Checklist
    - Performance gauge
- Social (select only 1 game element)
    - Leaderboard
    - Record of achievement
    - Discussion forum

For a better understanding, we have demonstrated examples of how to use the gamification element selection method in the MOOC context. According to the table, the main purpose is to encourage the user to pass the exercise in MOOC. Thus, we selected “context” as the game element to identify the objective. Then, we selected “Choices/quiz” to identify user behavior, which is “Correct answers in the quiz” and selected “Renewal/regeneration” to note that the user can re-submit the answers. Moreover, we selected “normative” to determine an achievement level of 70% for each chapter to be passed.

The next step is to identify the activity. We created the activity by selecting “collect” from the game accomplishment. Thus, the main activity is to collect scores from the quiz. Then, “Specific rule” is selected as a game element to determine the conditions which are “user got a score from the correct answer” and “pass first chapter exercise to unlock next”. We also selected “time-limited" for the user to attempt the quiz which is “Able to fail only 3 times a day (24 hrs.)”. At the end of the activity, “Social reward/peer pressure” is an incentive element which we selected for the users. They can earn social status which is represented in the leaderboard.

The final step is to select the gamification element. “Score” is selected as the resource which the user receives throughout the quiz. Meanwhile, we selected the “checklist” for the user to see their progress. Checklist represents the total score in each quiz session and the conclusion (Pass or Fail). Then, the total score from every user who did the quiz is ranked on the leaderboard. The leaderboard is an element by which the user can compare his or her scores with the scores of other users.

TABLE IV. AN EXAMPLE ON HOW TO USE THE GAMIFICATION SELECTION METHOD

Step to Gamification	Game Element	Detail
Identify Objective	Context	The exercise is placed at the end of each chapter which user need to pass all.
Identify behavior and measurement	Choices/quiz	Correct answers in the quiz.
	Renewal/regeneration	The user able to re-submit the answer.
	Normative	Achieved 70% of each chapter to pass.
Identify activity	Collect	Collect score from the quiz.
	Specific Rules	1. the user got score from correct answer. 2. Pass chapter exercise to unlock next.
	Limited of resources	Able to fail only 3 times a day (24 hrs.).
	Social reward/peer pressure	Social status in leaderboard.
Select gamification element	Score	Number score.
	Checklist	Pass checklist for every exercise chapter in subject.
	Leaderboard	Only top 5 users who get highest score.

IV. Conclusion

In this paper, we proposed a method which provides steps and a selection process of the game elements. The generic gamification frameworks have been reviewed and compared before being concentrated in 4 steps; Identifying objective, identifying behavior and measurement, identifying the activity, and selecting game elements. At the same time, the gamification categories and elements were taken from the taxonomy of gamification elements which consists of six categories; general framing, general rule and performance framing, constraint, incentive, social feature, and feedback and status information. The developer needs to follow the step to create gamification in a non-game context and needs to select appropriate game elements from each game category. Finally, an example was also provided for a better understanding. Future work, we aim to design new gamification activity and features in MOOCs by applies our method.

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References

[1] Meister, J. (2013). How MOOCs Will Revolutionize Corporate Learning And Development, Forbes, August 13.

[2] Monika Hamori (2018), Can MOOCs Solve Your Training Problem?, Harvard Business Review, January - February issue, viewed 5/8/2018: https://hbr.org/2018/01/can-moocs-solve-your- training-problem

[3] E. De Corte, L. Engwall, and U.Teichler. "The hype of MOOCs". In Erik De Corte, Lars Engwall and Ulrich Teichler (ed.), From Books to MOOCs?: Emerging Teaching in Higher Education, pp. xv-xxv. London: Portland Press Wenner-Gren International Series 2016, 2016.

[4] Chernbumroong, S., Suereephong, P. and Puritat, K., 2017. Massive Open Online Course Related Learning Style and Technology Usage Patterns of Thai Tourism Professionals. International Journal of Emerging Technologies in Learning (iJET), 12(11), pp.98-120.

[5] E.Lackner, M. Ebner, and M. Khalil. "MOOCs as granular systems: participant activity". eLearning Papers 42, pp. 28-37, 2015.

[6] R.M. Ryan and E.L. Deci. "Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being". American Psychologist, 55(1), pp. 68-78, 2000.

[7] Deterding, Khaled, Nacke, & Dixon, 2011; Deterding, Sicart, Nacke, O'Hara, & Dixon, 2011; Lee & Hammer, 2011; Muntean, 2011

[8] Domínguez, A., Saenz-de-Navarrete, J., de-Marcos, L., Fernández-Sanz, L., Pagés, C., Martínez-Herráiz, J.-J., 2013. Gamifying learning experiences: practical implications and outcomes. Comput. Educ. 63, 380–392.

[9] Goehle, G., 2013. Gamification and Web-based Homework. Primus: Probl. Resour. Issues Math. Undergrad. Stud. 23, 234–246.

[10] Chernbumroong, S., Sureephong, P. and Muangmoon, O.O., 2017, March. The effect of the leaderboard at different goal-setting levels. In Digital Arts, Media and Technology (ICDAMT), International Conference on (pp. 230-234). IEEE.

[11] A. Mora, D. Riera, C. Gonzalez, and J. Arnedo-Moreno. 2015. A Literature Review of Gamification Design Frameworks. In 2015 7th International Conference on Games and Virtual Worlds for Serious Applications (VS-Games). IEEE, 1–8.

[12] S. Deterding, D. Dixon, R. Khaled, and L. Nacke, "From game design elements to gamefulness: Defining gamification," pp. 9–15.

[13] K. Werbach and D. Hunter, For the win: How game thinking can revolutionize your business, 2012

[14] B. Merino de Paz, "Gamification: A tool to improve sustainability efforts," Ph.D. dissertation, 2013.

[15] M. Versteeg, "Ethics & gamification design: a moral framework for taking responsibility," 2013.

[16] D. Berdichevsky and E. Neuenschwander, "Toward an ethics of persuasive technology, "Communications of the ACM, 1999.

[17] B. Fogg, "Persuasive technology: using computers to change what we think and do, "Ubiquity, 2002.

[18] Hunicke, R., LeBlanc, M., and Zubek, R. MDA: A Formal Approach to Game Design and Game Research. Proc. AAAI workshop on Challenges in Game, AAAI Press (2004).

[19] Yee, N. (2007). Motivations of Play in Online Games. Journal of CyberPsychology and Behavior, 9, 772-775.

[20] Deterding, S., Dixon, D., Khaled, R. & Nacke, L. 2011. From game design elements to gamefulness: defining "gamification". Proc. 15th International.

[21] Dignan, A. Game Frame: Using Games as Strategy for Success. Free Press, NY, 2011.

[22] D. Robinson and V. Bellotti, "A preliminary taxonomy of gamificationelements for varying anticipated commitment," Proceedings of the CHI,2013

Knowledge expert co-creation-based conceptual framework for educational game

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***Abstract*—This paper aims to introduce and elaborate on a co-creation-based conceptual framework of five knowledge experts constructed as a guide towards the development of education games. To this end, we studied existing frameworks that have been proposed for the design of educational games and we involved knowledge experts who were currently supported by educational games applied to field-based environment on various game platform. We conclusively proposed a framework constructed for the design of any educational game. This framework used a participatory design method with game flow storyboard and learning object's documents as an involvement of experts of various related domains who contributed to the creation of educational contexts. We also tested our framework on the ASEAN MRA-TP used by Tourism industry professionals.**

Keywords— Component, game based learning, serious game, education game

I. INTRODUCTION

In recent years, there has been a significant development in the domain of education games. Of particular interest is the potential that education game related learning environments have by integrating effective problem solving and lesson learning with highly engaging learning experiences for learners. Several studies indicate that education games can provide an enhanced experience compared to more common teaching methods and thus have a strong potential as a learning tool. Many researchers present interesting frameworks proposed for the design of educational games. In general, the frameworks of education games can be broadly categorized into two groups: learner outcome and flow theory-based frameworks. For learner-based frameworks, Freitas& Jarvis proposed a four-dimensional framework. This framework comprises of four basic principles as follows: context, representation, learner and pedagogy. Salen & Zimmerman created the "Design, Play and Experience" framework which aims to depict the relation between the designer and the player and explicitly demonstrates the concepts that correspond to each layer designed depending on the phase and user type. Similarly, Yusoff presented a framework which provides a reference guide for the design of educational games with the focus on feedback and learner outcome. A Flow concept-based game design was first proposed by Kiili. The experiential gaming model framework aims to help game designers to understand the learning interactions and experiences players have during games. The core of this model is a circular learning process based on the flow theory which uses such terms as challenges, gamefulness and playability including all the necessary steps to ensure the successful achievement of learning objectives.

II. CONCEPTUAL FRAMEWORK

In this section we explain the proposed conceptual co-creation based framework for educational games. The elements of our framework can be divided into three groups: flow antecedents, the flow state and the knowledge experts. The flow antecedents (gray color) are factors that support the players in reaching the flow state and thus should be considered as highly important factors before designing an education game. The flow state is a subjective state of the game user explaining the feelings of the flow experience. The knowledge related factors (white triangle) that surround the flow antecedents are meaningful factors that affect the design of the learning experience and the game-based learning artefacts. The gray circles refer to the knowledge experts who are specialists with an important contribution to the design of flow antecedents and to the flow state of educational games.

III. RELATED WORK

A. Flow stste of education game

In terms of education games, Vygotsky adapted the original model of the flow state introducing the term 'zone of proximal development'. As regards learning activities, Mayes et al described a three-dimensional model of flow that represents how the procedure of the flow experience might be created via the learning activity. The most difficult part of the game design is to keep the game player in the flow state for as long as possible. Creating a flow experience is purposeful in the

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learning process. In the adaptive model of education game, it is also called the zone of proximal development.

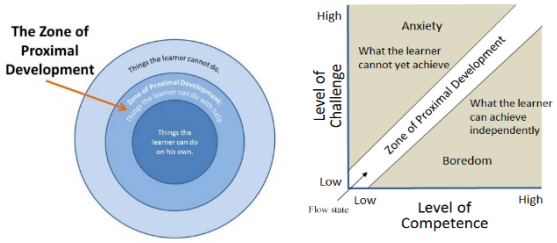

Fig. 1. Original flow state model)left (and the extended model introducing the zone of proximal development)right.(

B. *Knowledge*

Knowledge through sensing relates to sensory memory. It is the shortest term memory type. This ability is used to store sensory information after the original stimuli have ended which emphasizes that humans cannot hold the whole information of all sensory inputs at the same time and have a limited capacity which leads to bad learning effects. The knowledge integration accentuates the cognitive system of the long-term memory related to human synthesizing and problem-solving skills. The cognitive load theory of the human intellectual ability relates on the knowledge gathered in the long-term memory.

IV. METHODOLOGY

A. *Implementation of the co-creation based conceptual framework*

This section distributes information regarding the implementation and design process of our co-creation based conceptual framework for educational games that focuses on the education based on ASEAN MRA-TP which stands for "mechanism for agreement on the equivalence of tourism certification procedures and qualifications across ASEAN. When ASEAN nations mutually recognize each other's qualifications that will encourage a free and open market for the tourism labor force across the regions and will boost the competitiveness of the tourism sector in each ASEAN nation, while at the same time attracting needed talent to meet local skill shortages(What is the MRA?). Every ASEAN country's tourism industry will abide by the ASEAN-wide implemented tourism and hospitality standards set by this agreement and the skills will allow them to work in other ASEAN countries. This agreement allows ASEAN's tourism industry to recognize the skills of tourism professionals throughout the countries under a unified standard, allowing professionals to move and work in different countries under the same qualifications, as well as to enhance the overall quality of all ASEAN tourism services.

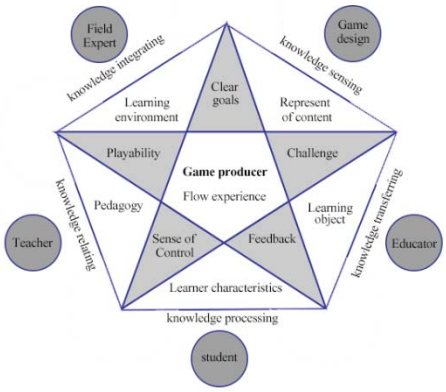

Fig. 2. Conceptual framework.

The basic outline of our framework is to ensure that the tourism professionals, game designers and game programmers work together to develop an educational game that both fulfills the ASEAN tourism standards and motivates the player to play the game and to learn and understand the subjects.

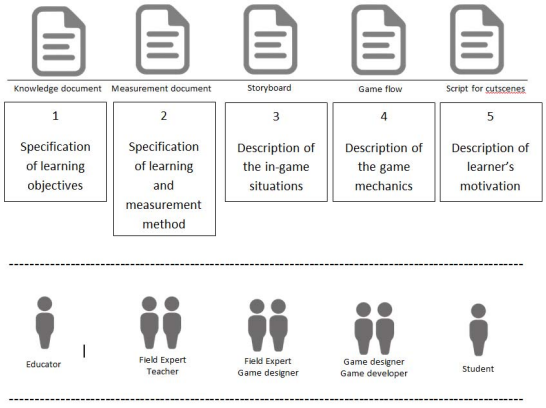

Fig. 3. Knowledge expert co-creation based conceptual framework.

B. *Game flow*

The game designers then begin designing the game flow, where the game starts off with an introduction scene, then brings in the main story of the game. The player is led to a game event, where different scenarios can happen forcing the user to make choices. The choices that the player makes will also affect the current situation, turning it into a successful play-through or a failed one. The game flow is created in a standardized way so that it can be used in many different situations, saving time and unnecessary efforts of game flow creation. Without a standardized game flow process, the game design would be confusing for they might change with every game the game designer designs, and would confuse the game programmers, causing more time spent on trying to understand the game flow, as well as causing disorganization.

C. *Storyboarding*

After the game flow has been finalized and confirmed by the development team the game designer will write up a storyboard that helps to describe the game flow better, using visuals as well as text details to deliver a clearer meaning to the game flow. The programmers are able to have a better understanding when using the storyboard in conjunction with the game flow. The storyboard itself links the different game events in the game flow together and helps the game programmers understand the sequences of the various game events. Without a storyboard, the game programmers might require the game designers to explain many things within the game flow itself, for the details might be too complex for the game programmers to understand within the context of their programming knowledge. It is not time-efficient and the game programmers might spend more time with trying to understand the game design itself than with actually programming the game.

D. *Measurement of the game's learning objectives*

When the players play with an educational game, the most important point for them is to understand the purpose of the game, and the learning objectives associated with it. The learning objectives can be measured as the player plays through the game. For example, if the learning objective is to have the player understand the laundering process in a hotel's on-site laundry, the player might have to play through an educational game where the player has to launder various types of clothes to understand the learning objectives

TABLE I. BLOOM'S TAXONOMY.

ITEM	NEEDED
Knowledge	Learner can recall information
Comprehension	Learner can explain and predict
Application	Learner can solve problems and use information
Analysis	Learner can see patterns or concepts and organizational structure may be understood
Synthesis	Learner can build a structure, put parts together to form a whole, with emphasis on creating a new meaning or structure
Evaluation	Learner can compare and make judgements about the value of ideas or materials

V. EXPERIMENTAL

In our framework, we also have a game designer for writing a script for the scenes in the game, ensuring that the game programmers know what dialogues to provide for the various characters in the game for the interactions with the player. Having good dialogues in the game helps enhance interactivity between the player and the game itself, giving the player more motivation to play and to acquire the skills highlighted in the learning objectives and supported by the subject materials.

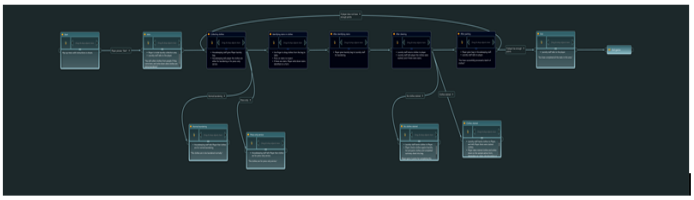

Fig. 4. The game flow is adapted to the game mechanism.

The educational game that we created is based on the methodology referenced in the previous section. The subject matter that we worked with was related to the hotel's laundry and housekeeping roles, therefore we asked for the experiences of the hospitality and tourism business learners to help us by giving us the subject material and necessary documents.

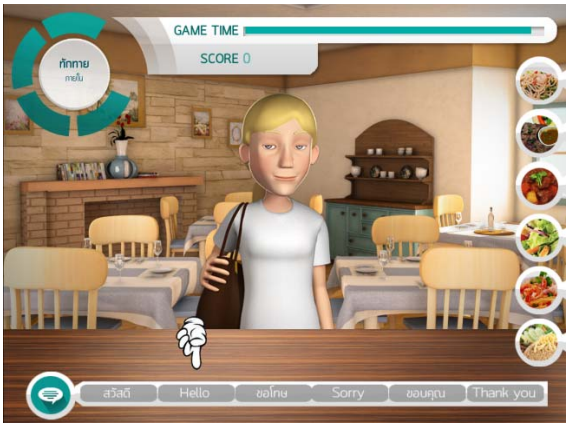

Fig. 5. MRA educational game on housekeeping

We started with the game flow first, as the game design that the storyboard would adapt to follows the sub-elements in the subject elements. The main application that we used for the creating and designing the game flow is artic y:draft2. The application allows us to draw out game designs like a flow chart, to have a sequential order as well as to have multiple choices. The game flow was designed after consulting with the learners multiple times, making sure to strike a balance between being overly detailed and overly simplified, as we wanted the players to be able to learn properly from the game, but at the same time we didn't want to burden the programmers by making it too complicated for them to understand. Each individual game was created based on an element of the subjects. Our framework proposed a knowledge representation approach based on the documented cooperation of five experts from different domains as shown in Figure 4. The experts involved were s follows: educator, field expert, teacher, game designer and learner .We also compared our framework with other frameworks as shown in Table 2 .

TABLE II. B COMPARISON OF SUPPORTED FEATURES / OUR PROPOSED FRAMEWORK AND OTHER FRAMEWORKS FOR EDUCATIONAL GAME.

Features	Four – dimensional	The Design, Play, and Experience	Experiential Gaming Model	EFM Model	Our framework
learning objectives	✓	✓	✓		✓
pedagogy	✓				✓
Content	instructional content		design knowledge		
psychology and motivation			flow theory	flow theory	flow theory
knowledge-based environment		✓	✓		✓
co-creation					✓

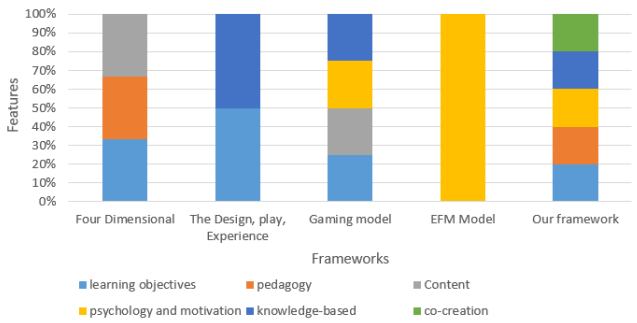

Fig. 6. Graph comparison of supported features between our framework and other frameworks.

VI. CONCLUSION

We proposed a framework for aiding the design and evaluation of educational games. The framework also provides design-support for making good educational games, because it reveals ways to optimize learning effects in line with the cognitive load theory and it involves various nowledge experts specialized in the field of educational games. In order to support the integration of learning objectives the framework distinguishes five levels of knowledge representation applying the cognitive load theory that provides means to consider game elements systematically from learning and interaction perspectives of different knowledge experts. Moreover, the framework has also been applied to the ASEAN MRA-TP project of tourism certification procedures and qualifications. Nevertheless our knowledge expert co-creation-based conceptual framework can be used as a guideline to various kinds of game designs and to reveal new ways to optimize learning effects and learning objectives. For a participatory design process, we actively involved each expert in the creation process of the storyboard, game flow and learning object documentation in order to avoid team conflict.

REFERENCES

[1] Erhel, S., &Jamet, E .2013. Digital game-based learning :impact of instructions and feedback on motivation and learning effectiveness. Computers & Education, 67, 156e167.

[2] Guillen-Nieto, V., &Aleson-Carbonell, M .2012 .Serious games and learning effectiveness :the case of It's a Deal !Computers & Education, 58)1(, 435e448.

[3] Robin Hunicke, V .Chapman .2004" .AI for Dynamic Difficulty Adjustment in Games ."Challenges in Game Artificial Intelligence AAAI Workshop .San Jose .pp .91-96 .J .Sweller, J .Van Merrienboer, F .Paas, Cognitive architecture and instructional design, Educ .Psychol .Rev .10)1998 (251-296.

[4] Wagner, Robert W .Edgar Dale .1970 .Professional .Theory into Practice. Vol .9, No .2, Edgar Dale)Apr., 1970(, pp .89-95 - http//:www.jstor.org/pss/1475566

[5] Freitas, S .and Jarvis, S .2006 .A Framework for Developing Serious Games to meet Learner Needs .Interservice/Industry

[6] Salen, K .and Zimmerman, E .2004 .Rules of Play :Game Design Fundamentals .Cambridge, Massachusetts :The MIT Press instructional design, Educ .Psychol .Rev .10) 1998 (251-296.

[7] Yusoff, A.; Crowder, R.; Gilbert, L.; Wills, G .2009" .A Conceptual Framework for Serious Games, "in The 9th IEEE

[8] Kiili, K .2005 .Content creation challenges and flow experience in educational games :The IT-Emperor case Internet and

[9] Song, M .and S .Zhang .2008 .EFM :A Model for Educational Game Design, in Lecture Notes in Computer Science, S .Link,

[10] Ibrahim, R .and Jaafar, A .2009" .Educational games)EG (design framework :combination of game design, pedagogy and content modeling", International Conference on Electrical Engineering and Informatics, 2009 .vol.1, pp .293-298.

[11] S.M .Barnett, S.J .Ceci .2002 . When and where do we apply what we have learn? A taxonomy for far transfer, Psychol .Bull .128 612-637.

[12] K.E .DeLeeuw, R.E .Mayer .2011. Cognitive consequences of making computer-based learning activities more game-like, Comput .Hum .Behav. 27)5 (2011 -2016.

[13] Y .Bereby-Meyer, S .Moran, E .Unger-Aviram .2004. When performance goals deter performance .Transfer of skills in integrative negotiations, J. Organizational Behav .Hum .Decis .Processes 93 142-154

[14] C .Ames, Classrooms .1992 . Goals, structures, and student motivation, J. Educ .Psychol .84 261-271.

[15] Y .Bereby-Meyer, A .Kaplan .2005. The effect of motivational goals and age on the ability to transfer knowledge, J .Contemp .Educ .30 1-22.

[16] Chaiklin, Seth. 2003" .The zone of proximal development in Vygotsky's analysis of learning and instruction ".Vygotsky's educational theory in cultural context 1 :39-64.

[17] Dale, Edgar" .Audiovisual methods in teaching ".1969.

[18] Csikszentmihalyi, M .1988" .The flow experience and its significance for human psychology", in Csikszentmihalyi, M., Optimal experience: psychological studies of flow in

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Linguistic Structure Analysis of Thai and White Hmong Languages for Machine Translation

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Abstract— **The Machine Translation (MT) is an automatic human language translation from one language to another language by computer namely "Interlingual MT". The most importance key of translation process is to understand the structure of the language. The research objectives are study the appropriate language structure, present the translation pattern, and develop a dictionary for Thai and White Hmong translations. The scope of the research is limited to the language structure which defines the word not exceed than 4 syllables. Linguistic structure analysis used the translation pattern and Human Aided Machine Translation (HAMT) process. The experimental results indicate that the translation process can be used in two ways are translation from primary language to target language and direct translation. Our dictionary has been developed with classification 6,677 words, 3,229 sentences were employed for system testing. The proposed prototype translation system is achieved a superior efficiency outcome of translation than Google and Microsoft by F-Measure are 0.496, 0.316, and 0.244 respectively. For future work, the researcher intend to present of the appropriate machine translation algorithm and committed to developing a translation application between Thai and Hmong languages.**

Keywords— linguistic structure analysis, Thai and White Hmong translation, human aided machine translation, automatic machine translation

I. INTRODUCTION

Over the past two decades, the technology of machine learning has become a part of life. Various technologies contribute to the development of quality of life such as machine translation [5-6], artificial intelligence [4, 11], supply chain and logistics technology [7], healthcare management [8] and so on. While the way of human life, the communication is necessary, as it is a tool for understanding others [9-10]. Even though the used of machine translation tools is widely offered, there are different technology and technique of machine translation are used in different area such as in Africa, North America, South America, Europe, Middle East and Southeast Asia. It is based on the different syntactic and grammatical of those languages.

At the same time, the most popular and interested in machine translation is the Natural language processing (NLP) which a field of artificial intelligence that helps the computer understand, interpret, and manipulate human language [11]. NLP is taken from many disciplines, including computer science and computer-based linguistics, to fill the gaps between human communication and computer literacy. Although the development of translation technology is more efficient, the need for human communication considerations is still present. In addition, most researchers place emphasis on the language of many users in the world [9, 11], on the other hand, the researcher neglects the language in the local or minority languages. Two of neglected languages are include White Hmong language and Karen language.

Simultaneously, translation technology that uses statistics and machine learning requires the big data to learn and translate [7, 11] such as Google Neural Machine Translation (GNMT) [12], Neural Machine Translation (NMT) [13] and Statistical Machine Translation (SMT) [4]. While, Hmong is one of the neglected languages and rarely data for translation technology. Therefore, the appropriate method of translation in the Hmong language is to use human help in developing the translation system called "Human Aided Machine Translation (HAMT)".

Moreover, the Hmong in Thailand has a large population [14]. Most Hmong people in Thailand can speak or communicate in Thai quit well, nevertheless they do not know how to translate between Thai and Hmong in a formal (text) translation form. It is a difficult for the people who want to study of both languages, especially researchers, teachers, merchants, officials and who deal with government agencies to improve the quality of life. Consequently, the development of Thai and Hmong translation tools is important to help the government agencies and Hmong. By reason of these reasons, this paper presents an analysis of the structure of Thai and White Hmong translations for the purpose of communicating with the Hmong ethnic group in Thailand. The research emphasizes on study the appropriate language structure, a simple translation pattern, and improve a dictionary for Thai and White Hmong translations.

This paper is organized into seven sections as the following: Introduction to the origin and importance of research, Literature review to link the relevant research, Research methodology to present the research process, Experimental results and analysis, Performance, Results and discussion to report the findings and Summary to discuss the results and define future research.

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II. Literature Review

A. Hmong Language

Hmong language is a dialect languages that influences the language of southern China. Originally Hmong was dispersed in Laos and Vietnam. The result of Vietnam War demonstrated a disaster for the Hmong in Southeast Asia, causing many to flee the area permanently. As a result, the Hmong have relocated around the world such as Australia, France, the United States and Thailand. The spread of Hmong around the world is so costly that many Hmong children stop learning and use their own ancestral language [14]. Due to this effect, the Hmong language may eventually be extinct.

Currently there are about 250,000 Hmong people in Thailand, spread in four provinces: Chiang Rai, Nan, Loei and Phetchabun [14]. One reason that the author would like to develop translation tools for Thai-Hmong language is to help the Thai people who require writing and reading Hmong language in Thailand have been able to communicate together and Hmong culture study in deep.

Although research and development tools are available for Hmong translators in the English version. The problem is that most Hmong people cannot communicate in English with Thai people. Therefore, it is necessary to improve the translation of Hmong and Thai languages.

B. Computerized Translation System

In Thailand, the pioneer computerized translation system was beginning in 1981. The objective of research is developed a computerized translation system compare with human translation process. There are many researches in computerized translation system such as Eason et al [1]. Concludes that the process of machine translation can be performed by the automatically computer systems. Likewise, Lewis and Yang [2] proposed the offline translations between English and Hmong language translation using the Statistical Machine Translation technique.

Moreover, there are several automatic online translation service is widely use and available on the Internet. One of the most popular is the Google Translator, which offers text or sentence typing, which is available in more than 100 languages, using a large number of statistical modeling technique to identify the content format of data and millions of patterns on the web. This technique used Neural System [3] known as "Google Neutral Machine Translation (GNMT)", which starts by English, Chinese, Japanese, Korean, Russian, Hindi, French, German, Spanish, Portuguese, Turkish, and Vietnamese. The advantage of this technique is the translation format be similar to natural language which translate the whole sentence at once instead of word-by-word translations. Moreover, the system is applied the border contexts and rearrange new sentences with meaning matching or close to the human language.

In 2016, Microsoft also developed the machine translation using artificial intelligence techniques. This offline system technique does not require high processing called "Neutral Machine Translation: NMT" with a high quality translation model that available on Android operating systems which contains AI chips specifically for offline translation [4]. Translation is the most important factors for choosing a superior translation tool. The test of sentence translation is defined to determine by the accuracy of online available system.

For this paper, the Human Aided Machine Translation (HAMT) is selected for computerized translation system. The key points that Hmong is one of the neglected languages. They have no enough data for any AI technology. The best appropriate method of translation in the Hmong language is to use human help in developing the translation system.

III. Research Methodology

This research is based on the fact of automatic translation systems using in present internet. The outcome of research expects information to assist tools development. The process of sequence of operations research is provided as the following:

A. Research Hypothesis

Structure analysis of linguistic and vocabulary can contribute better results of automatic translation system with less complicated methods.

B. Research Framework

The main target of the paper is to examine the available translations systems on the Internet and build a simple translation test system by classify the lexical to generate a Thai-Hmong dictionary. In additional, it includes some samples of Thai sentence for the experiment.

C. Research Scope

The scope this paper is aimed (1) to test and compare the sentence translations efficiency results of 3,000 sentences approximately with Google and Microsoft Translator by a measure an accuracy test by F-measure [15]. The proposed system is verified by Thai and White Hmong languages experts, (2) to create a Thai and Hmong dictionary that contains Thai word of 1 syllable, 2 syllables. 3 syllables and 4 syllables, based on their frequency of use and (3) to design a basic web-based translation system using the Thai grammatical method and classical words of White Hmong. The sample classical words are shown as in the Fig. 1. Examples of the basic sentence are shown in the Fig. 2.

ฉัน (Pronoun)	C̆hạn	(I, me)	= kuv
กิน (Verb)	kin	(eat)	= noj
ปวด (Verb)	Pwd	(pain, painful)	= mob
ท้อง (Noun)	Thx̂ng	(belly, tummy, paunch, abdomen)	= plab
ไป (Verb)	pi	(go)	= mus
เที่ยว (Verb)	theỳyw	(Travel, trip, journey, voyage)	= ncig teb chaws

Fig. 1. The classical words

Thai sentence (S + V + O)	White Hmong sentence (S + V + O)
ฉันกินข้าว (C̆hạn+ kin+ K̂hāw) (I eat rice)	kuv+ noj+ mov
ฉันปวดท้อง (C̆hạn+Pwd+Thx̂ng) (I have a stomachache)	Kuv+ mob+ plab
ฉันไปเที่ยว (C̆hạn+pi+theỳyw) (I go to travel)	Kuv+mus+ncig+teb+ chaws

Fig. 2. Examples of the basic sentence structure

D. Research Procedure

The process of this article consists of five steps: (1) to collect and study the vocabulary information of two

languages, based on the basic sentences of Thai and English from various sources [5], (2) to consolidate Thai-Hmong words into a dictionary, (3) to implement a translation program that works on the website, (4) to proof a translation of each sentence and record the results and (5) to summarize the experiment results.

E. System Development Tools

The system is implemented by PHP for the entire website and MySQL as database.

F. Creating a Dictionary

The vocabulary database is created based on Thai vocabulary by using 1 to 4 syllables Thai words, the total vocabularies are classified at 6,677 words accompany with database design consists of Entity Name, Attribute, Data Type, Data Description. Each field is defined as: (1) id used as vocabulary identify each field, (2) Thai word field contains Thai lexical, (3) word type indicates a category of word, (4) Hmong word1 will keep the Hmong lexical meaningful and (5) Hmong word2 keep the second meaning of Hmong word as options. For example, to define the vocabulary table as shown in Table I.

TABLE I. EXAMPLE OF VOCABULARY IN DATABASE

Id	Thai Word	Meaning		
		Type	*Hmong word1*	*Option*
1	ก็	v.,adv. Conj.	kuj	xxxx
2	กฎ	n.	Txoj cai	xxxx
3	กงสุล	n.	Tus thawj coj	xxxx
4	เคี้ยว	v.	cua	zom
5	ยินดี	n.	zoo siab	xxxx

G. System Methodology

The overview of all system operation is shown in Fig. 3 Starting from ① enter the Thai sentence by the user on screen. ② Through the word segmentation process with the LexTo[1] program to extract Thai word such as a sample meaning of "I eat rice" in Thai as below.

ฉันกินข้าว (Cẖạn kin K̂hâw) = **ฉัน + กิน + ข้าว**

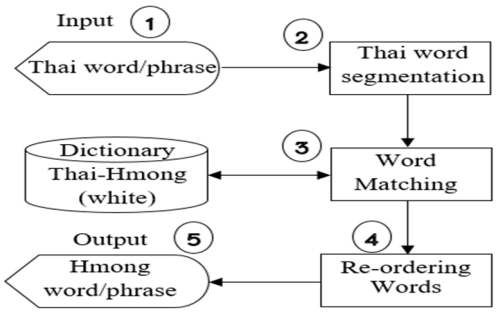

Fig. 3. The Overview of Basic Thai-White Hmong Translation System

Therefrom, ③ search the Hmong Thai words in the dictionary until found as matching words which the process of a simple Thai and Hmong sentence pattern, and a sample algorithm of the translation process are shown in Fig. 4-5. In ④ reordering and assembly all words before sent to next process. Finally, ⑤ a whole sentence display on the screen as final result.

Sentence Patterns:

Thai Sentence Pattern X: [ThPattern$_x$]
Thwd{1} + Thwd{2} + Thwd{3} + … + Thwd{ x_n }

Equivalent to:

White Hmong Sentence Pattern X: [HmPattern$_x$]
Hmwd{1} + Hmwd{2} + Hmwd{3} + … + Hmwd{ x_n }

Fig. 4. Basic sentence patterns

An example as below is a sample of algorithm for searching between a Thai and Hmong word.

Algorithm:

- If found Thai word then retrieve Hmong word from Hmong word1. Example:
  If Thai word = "กงสุล" then retrieve "Tus thawj coj"
- If not found Thai word then skip to next word. Example:
  If Thai word = "ชาตรี" then replace the same word and skip

Fig. 5. A sample algorithm for vocabulary matching process

IV. EXPERIMENT

The translated performance tests were measurement and compared with 3,229 sentences. The experimental results illustrate in Table II.

TABLE II. EXAMPLE OF TRANSLATION OF OTHER MACHINES

Thai Sentence	Translation		
	Microsoft	*Google*	*chk*[a]
ฉันกินข้าว	Kuv noj mov	Kuv noj mov	✓
ฉันปวดท้อง	Kuv plab	Kuv muaj mob plab	×
ฉันไปเที่ยว	Kuv mus kev deb	Kuv tau mus	×

[a] Note: Check (chk): × = incorrect ordering words, ✓ = Correct

Result analysis:

For the first sentence "ฉันกินข้าว", both of Microsoft and Google possess a correct result and the same meaning as "I eat rice". Whereas that the second sentence "ฉันปวดท้อง" the meaning is "I have a stomachache", the Microsoft's result gave "Kuv plab" that's mean "ฉันท้อง = I'm pregnant". The result of translation is wrong meaning and gives the other meanings. And also the Google's result translated to "Kuv muaj mob plab" means "ฉันมีป่วยท้อง = I have stomach sick". The result is wrong position of word, which the answer of this result must be "kuv mob plab". In addition to the last sentence "ฉันไปเที่ยว" means "I go to travel"; the result from Microsoft shown the meaning result as "ฉันไปทางไกล = I go the distance", while as Google presented the meaning as "ฉันได้ไป = I had gone" which the correct sentence should be "kuv mus ncig teb chaws". These causes are mistakes retrieval. All of errors can occur with translations on the Internet. When compare proposed system and two mention above systems, the experimental results of our system are shown in the Fig. 6.

[1] LexTo is a Thai word segmentation program, was developed in 2006 by Human Language Technology Laboratory, National Electronics and Computer Technology Center (NECTEC), Thailand

Fig. 6. Screen of the proposed system

V. Performance Evaluation

The proposed system is assessed by translation performance between Thai and White Hmong sentences from various sources as the 3,229 input sentences. Furthermore, the performances of systems are compared via regard to the efficiency measurement of F-measure [15] in Table III.

TABLE III. EFFICIENCY MEASUREMENT

Translation System	Performance Evaluation		
	Precision	*Recall*	*F-Measure*
Proposed System	0.568	0.44	0.496
Google	0.281	0.36	0.316
Microsoft	0.198	0.319	0.244

According to the experimental result of efficiency measurement as above are demonstrates that the proposed system results reach the highest score evaluations: Precision 0.568, Recall 0.44, and the efficiency F-Measure is 0.496.

VI. Results and Discussion

In this experiment, we compare three translation systems of 1) the proposed system, 2) Google, and 3) Microsoft Translator, which were verified by human with the accuracy result are 2,420 sentences or 75%, 1,679 sentences or 52%, and 1,410 sentences or 44% in order. It indicates that the methods and techniques are significant and affect translation results. Especially, if the system has an appropriate management with lexical in the dictionary and properly algorithm. Consequently, it will achieve the high accuracy result in translation as well. In addition, it will increase the speed processing and also reduce the storage of vocabulary in the system.

However, this preliminary research idea to compare Thai and White Hmong automatic translation on different website sources. Though, it becomes the fundament to efficiency development guide of the system in future. For future work, we will increase a numerous of vocabulary in dictionary and sentences including to determine the sentence in various groups which coverage in any domain. Additionally, should use more efficient database system with new technologies, and reduce errors for better results.

VII. Summary

The goal of this research are examine the appropriate language structure, present the translation pattern, and develop a dictionary for Thai and White Hmong translations. After that, compare the accuracy results with the various Thai-White Hmong automatic language translation sources on the website. The translation system is implemented by simple grammatical and classical techniques via sorting from left to right with preparation of properly vocabulary to reduce the size of translation. These are important factors to contribute the automatic translation system achieves with high accuracy result. The accuracy of translation for three systems by F-Measure; the proposed system, Google and Microsoft Translator revealed in 0.496, 0.316, and 0.244 respectively.

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References

[1] K. Chancharoen, N. Tannin, and B. Sirinaovakul, "Sentence-based machine translation for English-Thai," in IEEE. APCCAS 1998. 1998 IEEE Asia-Pacific Conference on Circuits and Systems. Microelectronics and Integrating Systems. Proceedings (Cat. No.98EX242), 1998, pp. 141–144.

[2] W. D. Lewis and P. Yang, "Building MT for a severely under-resourced language: White Hmong," in *Association for Machine Translation in the Americas*, 2012.

[3] M. Johnson *et al.*, "Google's multilingual neural machine translation system: enabling zero-shot translation," *arXiv preprint arXiv:1611.04558*, 2016.

[4] K. Chen *et al.*, "A Neural Approach to Source Dependence Based Context Model for Statistical Machine Translation," *IEEE/ACM Transactions on Audio, Speech, and Language Processing*, vol. 26, no. 2, pp. 266–280, Feb. 2018.

[5] Z. Yang, W. Chen, F. Wang, and B. Xu, "Generative adversarial training for neural machine translation," *Neurocomputing*, vol. 321, pp. 146–155, Dec. 2018.

[6] D. Moussallem, M. Wauer, and A.-C. N. Ngomo, "Machine Translation using Semantic Web Technologies: A Survey," *Journal of Web Semantics*, vol. 51, pp. 1–19, Aug. 2018.

[7] K. Govindan, T. C. E. Cheng, N. Mishra, and N. Shukla, "Big data analytics and application for logistics and supply chain management," *Transportation Research Part E: Logistics and Transportation Review*, vol. 114, pp. 343–349, Jun. 2018.

[8] H.-S. Kim, K.-H. Lee, H. Kim, and J. H. Kim, "Using mobile phones in healthcare management for the elderly," *Maturitas*, vol. 79, no. 4, pp. 381–388, Dec. 2014.

[9] M. R. Costa-jussà and J. A. R. Fonollosa, "Latest trends in hybrid machine translation and its applications," *Computer Speech & Language*, vol. 32, no. 1, pp. 3–10, Jul. 2015.

[10] A. M. Turner, M. K. Brownstein, K. Cole, H. Karasz, and K. Kirchhoff, "Modeling workflow to design machine translation applications for public health practice," *Journal of Biomedical Informatics*, vol. 53, pp. 136–146, Feb. 2015.

[11] I. Zeroual and A. Lakhouaja, "Data science in light of natural language processing: An overview," *Procedia Computer Science*, vol. 127, pp. 82–91, Jan. 2018.

[12] Y. Wu *et al.*, "Google's neural machine translation system: Bridging the gap between human and machine translation," *arXiv preprint arXiv:1609.08144*, 2016.

[13] G. Mahmut, M. Nijat, R. Memet, and A. Hamdulla, "Exploration of Chinese-Uyghur neural machine translation," in *2017 International Conference on Asian Language Processing (IALP)*, 2017, pp. 176–179.

[14] J. Lemoine, "What is the actual number of the (H) mong in the world?," *Hmong Studies Journal*, vol. 6, p. 1, 2005.

[15] C. J. Van Rijsbergen, "Foundation of evaluation," *Journal of documentation*, vol. 30, no. 4, pp. 365–373, 1974.

Clustering of Learners Performance based on Learning Outcomes for Finding Significant Courses

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***Abstract*— Education is the most critical topic globally. As a result, an analysis of educational insights concerned to find patterns and knowledge which is interesting in educational management. Therefore, this paper proposes a new method of clustering the attributes (courses) that support the students' performance, identify the attributes (courses) that effect to each group (cluster) of students' outcomes, and evaluate the model performance. The sample is conducted from 249 students from Phadungnaree School, Maha Sarakham province, Thailand. The results show that there is a variety of cluster in students' performance with importance attributes (courses) of students programs, while the model performance is very significant to the model. In the future work, it will be implemented to the application and program recommendation for secondary school.**

Keywords*— *Educational Data Mining (EDM), Student's Performance, Knowledge Management in Education, Student Model, Study Learning Styles

I. INTRODUCTION

During the two-decade, data mining is a new trend of educational reform for student development and knowledge discovery in the students' data set, which is focusing on finding useful attributes and patterns for students' performance [1-3]. The student's performance is more important than the academic results and grade point average (GPA). Many researchers in this field have researched to focus on the discovery of knowledge that is beneficial to both the institution and the learner in order to help the institution to manage it better. Meanwhile, the work helps students to manage better their academic achievement [4] and delivery of knowledge by increasing their effectiveness [5-6].

Recently, grade point average (GPA) is used to indicate student performance [7]. It showed only an overview of student's results, while using the data mining technique provided insights analysis into the learning behavior of students [1-3, 7]. There are different research results to illustrate the advantages of data mining techniques such as analyzing student data, classifying student learning styles, creating an application for enhancing students' performance [2, 8]. The weakness of such research is the analysis of data and factors are not directly related to the performance of the student. It is using a questionnaire to find out the attitudes towards the academic results. It also uses social factors to indicate the relevance of students' performance and the educational environment to evaluate the levels of school with students' performance [2]. However, this paper provides an in-depth analysis of data and factors that directly relate to the learner. The objective of this paper is aimed to propose a new method to identify the attributes that support the students' performance and offer learning models for education in Thailand.

Furthermore, the newly discovered knowledge and method will help students as well as a teacher to improve the quality of student's performance and recommend an appropriate major for a student in upper secondary level and higher education. It identifies the possible major related to previous academic results. It also motivates and creates greater stimulating with students in order to help them discover the process of the professional pathway with a better opportunity to a student in the future.

The outline of the paper is structured into five sections. A summary of the related work is provided in Section II. Section III contains the research methodology implemented in this paper. The research results are discussed in section IV. Finally, section V contains the conclusion of this paper.

II. LITERATURE REVIEWS

A. Thailand Educational System

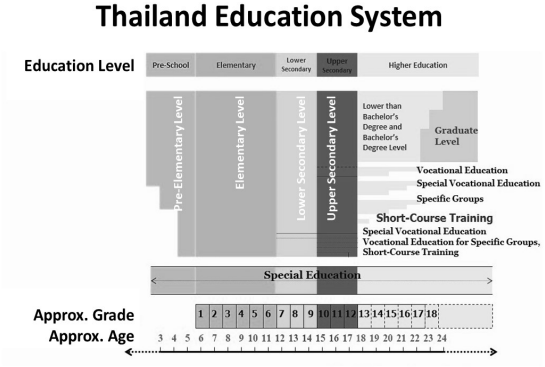

Fig. 1. Structure of Education in Thailand

According to Figure 1, the structure of education in Thailand is separated into two levels, which are primary education and higher education. Primary education is separated into three levels including pre-elementary level, elementary level, and secondary level. Also, higher education

is the advanced academic level, which is portioned into two levels; diploma and degree levels [9-10].

This paper is only scoped the group's study in the secondary level, which secondary level is a formal education system that divided into two level including lower secondary level and upper secondary level.

B. Student's Performance

Student's performance is the learner's ability to learn by considering the success level of the learner [1-3, 7]. The data is collected as a result of each course.

The process of assessing the results, the learners were considered in all five skills including the capacity of communication, the capacity of thinking, the capacity of problem-solving, capacity for applying life skills, and capacity for technological application to judge the student's performance on various topics. Also, the teacher is responsible for collecting the information from all learners on a regular and continuous basis. Additionally, it correctively measures that learners can develop their potential as much as possible.

According to the education criteria, teachers will judge the learning outcomes of all courses. The students should attend at least 80 % of all study time. The students should have to be assessed for all metrics and must meet all criteria set by the institution. The students must be judged according to the learning outcomes of each course. Moreover, the students must be assessed and supposed to meet all the criteria set by the institution [9-10].

III. Research Methodology

The research methodology consists of four stages; (1) data acquisition, (2) cluster analysis, (3) models and data analysis, and (4) models evaluation as shown in Figure 2.

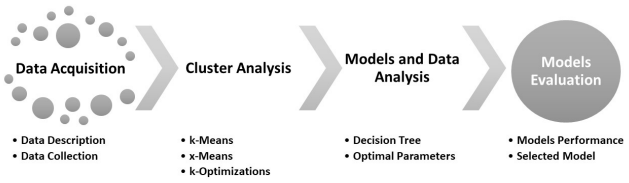

Fig. 2. Research Methodology

A. Data Acquisition

Data acquisition is a stage in defining the scope of data and samples for collecting data. It composes of two sections including data description and data collection.

1) Data Description

This paper is taking place in a middle-size of the sample, which is a Phadungnaree School in Maha Sarakham, Thailand. The Phadungnaree school offers two levels of education; a lower secondary level, which consists of two education programs and an upper secondary level with eight education programs.

The scope of the target group is collected only at the lower secondary level including four groups of students explicitly. Group 1 is the student during the academic year 2011-2013. Group 2 is the student during the academic year 2012-2014. Group 3 is the student during the academic year 2013-2015. Group 4 is the student during the academic year 2014-2016.

2) Data Collection

This step was conducted by 249 students during the academic year 2011-2016 from Phadungnaree School after defining the scope of the data. They provided academic results including course title, grade of each course, grade point average (GPA), and transcript, shown in Table I.

TABLE I. Data Collection

Groups	Data Collection					
	Number of Students	*Total Courses*	*Total Credits*	*G.P.A.*		
				Min	*Max*	*Average*
Group 1	66	94	93.50	2.48	3.97	3.15
Group 2	63	97	97.50	2.37	3.91	3.12
Group 3	60	96	97.00	2.51	3.70	3.09
Group 4	60	95	95.50	2.70	3.84	3.25
Summary:	**249**	**-**	**-**	**2.37**	**3.97**	**3.15**

Table I demonstrates the number of data collection by division and number of students completing the program. It is shown that the total of data collection is equal to 249 students. The minimum of G.P.A. is equal to 2.37. The maximum of G.P.A. is equal to 3.97. In addition, the average of G.P.A. is equal to 3.15.

B. Cluster Analysis

1) k-Means

k-Means is used to determine the number of the optimal cluster in each data series. For example, the minimum of G.P.A. in group 1 is equal to 2.48, the maximum of G.P.A. in group 1 is equal to 3.97, and the average of G.P.A. in group 1 is equal to 3.15. The mean of G.P.A. in group 1 is equal to 3.23. It can be seen that the average of G.P.A. is lower than the mean of G.P.A., which is used k-Means to re-group the appropriate cluster in each data series.

2) x-Means

x-Means clustering is the change management of k-Means clustering, which manages cluster allocations by trying to replicate partitions and separates the best results until a certain threshold is reached. The goal is determining intrinsic group in a set of unlabeled data.

3) k-Optimizations

k-Optimization is based on elbow decision concept for selecting k-value and x-values. The decision of selecting k-value and x-values is selecting the value where k and x have a urgent change. For example, the vertical change is markedly horizontal, shown in Figure 3.

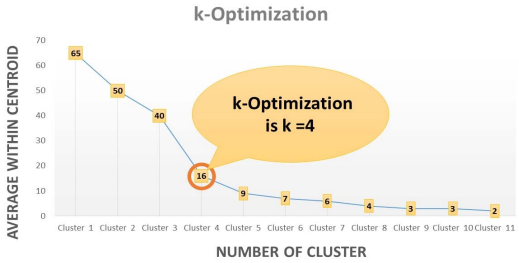

Fig. 3. k-Optimization

C. Models and Data Analysis

1) Decision Tree

Decision Tree is a tool that used to find the significant factors by applying attribute selection from the node in the decision tree model [11]. In this paper, it was developed the

effectiveness of the clustering by applying the decision tree to test the clustering performance and select the best decision tree for creating and implementing the model.

2) Optimal Parameters

The optimal parameters are the methods of the selected parameters (signification factors) for the model created in the previous process. There are two optimize parameters operator; evolutionary operator, and quadratic operator.

The evolutionary optimize parameters operator is used to find a set of parameters for optimal values by using an evolutionary method. It is often more reasonable than grid search and greedy search, and leading to progressive results.

The quadratic optimize parameters operator is used to find the optimal values using a quadratic interaction model from the collected parameter set/performance pairs. It tries to calculate a new parameter set that might lie in between the given grid lines. The result will either be the best performance from the original.

D. Models Evaluation

1) Models Performance

Models performance is used the cross-validation methods to evaluate model by separate the data collected into two sets including a training dataset and testing dataset. Training dataset is used for building the model. The testing dataset is used for testing the model. The cross-validation methods in this paper are two types including k-fold cross-validation and leave-one-out cross-validation, shown in Figure 4.

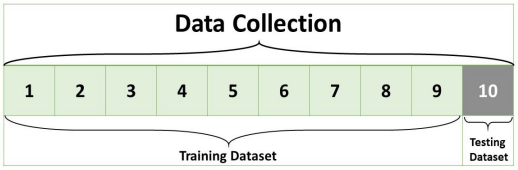

Fig. 4. Cross-Validation Method

2) Selected Model

The selected model is considered to base on an overview of the model results, which is reasonable considering the validity, effectiveness, model pattern, and applicability. The criteria of consideration are accuracy, precision, and recall. All criteria are discussed in the next section.

IV. Research Results and Discussion

This section presents the research results and brings the results to the discussion after completing the research methodology process.

A. Research Results

Results in the previous process are divided into two parts; (1) optimal clustering analysis, and (2) models analysis and evaluation.

1) Optimal Clustering Analysis

There are two optimal value results from the research methodology process; k-Optimization for k-Means clustering, and x-Means summary from k-Optimization as shown in Figure 5 to Figure 9.

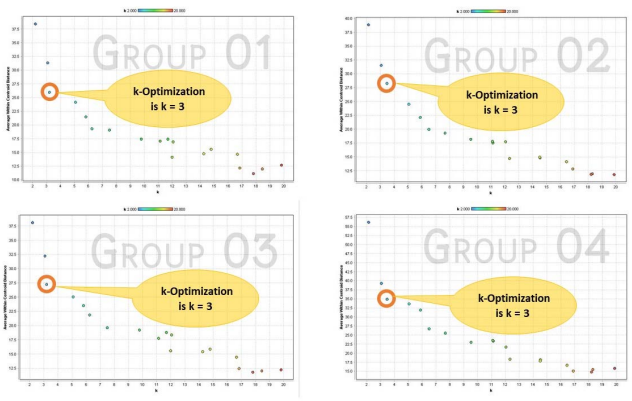

Fig. 5. k-Optimization for k-Means

Figure 5 show that k-Optimization is equal to 3. From all groups, the *k* values selected vertically and horizontally change in the elbow decision concept. The *k* values are determined by the vertical and horizontal sudden changes.

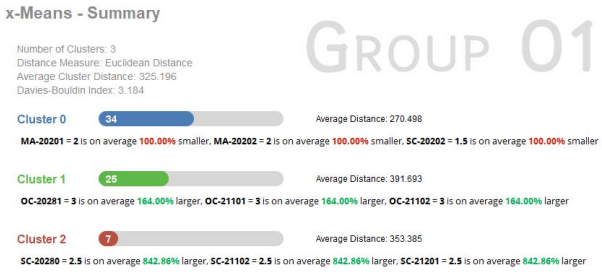

Fig. 6. x-Means summary from k-Optimization of group 1

Figure 6 show x-Means summary from k-Optimization of group 1. It found that in Cluster 0, the Mathematics (MA-20201, MA-20202) and Science (SC-20202) are on average 100% smaller. It means that Mathematics and Science have the most detrimental effect in Cluster 0.

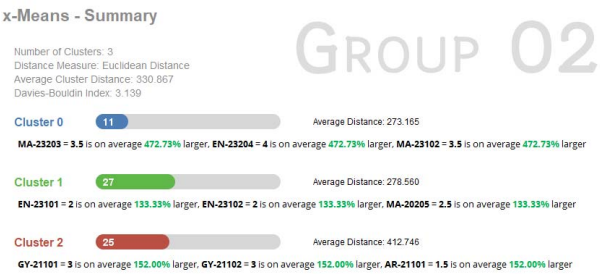

Fig. 7. x-Means summary from k-Optimization of group 2

Figure 7 shows the x-Means summary from k-Optimization of group 2. It found that the course in each group affects different clusters. For example, Cluster 0 consists the influential courses are Mathematics (MA-23203, MA-23102) and English (EN-23204), while Cluster 2 consists the influential courses which are Gymnastics (GY-21101, GY-21102) and Art (AR-21101).

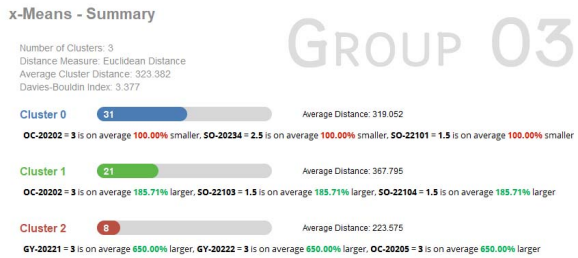

Fig. 8. x-Means summary from k-Optimization of group 3

Figure 8 show x-Means summary from k-Optimization of group 3. It found that courses do not have the weight and influence student performance are Occupation (OC-20202) and Social Science (SO-20234, SO-22101).

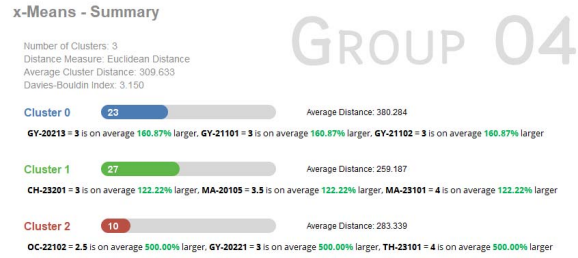

Fig. 9. x-Means summary from k-Optimization of group 4

Figure 9 show x-Means summary from k-Optimization of group 4. It found that courses that do have the weight and influence student performance in Cluster 0 are Occupation (OC-22102), Gymnastics (GY-20221), and Thai Language (TH-23101).

2) Models Analysis and Evaluation

This section discusses about two topics; (1) optimal performance for parameters, and (2) models performance.

a) Optimal Performance for Parameters

The optimal performance for parameters is determined by comparing performance from decision tree after building clustering the students' performance in the previous section. The performance in this section consists of two areas of decision; maximum depth (MD) and performance (P), shown in Table II.

TABLE II. OPTIMAL PERFORMANCE FOR PARAMETERS

Group 1		Group 2		Group 3		Group 4	
MD	*P*	*MD*	*P*	*MD*	*P*	*MD*	*P*
2	0.623	2	0.600	2	0.521	2*	0.562*
3	0.717	3	0.560	3	0.625	3	0.542
5*	0.774*	5*	0.620*	5*	0.646*	5	0.562
7	0.774	7	0.620	7	0.604	7	0.562
10	0.774	10	0.620	10	0.604	10	0.562
15	0.774	15	0.620	15	0.604	15	0.562

According to Table II, it shows that the optimal performance for parameter in group 1 is equal to 5 maximal depths, the optimal performance for parameter in group 2 is equal to 5 maximal depths, the optimal performance for parameter in group 3 is equal to 5 maximal depths, and the optimal performance for parameter in group 4 is equal to 2 maximal depths. Therefore, it can be concluded that an overview of the appropriate maximal depth is equal to 5. After knowing the optimal maximal depth, the next section discusses the performance of the model.

b) Models Performance

The model's performance is aimed to describe how to select the appropriate model. The instrument consists of three parts to consider the model's performance; accuracy, precision, and recall. The results obtained at the appropriate depths given to the previous topics are shown in Table III.

TABLE III. SUMMARY OF MODELS PERFORMANCE

Groups / Cross-Validation (CV)	Model Performance		
	Accuracy	*Precision*	*Recall*
Group 1			
• 5-Folds CV	63.74 %	64.77 %	62.17 %
• 10-Folds CV	69.52 %	70.93 %	66.54 %
• leave-one-out CV	56.06 %	58.47 %	54.10 %
Group 2*			
• 5-Folds CV*	79.10 %*	78.57 %	79.32 %
• 10-Folds CV	77.62 %	75.70 %	77.10 %
• leave-one-out CV	74.60 %	74.72 %	71.97 %
Group 3			
• 5-Folds CV	51.67 %	51.76 %	48.87 %
• 10-Folds CV	55.00 %	55.46 %	54.60 %
• leave-one-out CV	53.33 %	53.08 %	54.17 %
Group 4			
• 5-Folds CV	53.33 %	52.65 %	52.57 %
• 10-Folds CV	53.33 %	49.92 %	47.97 %
• leave-one-out CV	60.00 %	56.08 %	58.29 %

Table III displays that the performance of the model from all groups is approximately 60 – 70% of accuracy.

At this state, the results show that the optimal clustering is k-optimization equal to 3, which is affected to each group clustering as present the critical course for student's performance. Also, the model performance supports the research results that show the high accuracy. In the next section will discuss the advantages of research findings and knowledge discovery.

B. Discussion

The results of the research indicate that the course will affect the student's success pattern. Therefore, the dimensions discussed in this section are the analysis of courses that affect the success of the learner and the course significant.

1) Significant Model

Due to some limitations, this paper chose to consider some groups of data by selecting from the groups with the highest accuracy of the model performance. The second group is selected to participate in the discussion with the models derived from the analysis, shown in Table IV and Figure 10.

TABLE IV. 5-FOLD CROSS-VALIDATION RESULTS

Predicted / Actual	True Condition			Precision
	True Group 1	*True Group 2*	*True Group 3*	
Predicted Group 1	11	2	0	84.62 %
Predicted Group 2	2	28	11	82.35 %
Predicted Group 3	0	5	4	68.75 %
Recall	84.62 %	80.00 %	73.33 %	

The accuracy of model performance: 79.10 %

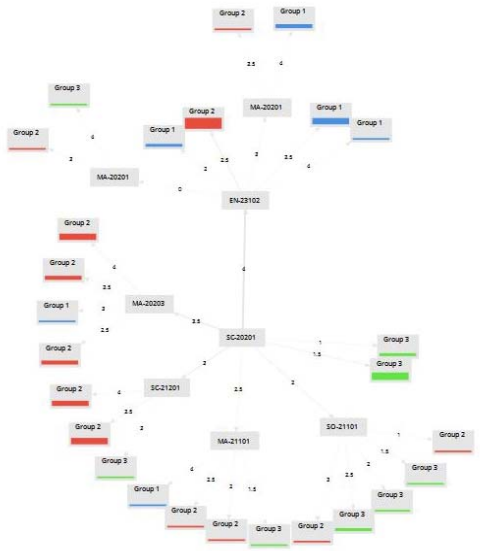

Fig. 10. Decision Tree Model

Figure 10 shows the structure of the decision tree, which the essential courses for the structure (Root Node) is Science (SC-20201). Figure 10 and Table IV found the necessary courses for each group as presented in the next section.

2) Significant Courses

The basic courses depend on the impact on the learning outcomes in finding a significant course. As shown in Figure 11, the majority of the member is in the Cluster 1, where the impact of the course on learning outcomes is two-dimensional; support dimension, and contradicts dimension.

Fig. 11. Important Factors

The courses in the support dimension are four courses including Chinese Language (CH-23202), Mathematics (MA-22201), and Gymnastics (GY-22101, GY-23101). The courses in the contradict dimensions are three courses including Social Science (SO-21101, SO-23101), and Occupation (OC-23102).

At the end of this section, it found that the clustering of learner success resulted in a pattern of success that reflected the relevant courses and within the group of learners.

V. Conclusion

This paper proposes a new method for clustering the attributes (courses) that supports the students' performance, identifies the attributes (courses) that effect to each group (cluster) of learners' success, and to evaluate the performance of the model.

The research results showed that the learners' success of each group is different. The course will affect the success of the learners at several levels. Figure 6 to Figure 9 showed the differences in the courses of the analyzed groups. Also, Figure 11 also illustrates the dimensions that supports and conflicts the course to the learner's success clearly.

Finally, the results show that there is a variety of cluster in students' performance with importance attributes (courses) of students programs. The model performance is very significant to the model. In future work, it can be implemented to the application and program, which is recommended to propose appropriate educational programs within secondary schools.

Acknowledgment

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References

[1] P. Nuankaew, W. Nuankaew, S. Bussaman, and P. Jedeejit, "Education mining in the relationship between general knowledge and deep knowledge for lifelong learning," in *2017 14th International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology (ECTI-CON)*, Phuket, 2017, pp. 694–697.

[2] P. Nuankaew, W. Nuankaew, K. Phanniphong, and S. Bussaman, "Mobile Applications for the Prediction of Learning Outcomes for Learning Strategies and Learning Achievement in Lifelong Learning," in *Teaching and Learning in a Digital World*, Cham, 2018, pp. 400–412.

[3] K. Pupara, W. Nuankaew, and P. Nuankaew, "An institution recommender system based on student context and educational institution in a mobile environment," in *2016 International Computer Science and Engineering Conference (ICSEC)*, 2016, pp. 1–6.

[4] B. J. Zimmerman, "Self-Regulated Learning and Academic Achievement: An Overview," *Educational Psychologist*, vol. 25, no. 1, pp. 3–17, Jan. 1990.

[5] R. B. Barr and J. Tagg, "From Teaching to Learning — A New Paradigm For Undergraduate Education," *Change: The Magazine of Higher Learning*, vol. 27, no. 6, pp. 12–26, Nov. 1995.

[6] H.-J. So and T. A. Brush, "Student perceptions of collaborative learning, social presence and satisfaction in a blended learning environment: Relationships and critical factors," *Computers & Education*, vol. 51, no. 1, pp. 318–336, Aug. 2008.

[7] S. Helal *et al.*, "Predicting academic performance by considering student heterogeneity," *Knowledge-Based Systems*, Jul. 2018.

[8] A. M. Shahiri, W. Husain, and N. A. Rashid, "A Review on Predicting Student's Performance Using Data Mining Techniques," *Procedia Computer Science*, vol. 72, pp. 414–422, Jan. 2015.

[9] K. of T. O. of the P. M. O. of the N. E. Commission, *National education act of BE 2542 (1999)*. Office of the National Education Commission, Bangkok, Thailand, 1999.

[10] C. Sereerak, et al., *The 2016 Educational Statistics*. Office of the Permanet Secretary, Bangkok, Thailand, 1999.

[11] P. Nuankaew and P. Temdee, "Of online community: Identifying mentor and mentee with compatible different attributes and decision tree," in *2015 12th International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology (ECTI-CON)*, Hua Hin, Cha-am, Thailand, 2015, pp. 1–6.

Study Materials and Knowledge Structure Management using MyTeLeMap

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***Abstract*—*This research describes a tool for managing lesson knowledge structures for Web-based and on-line learning, allowing experts and teachers to attach study material links at each structure component. Experimental studies are planned to validate the design of the knowledge structures and the effectiveness of the tools. Learners are expected to gain significantly higher levels of achievement by using the knowledge structures and associated tools proposed in this research.*

Keywords—Knowledge structure, learning management system, self-learning, web-based learning

I. INTRODUCTION

Knowledge representation is the explicit representation, structuring, and linking of knowledge and has been deployed to: represent the content structure of study documents [1], supporting learners in their own knowledge acquisition [2], and enabling suggestions to learners [3]. Knowledge relationships can be represented in many forms (maps, trees, networks, and graphs) and may be called concept maps, knowledge maps, and knowledge structures.

There are several methods of building knowledge structures [1, 2] and an interesting question is how such structures can pedagogically support learning and teaching activities. A literature review found some knowledge structure and concept map building in use in educational technology.In this research, Thai school teachers were surveyed and interviewed and the preliminary data suggested that even though knowledge structures have been recommended for many years, school teachers did not report using them in their teaching. “Mind maps” were used to support learners’ conceptualization and understanding of the course content. A mind map is a rather rough note of content information, where the relationships among the content items are usually vague and imprecise [3].

E-learning resources typically comprise online courses, online websites, lesson videos, instructional TV, and so on. Such resources allow learners to spend more time studying and practicing/solving lesson problems on their own at times and in places which may suit them better. e-Learning usually includes some form of learning management system (LMS) which allows lesson and assessment administration. It may be difficult, however, for learners to find and access materials which match their abilities or knowledge or to identify the relationships among the knowledge being taught. This research describes a tool for representing knowledge structures and for suggesting learning paths and learning resources to support a learner in achieving a desired learning outcome.

II. LEARNING MANAGEMENT SYSTEM AND THAILAND E-LEARNING

In Thailand education, Saiyasombut & Siam Voices [4] reported that Thai learners are not being well equipped with the type of knowledge and skills that will enable them to do well in the future in which many key aspects of life will require a more demanding level of literacy. These problems can be found in any classes and any subjects. Thai classrooms tend to provide similar learning environments and all learners are assumed to have the same level of knowledge [5]. Thai learners are taught to ‘remember’ rather than ‘understand’. Consequently, they have inadequate ‘thinking process’ and ‘solving problem skills’ which are important, for example in order to learn Mathematics effectively [6]. Resources are also an important factor, and there is still a lack of good resources for learning [7]. As introduced above, E-learning is one type of resource for overcoming this problem, and there are many online study materials available which learners can access at any time and any place. Learners can retrieve supplementary online resources and familiarize themselves with missing knowledge before their course starts. There are many commonly used e-Learning systems in Thailand though they are mainly learning management systems, for example Learn Square (http://www.learnsquare.com/), ClassStart (www.classstart.org), and Moodle (https://moodle.org/). The current learning management systems are rather the place for managing study documents and resources with little structured support for explicitly articulating the relationships among the knowledge being taught.

III. KNOWLEDGE STRUCTURES AND RELATED APPLICATIONS

Several types of knowledge structure have been proposed in the literature. In Kickmeier-Rust, Albert, and Steiner [8], a node represents a knowledge state (or a task), which is the set of the available knowledge of a person at a particular point in time, for example, “VWX”. The structure represents the set of all possible knowledge states of a learner. The prerequisite relationships are defined within this set of knowledge states, for example, a prerequisite to “VWX” is “VX”. Each item of knowledge in a state represents a problem or subject matter which a learner is required to solve or understand, for example, the learner is required to achieve the node V before proceeding to the node VW and VX. Another example is the node “VWX” represents the learner’s ability to solve the problems or understand the subject matter “V”, “W”, and “X”. Considering each state, the front subject matter is the prerequisite of the adjacent latter subject matter.

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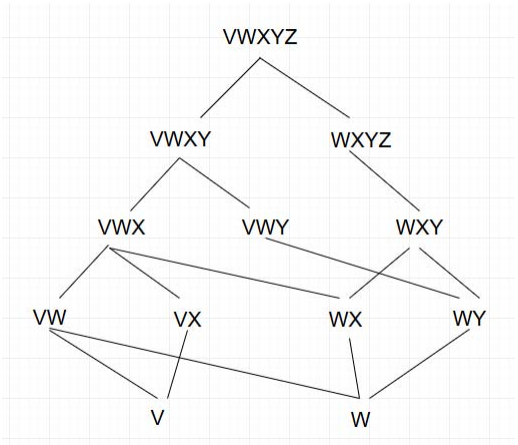

Fig. 1. Knowledge Structure (Kickmeier-Rust, Albert, and Steiner [8])

Another representation of knowledge was introduced by Albert, Hockemeyer, Mayer, and Steiner [9]. This structure is illustrated in Fig 2. Its design is considered in terms of structures of defined concepts and actions. According to the cognitive structural approach, skills are represented by declarative (concepts) and procedural (actions) elements. For example, the skill 'apply the Pythagorean Theorem' consists of the concept 'Pythagorean Theorem' and the action 'apply'. The concept indicates the target to which the action refers. Actions are hierarchically structured behaviours. Bloom's taxonomy [10] can be adopted for representing the actions in the educational domain. Each node of the knowledge structure contains a set of concepts and corresponding actions, and has a prerequisite relation with some other nodes. A prerequisite relation is a type of parent-child relationship where the achievement of the 'child' node is required before the 'parent' node can be achieved.

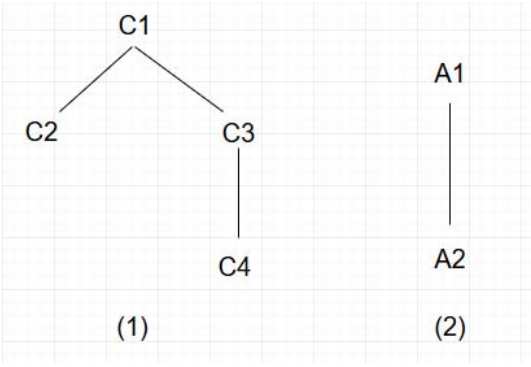

Fig. 2. Knowledge Structure (Albert, Hockemeyer, Mayer, and Steiner [9])

Maurer et al. [11] suggest different ways of visualizing the knowledge structure maps. The force-directed graph is one of them and is based on [11]. Such a graph depicts the quantity of a relation or multiple-domain graphs including knowledge elements and their relations from several domains as shown in Fig 3. This approach of visualizing knowledge was also applied to knowledge transfer in Small and Medium-Sized Companies (SME). First, the tasks, competences and their relations to an employee were acquired in interviews. Then a graph was applied to show the entire network of tasks, competences and relations. The knowledge receivers (learners) of the knowledge transfer used this graph to identify knowledge issues which were confusing for them. This helps in self-monitoring in persons' abilities.

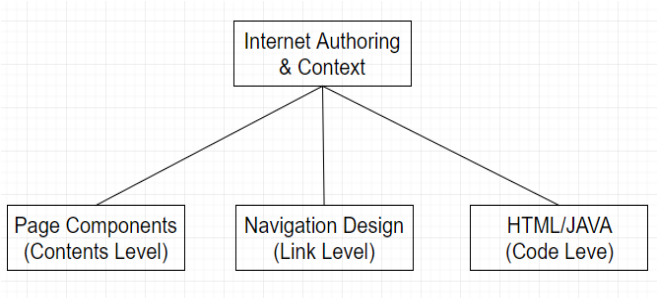

Fig. 3. Knowledge Structure (Maurer et al. [11])

A number of researchers propose the use and application of knowledge structures within educational support systems. CoMPASS software (Concept Mapped Project-Based Activity Scaffolding System) contains a hypertext system and curriculum modules based on a pedagogical framework [12]. This system supports the idea that a concept map is a way of mining knowledge from knowledge elicitations by learners. It is claimed to help learners in their thinking processes, is easy to understand, and helps learners in better understanding the courses or lessons. Carvalho et al. [13] developed two algorithms, SAgent and WAgent, for filtering and ranking results obtained by search engines. Their proposed algorithms are capable of identifying pages that the subjects considered relevant to their context on a map. A particular part of the map can be searched by a mobile agent that analyzes the content of the map and moves through a set of meta-search servers to carry out the search filtering and ranking. This is to provide more relevant search results.

IV. MANAGEMENT TOOL FOR KNOWLEDGE STRUCTURE AND STUDY MATERIALS

In this research, a tool for suggesting learning resources' links based on knowledge structures has been implemented as a prototype called 'MyTeLeMap'. The current tool incorporates the designed knowledge structures and their associated learning resources (mainly html links). Graph visualization libraries (such as Graphviz [14] and Microsoft Automatic Graph Layout [15]) display the graph nodes and edges from the knowledge database. Google's API is used to gather links from the web. The system also allows experts to attach links to structural components.

Fig. 4 shows the prototype home page containing a list of popular maps and other related user menu items. In Figs. 5 and 6, the chosen knowledge structure is shown and the corresponding links of associated nodes are suggested. The links are obtained from a Google search using the Google API, where the search keywords are extracted from the knowledge keywords in a node. A list of websites (e.g., Wikipedia, YouTube and Thailand Learning Resources Websites) is given to the users for filtering the search results. In Fig. 7, the nodes are suggested based on the current and previously visited nodes. Fig. 8 shows the management features which allow a teacher to manage knowledge structures including attaching study materials links. In Fig. 9, recommended study materials links are suggested to the learners. This is managed by the expert/teacher who creates the particular knowledge structure.

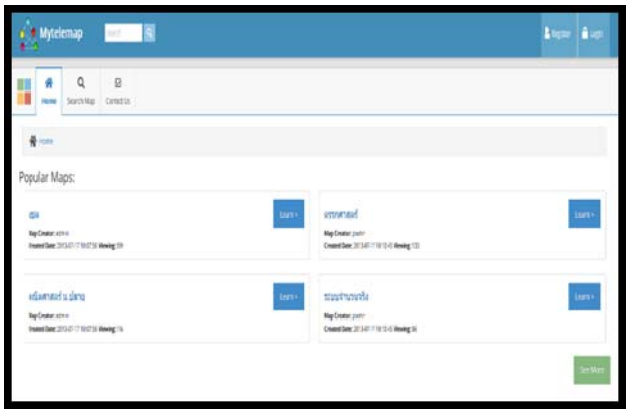

Fig. 4. MyTeLeMap Homepage (www.mytelemap.com)

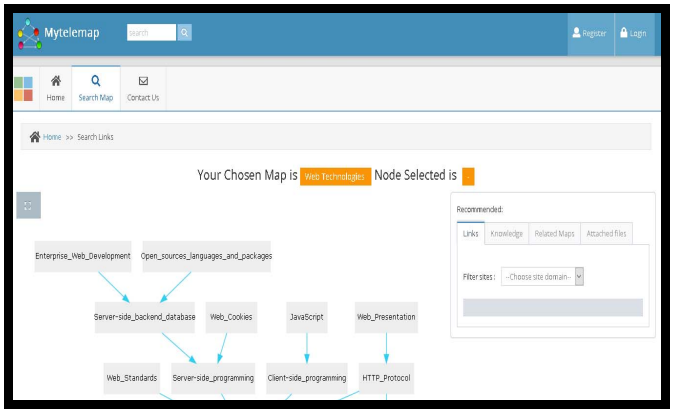

Fig. 5. Knowledge Structure Page under a Lesson 'Web Technologies'

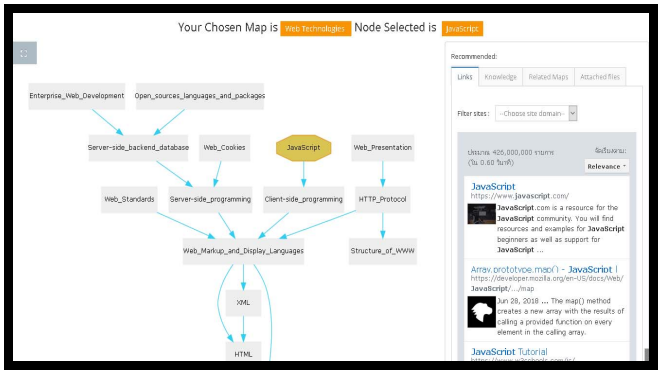

Fig. 6. Knowledge Structure Page under a Lesson 'Javascript'

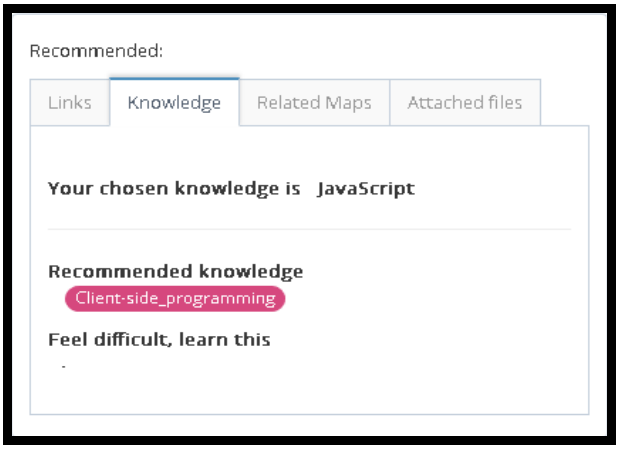

Fig. 7. Learning Path Recommendation under a knowledge 'Javascript'

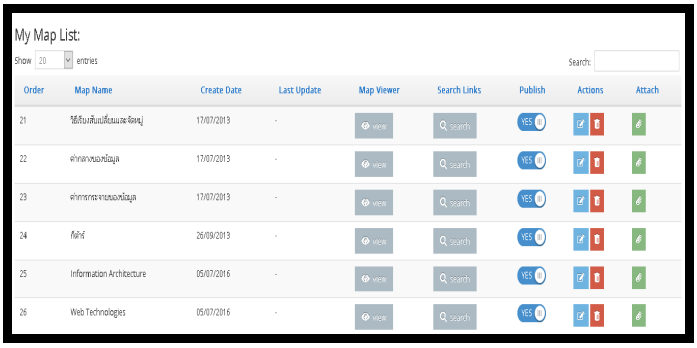

Fig. 8. Management Page for Managing Knowledge Structure

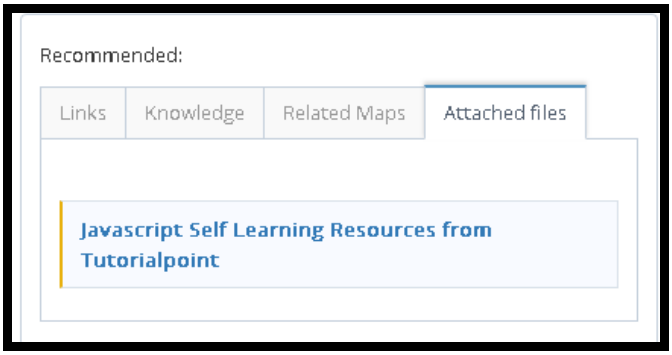

Fig. 9. Attached Study Materials Links by Teachers

Currently, there are 30 structures available in the system. These structures are designed by experts from different domains (mathematics, computers, and art). They all are trained by the researcher. Information on subject matter and learning outcomes has been obtained from school teachers, and a task analysis was undertaken to give a diagrammatic representation of the subject matter. Knowledge structures were built by following four steps.

Step 1: Choose Target knowledge domain

Step 2: Undertake task analysis of subject matter based upon Merrill's analysis [16]

Step 3: Decompose levels and relationships in the task analysis

Step 4: Structure the subject matter

The relationship among nodes is a parent-child, prerequisite, relationship. A sample set of knowledge structures have been created. Fig. 10 shows a sample of an initial knowledge structure for a web technologies lesson.

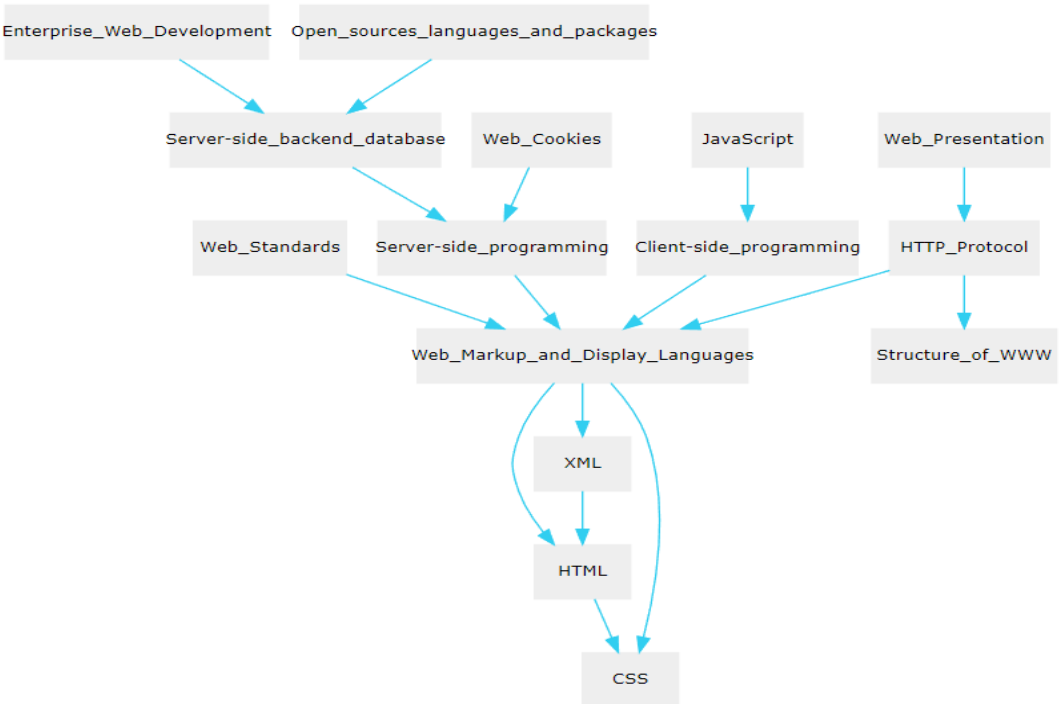

Fig. 10. Knowledge Structure for Web Technologies Lesson

V. PRELIMINARY STUDIES

A preliminary questionnaire study of 173 school teachers from Songkhla province showed that they have used some tools for building knowledge structures, such as a mind-mapping tool and the Cmap tool [17]. Most of them (136 school teachers) recognized and used mind-maps during their teaching activities, and the survey showed that most of their structures were mind maps. None of them represented or designed pedagogical structures with linkage among the knowledge components. They were interested in using a tool for building pedagogical knowledge structure (interested = 106, highly interested = 61) and were willing to use the structures and their applications as educational aids (interested = 101, highly interested = 62).

A preliminary interview study was conducted with 10 school teachers from the schools mentioned. Even though knowledge structures have been recommended for many years, school teachers still did not report using them in their teaching. However, the teachers felt that knowledge structures were useful and that they could benefit education more. For example, such maps could help learners think about and understand the relationships among the information shown. On the teachers' sides, they thought that designing knowledge structure could be another way of sharing their tacit knowledge with other teachers.

VI. CONCLUSION AND FUTURE WORKS

A knowledge-based system for suggesting study material links from the Web (MyTeLeMap) has been described in this research. The aim of the approach is to assist learners to achieve their desired knowledge. The study materials are links from search engine results, and links provided by experts and teachers. Preliminary studies were conducted which explored teachers use of knowledge structures. Most of them used mind maps as knowledge structures..

An experiment is planned to compare whether learning using the prototype MyTeLeMap is better than learning by using Learning Management System (LMS). The experiment will be concerned with the second, 'learning', level of Kirkpatrick's four levels of evaluation [18]. The participants will be assigned to one of two groups: one

experiencing the MyTeLeMap learning mode, and the other experiencing the LMS (Moodle). Participants will take a pre-test and a post-test, before and after experiencing the respective learning modes, being a multiple choice test of 20 questions, and the scores will be compared for each learning mode. The questions will be based on the Web Technologies knowledge structure shown in Figure 9. We expect that both learning modes will help learners in learning, but that MyTeLeMap will help significantly more than LMS in terms of supporting learners' achievement of knowledge and prerequisites.

Currently, there are some limitations, such as the system's dependency on the search engine API. The coding function within such APIs tends to be changed regularly, which may affect the future usability of the application. A future plan is to include the search engine directly within the system and improve its usability and accessibility. In addition, a future plan is to have the search results ratedby the learners to give improvement to the relevance and appropriateness of the links.

ACKNOWLEDGMENT

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REFERENCES

[1] Li-Yu, L., Yu-Shih, L. and Chih-Ping, C. Constructing personal concept map automatically via Correlative Test-Items Structure. City, 2012.

[2] Nitchot, A., Gilbert, L. and Wills, G. Competence-based System for Recommending Study Materials from the Web: Design and Experiment. City, 2011.

[3] D'Antoni, A. V., Zipp, G. P., Olson, V. G. and Cahill, T. F. Does the mind map learning strategy facilitate information retrieval and critical thinking in medical students? BMC medical education, 10, 1 2010), 61.

[4] Saiyasombut, S. and Siam Voices Thai education failures – Part 3: PISA scores & a challenge for the 21st century. asiancorrespondent.com, City, 2012.

[5] Sirisoonthorn, S. Why Thai students weak at Mathematics? , City, 2012.

[6] Parinya Plicharoensuk Reasons why Thai students are weak in Mathematics. City, 2012.

[7] Thai Education Testing Oranization. Summary of international education performance and related factors for Thai Education in Science, Mathematics and Reading. 2009.

[8] Kickmeier-Rust, M. D., Albert, D. and Steiner, C. Lifelong Competence Development: On the Advantages of Formal Competence-Performance Modeling. City, 2006.

[9] Albert, D., Hockemeyer, C., Mayer, B. and Steiner, C. M. Cognitive Structural Modelling of Skills for Technology-Enhanced Learning. City, 2007.

[10] Engelhart, M. D., Furst, E. J., Hill, W. H. and Krathwohl, D. R. Taxonomy of Educational Objectives, Handbook I : The cognitive domain. David McKay, New York, 1956.

[11] Maik, M., Thomas, B. and Udo, L. 6.2.2 Information visualization for the Structural Complexity Management Approach. INCOSE International Symposium, 19, 1 2009), 939-954.

[12] Setten, M., Pokraev, S. and Koolwaaij, J. Context-Aware Recommendations in the Mobile Tourist Application COMPASS. Springer Berlin Heidelberg, City, 2004.

[13] Carvalho, M., Hewett, R. and Cañas, A. J. Enhancing Web Searches from Concept Map-based Knowledge Models. City, 2001.

[14] Ellson, J., Gansner, E. R., Koutsofios, E., North, S. C. and Woodhull, G. Graphviz and Dynagraph -Static and Dynamic Graph Drawing Tools. City, 2004.

[15] Nachmanson, L. Microsoft Automatic Graph Layout. City, 2015.

[16] Merrill, M. D. Knowledge objects and mental models. City, 2000.

[17] Youens-Clark, K., Faga, B., Yap, I. V., Stein, L. and Ware, D. CMap 1.01: a comparative mapping application for the Internet. Bioinformatics, 25, 22 (November 15, 2009 2009), 3040-3042.

[18] Kirkpatrick, D. L. Implementing the four levels : a practical guide for effective evaluation of training programs San Francisco : Berrett-Koehler Publishers, 2007.

A Review of Trends in Sustainable Manufacturing

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Abstract **This research aims to study as well as to understand the trends in the field of sustainable manufacturing during the period of time between 2009-2018AD – in order to demonstrate which groups and/or countries are interested in sustainable manufacturing, the nature of the topic being studied, as well as the effect of sustainable manufacturing on businesses. The main purpose of this paper is to study the history and background of the idea, and the definition of sustainable manufacturing, and also the trends which gained interest during the past ten years. Many business companies start to put more interest in how to manage the natural resources and how to deal with environmental issues. This, combined with the fact that consumers' interest began to shift towards caring about what they consumed and their health care, has encouraged many businesses to try to find the way to be involved in these initiatives. This includes innovations that can help them to take advantage on this opportunity.**

Keywords—Sustainable manufacturing; Trends

I. INTRODUCTION

Sustainable manufacturing is a new way to do business in a set of international applicable, common and comparable in order to measure environmental performance and creating value in business by manufacturing process in any business size. Sustainable manufacturing is behind the scene for many green activities in business process and green products. Sustainable manufacturing is a relatively new field that has received enormous attention during the last decade. It has evolved rapidly from traditional operational practices to using innovative processes that consider social, environmental and economic effects [1]. We will see from above that sustainable manufacturing is a new tool to fix environmental problems that has been created by manufacturing processes - such as CO2 emission or the use of unnecessary natural resources. It can provide businesses with profits or benefits for businesses' investors. The concept of sustainable manufacturing emerged at the United Nations conference on environment and development in 1992. The first goal or the mission of sustainable manufacturing has been used to manage or develop business for doing business activities and to mitigate the damage that has been made on environments in various ways such as health of employees and customers, natural resources etc. By using or fixing the manufacturing processes, the business itself can make profit in the same way. Nowadays, there is a critical concern for sustainable manufacturing because there is have no clear definition about sustainable manufacturing. Therefore, the researcher decided to review related researches and selected articles that have been discussed regarding sustainable manufacturing.

Moldavska and Welo [2] indicated sustainable manufacturing being the creation of manufactured products that use processes which minimize negative environmental impacts, conserve energies and natural resources, are safe for employees, communities, and consumers and are economically sound. Singh and Sultan [3] explained sustainable manufacturing has become a very important issue amongst industries around the world. Manufacturing industries are focusing on controlling negative environmental impacts, reducing cost, conserving energy and natural resources while producing new products through various methods and tools of Sustainable manufacturing assessment. Therefore, developing sustainable approaches to manufacturing companies has been regarded as a critical global concern.

Singh et al. [4] mentioned that sustainable manufacturing can also be adopted as a strategy to increase the competitive advantages and market share through overall sustainability performance of the organization in order to achieve sustainable development in the manufacturing sector.

II. LITERATURE REVIEWS

With the growing global concerns on sustainability issues such as scarcity of natural resources, rapid environmental degradation, unequal balance of social equities and intense global competitions. Sustainable manufacturing strategies have drawn attention [5]. By looking through three dimensions. The first one is ecomony - in economy dimension, the main role is to generate sales and profits, creating jobs, driving innovation etc. Activities from this

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dimension has been made for survival of business and growth. In the second part, Society, dimension is a role of responsibility and relation such as ensuring product safety repecting human rights. Thirdly, Environment - in environment, dimension are made in order to protect or suspend any activities that will harm the environment such as minising waste and emssions using enegies and resources effiently [1]. From the above, we can see the main role of sustainable manufacturing and the benefits of this tool. Then we will talk about the trend of sustainable manufacturing after the conclusion from a literature review, which proved that the number of researches increases every year since 1995. Which means the attraction of sustainable manufacturing are increasing every year. And during this past ten years, there has been 3,911 research work about sustainable manufacturing in web of science data base. However, it is not necessary that each literature review needs to address all these above points. The current study looks to build upon previous literature reviews focused on various concepts of Sustainable Manufacturing. In order to provide suggestions for future research, the author examined papers from 2009-2018 in variety of journal reviews or research papers that mentioned sustainable manufacturing in many different ways and different times. In below will show the meaning of sustainable manufacturing from researchers.

There has been work on case study about assessing sustainable manufacturing through re-manufacturing strategies in car industry. Sustainable manufacturing can identify improvement opportunities, including eco-efficiency, cleaner production and green technologies to make existing remanufactured products technically, economically, environmentally and socially sustainability [6]. There has been a work on case study which analyzes the drivers of sustainable manufacturing quality. This is the primary driver that leads to sustainable manufacturing adoption [4]. Mathematical problems in sustainable manufacturing production planning, inventory control and manufacturing network are key categories related to mathematical problem in sustainable manufacturing [5].

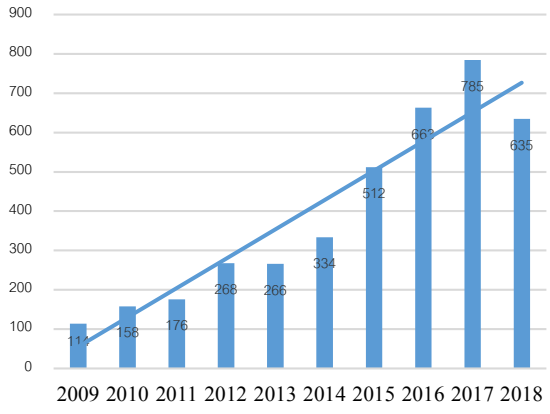

Figure 1. Number of Researches

Regarding Fig. 1, it shows the growing numbers of research in sustainable manufacturing since 2009-2018. The X-bar shows the number of research papers -- while Y-bar shows the year that research has been published. We can see that the number research increases almost every years. And the number of reasearches in 2018 increases more than six times compared to 2009. This could mean sustainable manufacturing are getting more attention from researchers. Also, judging from the number of researches, this could mean that sustainable manufacturing are a success in business concept as well.

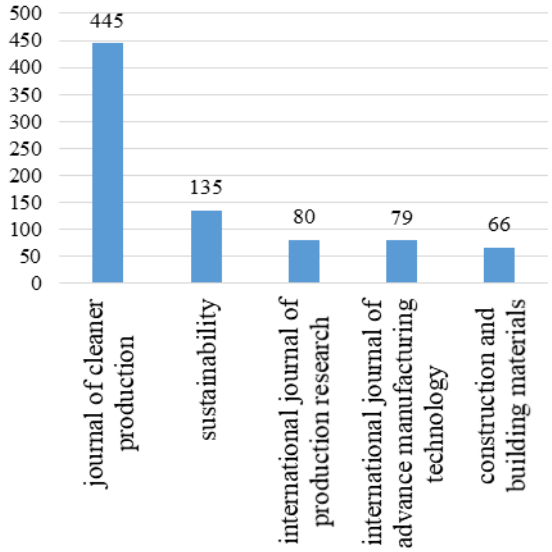

Figure 2. Top Five Publication Titles

From Fig. 2 is about publication titles of sustainable manufacturing researches. The X-axis of this chart shows publication title Y-axis shows the number of reasearch papers. First Ranking is journals of cleaner production. The number of researches on this title are 445, which is more than the other four titles combined. This could be an evidence that sustainable manufactruing can provide or support the business in green manufacturing part. Somehow, this could be the major impact about the new way of cleaner production by using sustainable manufacturing. In addition, the four other titles are sustainability,international journal of production research, international jounrnal of adcvance manufacturing and construction and building materials.

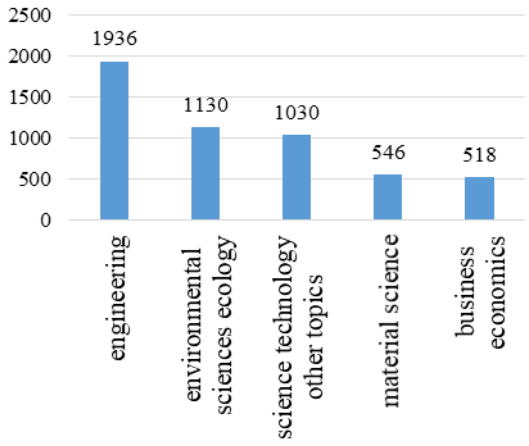

Figure 3.Top Five Subject Areas

Top five subject areas of research within sustainable manufacturing are described in Fig. 3 consisting of Engineering ranking first place. This could be due to the fact that sustainable manufacturing is related to managing manufacturing activities, in order to help solve or mitigate other issues. Thus, engineering is the subject that plays a very important role in the manufacturing process.While three others areas are science that have various issues. However, other subject areas from Fig. III are environemntal sciences ecology, science technology and materials science, respectively. The last subject area is business economics which could be evident that sustainable manufacturing may provide some good benefits and profits in those area as well.

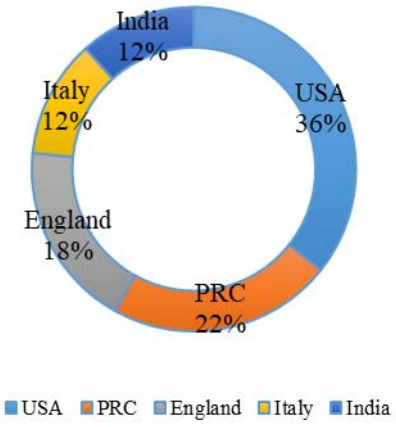

Figure 4.Top Five Nations

In Fig. 4, it shows the top five nations that has the most researchs about sustainable manufacturing going. We can see that all of these nations are also ranked amonst top 10 of the world biggest economic in 2018. As shown in Fig. IV, the results introduced that the USA is the first world biggest economic, followed by China. Two of these nations have been paying a lot of attention in sustainable manufacturing. The findings indicates thatthe number of researchs from USA and China cover more than 50% of the researchs in this top 5 group. From above this may be proof that sustainable manufacuturing have been receiving a lot of attention and success in world class business concept.

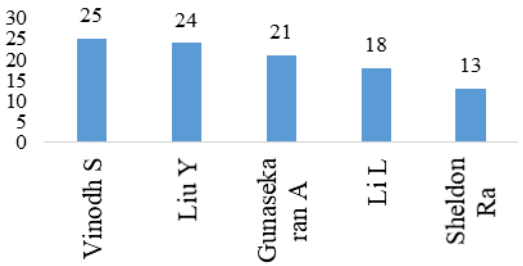

Figure 5.Top Five Researcher

Regarding Fig. 5, the result shows the top five researchers with regards to sustainable manufacturing. Four persons amongst the top researchers in sustainable manufacturing are Asians, with two being Chinese and another two being Indians. These two countries are considered largest production bases in Asia. Therefore, it leads to assume that China and India are extremely interested in the issue of sustainable manufacturing during this time in order to develop their production system up to date as well as making them becoming more potential – allowing them to be able to compete or dominate the market in terms of goods production. This is possible due to the fact that the two countries have large labor force and lower wages than Western countries. From the literature reviews, it discovers that from this top five researchers including two Chinese, two Indians and one being British. Whereas, their trend of researches about sustainable manufacturing were so different ways, the two Chinese researchers focus on energy consumption in sustainable manufacturing while two Indian researchers did their research in production concept or framework in metal or cars industry. As for British researchers, his works focuses on how to use sustainable manufacturing in bio chemical or material chemical industry.

III. Methodology

For methodology part, the study explains the sources of information that were used to study and to make a review regarding sustainable manufacturing. The scope of time that this research focuses is between 2009–2018AD. The selection of data is used as a basis for this research that have been gathered from databased including Web of Science and Scopus. Searching and sourcing for articles based on the

database are done, leading to many related articles for the knowledge of this area. Examination and selection of articles is based on the only those, of which main contribution revolves only around the concept of sustainable manufacturing.

IV. Conclusion

This paper involves the literature review of sustainable manufacturing topics since 2009 to 2018. It demonstrates the overall picture regarding the research article trends within the scope of sustainable manufacturing, in which way does sustainable manufacturing being interested in, as well as proving that the interest in this topic has been increasing every year since 2009. Sustainable manufacturing has been interpreted or defined in many ways by many researchers[7].In addition, the topic attracts giants of the world economics to study and develop frameworks or case studies of sustainable manufacturing which are suitable for their own industries. Even though the topic has been interpreted differently by researchers. See the results show that they all share the same view in regard to sustainable manufacturing -- that it has positive effects on businesses or development of manufacturing processes. From the author's point of view, by using manufacturing processes as a tool, sustainable manufacturing can be used as a way or framework that could generate profit as well as reduce pollution and environmental effects caused by businesses' activities.

For the next research concerning sustainable manufacturing, the authors would like to see the deeper studies done in specific group of industries or businesses. So that we could understand how sustainable manufacturing could be properly applied to each businesses' production processes, in order to be able to see a clear benefit for each segment. The author also wishes to discover clear, solid definition of sustainable manufacturing in order to discuss about sustainable manufacturing in the same way.

References

[1] M. Aboelmaged, "The drivers of sustainable manufacturing practices in Egyptian SMEs and their impact on competitive capabilities: A PLS-SEM model," *Journal of Cleaner Production,* vol. 175, pp. 207-221, 2018.

[2] A. Moldavska and T. Welo, "The concept of sustainable manufacturing and its definitions: A content-analysis based literature review," *Journal of Cleaner Production,* vol. 166, pp. 744-755, 2017.

[3] K. Singh and I. A. Sultan, "Modelling and Evaluation of KPIs for the Assessment of Sustainable Manufacturing: An Extrusion process case study," *Materials Today: Proceedings,* vol. 5, no. 2, pp. 3825-3834, 2018.

[4] S. Singh, E. U. Olugu, and S. N. Musa, "Development of Sustainable Manufacturing Performance Evaluation Expert System for Small and Medium Enterprises," *Procedia CIRP,* vol. 40, pp. 608-613, 2016.

[5] N. Hami, M. R. Muhamad, and Z. Ebrahim, "The Impact of Sustainable Manufacturing Practices and Innovation Performance on Economic Sustainability," *Procedia CIRP,* vol. 26, pp. 190-195, 2015.

[6] Y. A. Fatimah and W. K. Biswas, "Sustainability Assessment of Remanufactured Computers," *Procedia CIRP,* vol. 40, pp. 150-155, 2016.

[7] C. E. Siemieniuch, M. A. Sinclair, and M. J. Henshaw, "Global drivers, sustainable manufacturing and systems ergonomics," *Appl Ergon,* vol. 51, pp. 104-19, Nov 2015.

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Tracking People and Objects with an Autonomous Unmanned Aerial Vehicle using Face and Color Detection

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***Abstract*—We propose a people and object tracking algorithm for an autonomous unmanned aerial vehicle (UAV). It uses as a surveillance camera and can move anywhere. The camera from UAV is not fixed location as closed-circuit television. The face detection and objection detection are applied to support our proposed. In this research, the UAV model for this paper was AR-Drone 2.0. It has a constraint on the front camera because it has fixed the position of view and cannot change the view during flight. We designed two experiments. First, the face detection using images and applied to the popularity of the face detection, is a Haar-cascade classifier and max-margin object detection with convolutional neural network based features because they have high precision in analysis. Second, color detection system, which only focuses on the color of objects which can developed as an obstacle detection system. The results of the experiment can be accepted to adapt to tracking people and objects in the smart-city.**

***Index Terms*—unmanned aerial vehicle, drone, autonomous flight control, face detection, color detection, tracking algorithm**

I. Introduction

Recently, the tracking of people and objects detection are seen as the crucial factors for surveillance in the smart-city, and can be used to increase safety for the digital society. These methods can applied to support the closed-circuit television (CCTV) systems. Blind-spots in CCTV coverage can compromise coverage and lead to failure. There is a need to find other techniques providing better surveillance.

An unmanned aerial vehicle (UAV), called a *drone* [1], has been developed for many research areas [2]. It can controlled by a user or a program designed for an auto-flying the mission. Such as the military, disaster rescue facility, agriculture and transportation [2, 3]. It can lead to improving the smart device of UAV which is easy to control. Although, the remote control can control the drone with the frequency band (Hertz: Hz) which the most famous of the frequency band for the drone is 900 MHz and 2.4 GHz is suitable for Wi-Fi devices [4]. The low-frequency band can send the signal to be far more than the high-frequency band, but the signal is not stable.

Many companies produce commercial UAVs, but not functional for controlling the UAVs by coding any programs. However, a successful company called *Parrot* produces a UAV model called AR.Drone as shown in Fig. 1. For this UAV model, the developer can code for controlling the UAV by auto-flying and many researchers use it for research development [1, 5, 6]. The developer can communicate by using a smartphone or computer via Wi-Fi signal that are broadcasts from the AR.Drone. Also, it will fix IP address, which can support to being stable flight. The camera on the UAV can be recording video with a resolution of 720p which is enough for adapting to the image processing scheme.

II. Related Work

For the task of face detection, the Viola-Jones face detector [7] is well-known method that first proposed for object and then for pedestrian detection [8] and nowadays, this technique, called *Haar-cascade classifier* , has become a standard technique for face detection. The Viola-Jones face detector computes feature vector based on the Haar feature. It calculates from the rectangle detector or sub-window. The detector scans through the image with the size of 24 $\times$ 24 pixel resolution. The size of the detector will increase by 1.2 times. Then, the set of the feature vector is given to the AdaBoost classifier

Fig. 1: An example of the AR.Drone 2.0 used in this research.

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which is the weak classifier. This approach can process in real-time and get high precision.

Dalal and Triggs [9] proposed a feature extraction method called *histograms of oriented gradients (HOG)* and first designed for human detection. This method can use the shape for calculation of the intensity of gradients. Each sub-sampling of images will change the edge images as a cell, in which the orientation of the edge image will be calculated for each cell. Then the orientation can lead to create the histogram and send to learn with the support vector machine (SVM) using the linear kernel. The SVM is used as a binary classifier to be trained on positive and negative images, accordingly it is used to classify each of the sub-window images. Moreover, many research uses the HOG-SVM method [10, 11] for face detection as well.

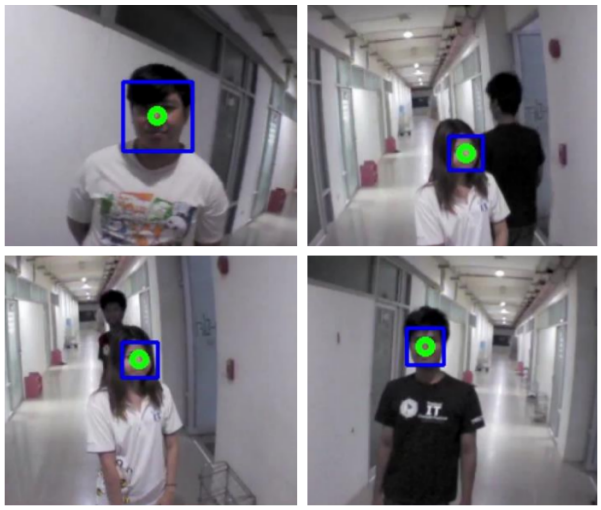
Furthermore, in [12], max-margin object detection (MMOD) is proposed for finding the object. In this approach, the non-overlapping sub-window image slide through image and uses the window scoring function to find the fewest possible detection mistakes. As for the feature extraction method, the spatial pyramid bag-of visual-words model combined with the HOG descriptor method are computed from each pixel location. The MMOD method is performed well on the face detection dataset and benchmark (FDDB).

In addition, in [13], a color image is converted into the HSV color space and an extracted area of the traffic light color such as red, yellow and green colors as the region of interest (ROI). The pixels of traffic light colors are represented as the set of feature vectors. Then the feature vector is given to the machine learning technique to create a model that uses it to classify if the ROI is that of the traffic light or not. In [14], the Haar-like feature and AdaBoost classifier was applied, and reported to have high accuracy.

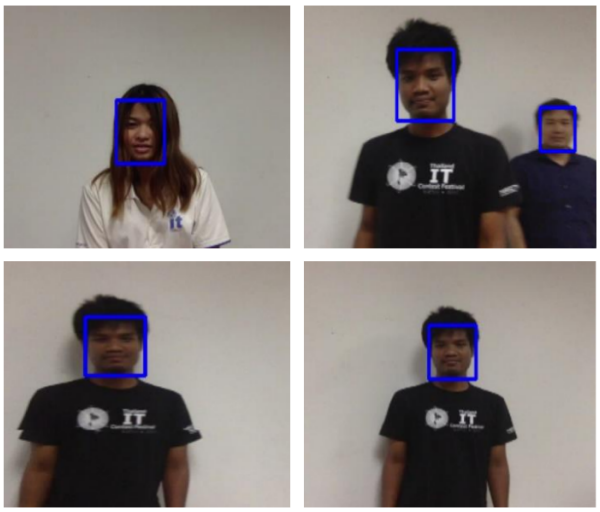
In [15, 16], the UAV was applied to marker recognition and using augmented reality (AR) for flying and tracking to the target by automatic flight and auto-landing.

Nevertheless, Davis [12] presents the max-margin object detection (MMOD) for finding the object. It is different to Dalal and Triggs because all area of the image will be used to analyze with HOG and then applied to the linear function which can develop to finding the objects. Their cases study has three samples, consist of TU Darmstadt cows, INRIA pedestrains and face detection dataset and benchmark (FDDB). Binagkit and Widyantoro [13] propose how to detect to the color of a traffic light, which the image is changed to being HSV color space. After that it is set the period of color such as red, yellow and green for extraction region of interests (ROI). The ROI is selected to learning with SVM by using RBF kernel.

Contribution. In this research, the aim of the study is a detection development of UAV for object detection and tracking people. The primary contribution has two approaches. First, the two well-known techniques of face detection including Haar-cascade classifier [7, 8] and max-margin object detection [12] with convolutional neural network based features (MMOD-CNN). Second, our research focuses on the color detection of the objects [13]. These two approaches can lead to tracking the people and objects based on face and color, respectively.



(a)



(b)

Fig. 2: Some examples of face detection using (a) Haar-cascade classifier and (b) MMOD-CNN methods.

Paper Outline. This paper is organized as follows: We survey related work in section II and describe the proposed people and object tracking algorithm in section III. Section IV, experimental settings and the results are presented and section V finalizes the paper with summary and future work.

III. Proposed People and Object Tracking Algorithm

A. Face Detection

We compare two face detection techniques namely Haar-cascade classifier [7] and max-margin object detection [12] with convolutional neural network based features (MMOD-CNN). As for the experiment, these two approaches applied to

the UAV. The results found that the precision of detection was directly related to the constrained illumination environment. Examples of the face detection using Haar-cascade classifier and MMOD-CNN methods are shown in Fig. 2(a) and Fig. 2(b), respectively.

B. Color Detection

To detect candidate regions of interest (ROI) from the image. The color image changes the color space from the RGB to HSV color space [13, 14] because the RGB color space represents the color of the R, G, and B channels. When the illumination slightly changes, it directly impacts the color image. The proposed method used the HSV color space to detect the ROI. This research focuses on three different colors including blue, green, and orange. The process of finding the ROI from the blue image is shown in Fig. 3.

C. Tracking Algorithm

The conception of our approach is using image processing and machine learning to control the UAV automatically by using face and object detection methods. In our method, the centroid of ROI $C_{i,j}$ that was found in the face and color detection steps are calculated by Equation 1.

$$\begin{aligned} i &= \tfrac{(x_2 - x_1)}{2} \\ j &= \tfrac{(y_2 - y_1)}{2} \end{aligned} \tag{1}$$

where x_1 and x_2 are pixel position on x-axis and y_1 and y_2 are pixel position on y-axis.

The centroid of the window $C_{h',w'}$ is computed by $h^{'} = h/2$ and $w^{'} = w/2$, which h and w are the height and width of the window, respectively.

The algorithm is called *turnDrone* use $C_{i,j}$ and $C_{h',w'}$ for turning the UAV as shown in Algorithm 1.

Algorithm 1 turnDrone

Input: Set $f(h, w)$ to initial the window size, $C_{i,j}$ is the centroid of the ROI and $C_{h',w'}$ is centroid of the window

while $C_{h',w'} \neq C_{i,j}$ **do**
  if $c_i < c_{h'}$ **then**
    move drone down, update $C_{i,j}$
  else
    move drone up, update $C_{i,j}$
  end if
  if $c_i < c_{w'}$ **then**
    turn drone right, update $C_{i,j}$
  else
    turn drone left, update $C_{i,j}$
  end if
end while

The Algorithm 2 is called *movingDrone*, this algorithm used to support flying which compares the size of the ROI. In this step, the size of the ROI S is compared to the threshold value T. If S is higher than T, the UAV will move backward. On the other, it will move forward. Moreover, this algorithm will calculate the distance between the UAV and object for suitable distance while flying and protection to crash the object.

Algorithm 2 movingDrone

Input: Set T to initial acceptance ratio, Sum pixel of object: $Z_0 = \sum o(i, j)$

while $Z_o \neq T$ **do**
  if $Z_o > T$ **then**
    move drone backward, update Z_o
  else
    move drone forward, update Z_o
  end if
end while

IV. Experimental and Results

In the experiment, we used a web camera on a laptop computer to experiment with algorithms in the indoor environment. These two face detections techniques performed the high precision of the face detection. Subsequently, we performed face detection techniques using the frontal camera on the UAV. The camera on UAV takes video and send to a computer which is the flight center control. It processes the images then apply to our algorithms for auto-flight control. The precision of the frontal camera on the UAV was slightly less when compared to the web camera on the laptop computer.

The result of validation with images on the web camera, obtained the accuracy to detect although an illustration may affect to calculate. Secondly, using images from UAV, we found that the result was not accurate detection, because of having some problem such as the quality of images that obtained from the UAV and sometimes lost the Wi-Fi signal.

The experiment for measuring the precision of UAV in the Wi-Fi signal area is designed. The camera on UAV takes video and send to computer server which being the center control flight. It processes the images then apply to our tracking algorithms for auto-flight of UAV. Each method is tested with 10 times.

The image from the web camera can be used for face detection. However, one important factor for testing of the face detection; it is the UAV model. We applied our methods to AR.Drone 2.0 model which the camera cannot change the angle view. Thus, the appropriate height to use AR.Drone for face detection is between 150 and 190 centimeters.

As for the color detection, the result found that green and blue color obtained the better result than the orange color. Because the orange color (see Fig. 4(a)) is closely to skin of human also processing appears some skin of arms on the image as shown in Fig. 4(b).

In addition, the face detection needs more computation time than the color detection and so needs longer time to track people. Because the UAV has to move and turn during

(a) (b) (c)

Fig. 3: An illustration of finding the region of interest (ROI). (a) The original image presented with blue color. (b) The algorithm filtered the image containing the blue color and represented as white color on the black background. (c) The ROI of the blue color image.

TABLE I: The range of HSV color space used in this research.

Color	RGB value	HSV Lower Range	HSV Upper Range
Orange	40, 99, 225	0, 100, 100	20, 255, 255
Blue	142, 52, 18	102, 100, 100	122, 255, 255
Green	65, 178, 141	30, 100, 100	50, 255, 255

tracking. Furthermore, the range of HSV values used in this research is shown in Table I.

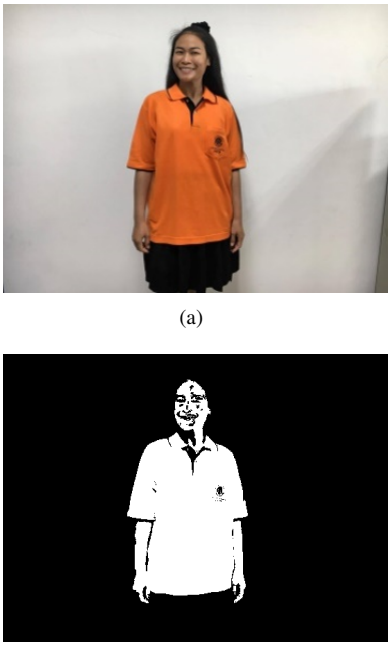
Our results showed that using the color detection obtains the better detection performance than the face detection. This is because of color detection being robust to changes in illumination.

Also, the experiment showed the error occurs when finding the ROI from the orange color image as shown in Fig. 4. In addition, we perform color detection to detect and track a small green ball as an object. The UAV was moved following the object and face as shown in Fig. 5 and Fig. 6, respectively. keeping the same distance between the UAV and the object.

V. Conclusion

In this paper, we proposed the approaches to tracking people and object by using the auto-flying control of the unmanned aerial vehicle (UAV). We applied to Haar-cascade classifier and max-margin object detection with convolutional neural network based features (MMOD-CNN) for face detection, and color detection to find the region of interest from the image. The experiment was designed to use an image from the web camera of a computer and a camera for the frontal of the UAV. The result showed that the color detection outperforms the face detection due to computation time. Color detection experimented with three colors including blue, green, and orange. The color detection could even detect and track the small objects. We found that color detection may fail, for example with orange color because this color is closed to Asian skin color. Finally, the experiment showed that these approaches can adapted to tracking people and objects, and they can be applied to be the monitoring system in the smart-city.

In the future, we will develop with another UAV model, which can change the angle of the camera. Nevertheless, some approaches would be applied to our algorithms, which can lead to being highly stable and highly efficient auto-flight. Our approach may refer to ontology and machine learning. Moreover, the deep learning technique will be designed which can lead to achieving high precision of face detection and good tracking systems.



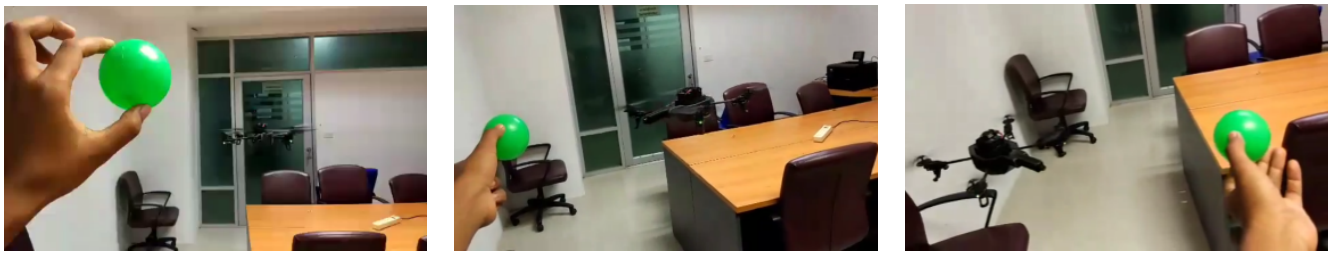
(a)

(b)

Fig. 4: An error occurs when finding the ROI from the orange color. (a) The original image presented with orange color. (b) The binary image that containing both the orange color and skin, because of the skin of the people was in a range of the orange color.

References

[1] K. Surakul, S. Sodsee, and S. Smanchat, “A control of multiple drones for automatic collision avoidance,”



(a) (b) (c)

Fig. 5: Illustration the AR.Drone 2.0 while tracking and following the green object.

Fig. 6: Illustration the AR.Drone 2.0 flies in indoor environments using the front camera to detect face from the image.

Information Technology Journal, vol. 11, pp. 91–101, 2015.

[2] A. J. A. Rivera, A. D. C. Villalobos, J. C. N. Monje, J. A. G. M. nas, and C. M. Oppus, "Post-disaster rescue facility: Human detection and geolocation using aerial drones," in *IEEE Region 10 Conference (TENCON)*, Nov 2016, pp. 384–386.

[3] W. G. Aguilar, V. P. Casaliglla, and J. L. Polit, "Obstacle avoidance based-visual navigation for micro aerial vehicles," *Electronics*, vol. 6, pp. 1–23, 2017.

[4] M. LaFay, *Drones for Dummies*. Wiley, Jul 2015.

[5] L. Orozco, F. Coloma, C. Oyos, D. Alulema, D. Morocho, and F. Encalada, "Design and implementation of a control of position system for the quadricopter AR.Drone 2.0 by Parrot," in *IEEE International Conference on Automatica (ICA-ACCA)*, Oct 2016, pp. 1–6.

[6] P. Suwansrikham and P. Singkhamfu, "Indoor vision based guidance system for autonomous drone and control application," in *International Conference on Digital Arts, Media and Technology (ICDAMT)*, Mar 2017, pp. 110–114.

[7] P. Viola and M. J. Jones, "Robust real-time face detection," *International Journal of Computer Vision*, vol. 57, no. 2, pp. 137–154, May 2004.

[8] P. Viola, M. J. Jones, and D. Snow, "Detecting pedestrians using patterns of motion and appearance," in *9th IEEE International Conference on Computer Vision*, vol. 2, Oct 2003, pp. 734–741.

[9] N. Dalal and B. Triggs, "Histograms of oriented gradients for human detection," in *IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR)*, vol. 1, Jun 2005, pp. 886–893.

[10] H. Bristow and S. Lucey, "Why do linear SVMs trained on HOG features perform so well?" *CoRR*, vol. abs/1406.2419, pp. 1–8, 2014. [Online]. Available: http://arxiv.org/abs/1406.2419

[11] H. S. Dadi and G. K. M. Pillutla, "Improved face recognition rate using HOG features and SVM classifier," *IOSR Journal of Electronics and Communication Engineerin*, vol. 11, pp. 34–44, 2014.

[12] D. E. King, "Max-margin object detection," *CoRR*, vol. abs/1502.00046, pp. 1–8, 2015. [Online]. Available: http://arxiv.org/abs/1502.00046

[13] J. L. Binangkit and D. H. Widyantoro, "Increasing accuracy of traffic light color detection and recognition using machine learning," in *10th International Conference on Telecommunication Systems Services and Applications (TSSA)*, Oct 2016, pp. 1–5.

[14] H. Park, N. Kim, H. Hernsoo, and Y. Han, "Traffic light detection and recognition using AdaBoost classifier based on haar-like feature," in *ISER 59th International Conference*, Jun 2017, pp. 6–9.

[15] J. Kim, Y. S. Lee, S. S. Han, S. H. Kim, G. H. Lee, H. J. Ji, H. J. Choi, and K. N. Choi, "Autonomous flight system using marker recognition on drone," in *21st Korea-Japan Joint Workshop on Frontiers of Computer Vision (FCV)*, Jan 2015, pp. 1–4.

[16] T. Zhao and H. Jiang, "Landing system for AR.Drone 2.0 using onboard camera and ROS," in *IEEE Chinese Guidance, Navigation and Control Conference (CGNCC)*, Aug 2016, pp. 1098–1102.

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Improving model using estimate error for daily inflow forecasting

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***Abstract*—Inflow forecasting is one of the important components for reservoir operation and resource management. To obtain enhanced accuracy for forecasting reservoir inflow, this paper proposed an improved model for forecasting the inflow of Bhumibol reservoir. The 3,169 records of daily inflow data from June 1, 2008, to February 1, 2017, had been collected to calculate the inflow into the reservoir by using Artificial Neural Networks (ANN) Back-Propagation Learning Algorithm for forecasting the inflow of the reservoir in the main model and error prediction model. The performance of the model can be evaluated by four methods: the coefficient of determination (R^2), the Nash-Sutcliffe efficiency (NSE), the Root Mean Square Error (RMSE) and the Mean Absolute Error (MAE).Thus, these proposed main and error prediction models were combined to support the forecast of reservoir inflow. The performance of the proposed model can be evaluated by following measured values: $R^2$was 0.927, NSE was 0.925, RMSE was 6.805 and MAE was 3.611. This indicates that the improved model provides more accurate value.**

Keywords—Artificial Neural Network, Model Forecasting, Reservoir Inflow, Error Prediction

I. INTRODUCTION

Nowadays, the problem of water crisis has intensified such as water shortage in the dry season. Flood problems happen in many areas during the rainy season. These problems may occur due to the changing nature of the world's climate and water management is more complicated with the changing circumstances. This is why the effective water management is difficult. In order to conduct the proper management of water in the reservoir, the precise forecasted flow of water into the reservoir is required[1-3]. In the past, many researchers have developed accurate and easy-to-use models for predicting water flow in reservoirs. Previously, ARIMA was used as a statistical model with time series. This model provides good results for linear data but not suitable for nonlinear data[4-6]. So far, some researchers have used the method of machine learning, especially the artificial neural network, which solves problems with both linear and nonlinear data. Therefore, these method provides better predictive efficiency than the ARIMA method[7-10]. However, from the above researches, some errors have occurred in the simulation model of the neural network in extreme weather conditions such in the wet year and dry year. During the wet year, the water flow in the reservoir is quite high while in some areas such as Thailand sometimes suffers from acutely drought in the dry year, there is no water inflow into the reservoir. The predicted model cannot provide the efficient forecast amount of water entering the reservoir. From the above-mentioned problem, the researchers have the idea of using the error information to create a model to estimate the error that will occur with the model. The main simulation is to increase the efficiency of flow forecasting in the reservoir.

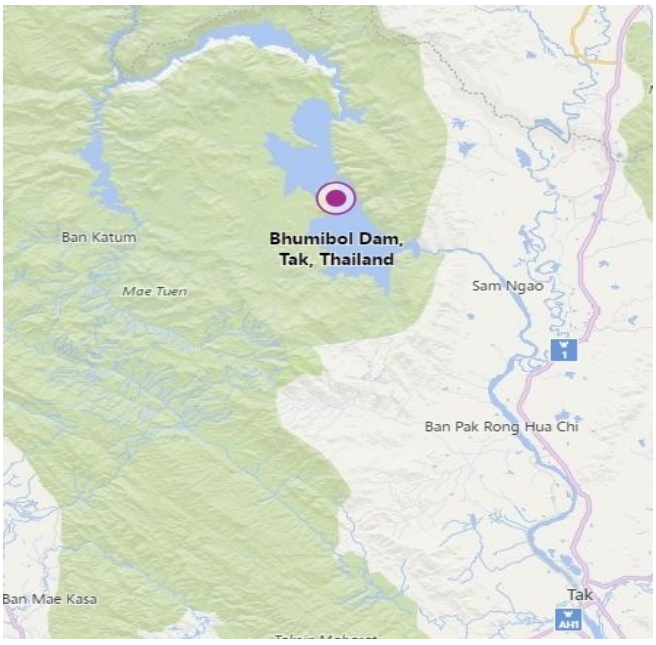

Fig. 1. The topography of Bhumibol reservoir, Tak Province, Thailand.

II. DATA AND STUDY AREA

This study collected the amount of water entering the reservoir in daily used basis from Bhumibol Dam. The Bhumibol Dam, one of multi-purpose dams of the Electricity Generating Authority of Thailand (EGAT), is a concrete arch dam that walls the Ping River at Khaokaew area of Sam Ngao district, Tak province with, the geographic coordinates: 17°14′33″N 98°58′20″E, as shown in Figure 1. The reservoir capacity is 13,462 million cubic meters with about 300 square kilometers of water surface. The length of the reservoir starts from Hod district in Chiang Mai province with the length of 207 kilometers. The researchers collected data for 8 years from 01/06/2008 to 02/02/2017 with the total amount of 3,169 records. The data characteristic is time

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series data which is stored regularly in the same range, such as daily, monthly, annual data, etc. The utilized data in this study is daily data which identified as seasonal variation. The seasonal variation can be described that the amount of water entering the reservoir is not much different in the same period of the year and the maximum inflow normally occurs in October of each year, which is the rainy season in Thailand. The volume of inflow water is zero because there is no inflow water in the basin during that day, which mostly occurs during the dry season. In addition, some range of data is subject to irregular variation, which is the period when the amount of inflow water in the basin is extremely high because of heavy rain in the upstream area and side flow together with flooding during that period.

III. METHODOLOGY

A. Proposed Model

The proposed model for predicting water inflow will be divided into two parts: inflow forecasting or main model and predicted error model. The main model is processed for forecasting the inflow of water into the reservoir by using daily data of inflow as input data and the ANN technique as modeling. While the another model is predictive error modeling using the difference data between the collected existing inflow data and predicted inflow result from the model with the same ANN technique. The predictions of both models are integrated into updating as a model for predicting inflow water. This approach for integration of two main models can be depicted as shown in Figure 2.

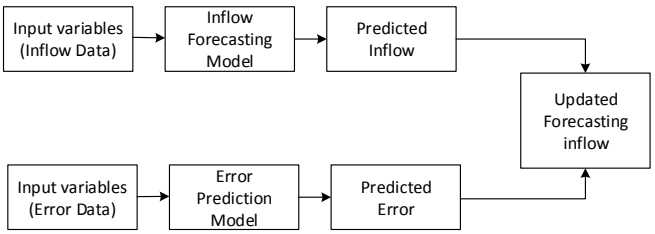

Fig. 2. Integration of Inflow Forecasting Model from Main and Error Prediction Models

At the beginning of this experiment, the researchers used the 3,169 records of inflow water to create a model with the ANN technique for predicting the inflow of water into the reservoir by using MATLAB program. Therefore, the preparation of data for learning or data for prediction must be prepared in the matrix data table form to train the neural networks. Data is divided into two parts: Input and Output, which can be used in comparison with the results. These two parts are described as follows.

$$Input = \begin{bmatrix} V_1 & V_2 & \cdots & V_k \\ V_2 & V_3 & \cdots & V_{k+1} \\ \vdots & \vdots & \cdots & \vdots \\ V_{n-(k+1)} & V_{n-(k+2)} & \cdots & V_{n-1} \end{bmatrix}$$

$$Output = \begin{bmatrix} V_{k+1} \\ V_{k+2} \\ \vdots \\ V_n \end{bmatrix}$$

Where is the observed water flow into the reservoir daily; k is the number of days that required to use in forecasting such as 10, 20 and 30 days; n is the total recorded days.

When the inflow water flows into the reservoir is estimated from the main model, the error can be found as in :

$$\varepsilon(t) = V(t) - P(t) \quad (1)$$

Where $P(t)$ represents the water inflow in the reservoir is predicted from the main model during day t; $\varepsilon(t)$ means the difference value between the actual value and the value obtained from the forecast of day t. This is defined as the error value.

The proposed model is the model that integrates main models and error prediction models as calculated according to:

$$\hat{P}(t) = P(t) + \hat{\varepsilon}(t) \quad (2)$$

Where $\hat{\varepsilon}(t)$ represents the forecasted error is predicted from the error model during day t; $\hat{P}(t)$ means the water inflow in the reservoir from the proposed model during day t;

The preparation of error information for learning, the data must be prepared in the form of matrix data tables. To train neural networks, data is divided into two parts: Input and Output, for being used in comparison with the results. These are as follows.

$$Input = \begin{bmatrix} \varepsilon_1 & \varepsilon_2 & \cdots & \varepsilon_k \\ \varepsilon_2 & \varepsilon_3 & \cdots & \varepsilon_{k+1} \\ \vdots & \vdots & \cdots & \vdots \\ \varepsilon_{n-(k+1)} & \varepsilon_{n-(k+2)} & \cdots & \varepsilon_{n-1} \end{bmatrix}$$

$$Output = \begin{bmatrix} \varepsilon_{k+1} \\ \varepsilon_{k+2} \\ \vdots \\ \varepsilon_n \end{bmatrix}$$

Where ε_i mean the difference value between the actual value and the value obtained from the forecast of day t. This is called the error value. k is the number of days that required to use in forecasting such as 10, 20, and 30 days n is the total recorded days

B. Model Accuracy Indicators

The efficiency or performance of the model can be measured by following four methods.

- *The coefficient of determination (R^2)*

R^2 is an estimation of the distribution with the spread of the measurable real-valued dataset and the predicted dataset.

$$\frac{\sum_{i=1}^{n}(O \quad \bar{O})(P \quad \bar{P})}{\sqrt{\sum_{i=1}^{n}(\quad \bar{O})^2 \sum_{i=1}^{n}(P \quad \bar{P})}}$$

Where O_i and $P_i$are the actual inflow and the predicted inflow, respectively. $\bar{O}$ and $\bar{P}$ are the mean of the actual inflows and predicted inflows to the reservoir respectively, and n is the total number of data. The range of $R^2$is between 0 and 1, where the value of zero denotes no relation, while the value of 1 denotes the distribution of the predicted values are equal to the actual values.

- *The Nash-Sutcliffe efficiency (NSE)*

NSE is the most commonly used index for model accuracy or the efficiency and effectiveness of simulated models in predicting the desired values.

$$\frac{\sum_{i=1}^{n}(O \quad P)}{\sum_{i=1}^{n}(O \quad \bar{O})}$$

NSE has a value between -∞ and 1.If the NSE value is 1, this means the model can predict the value without error or perfect fit.

- *Root mean square error (RMSE)*

RMSE, the square root of the average squared value, is a method of measuring the error tolerance of the predicted value from the model to the actual measured value.

$$\sqrt{-\sum(\quad P)}$$

RMSE values are always greater than zero. If the value is close to zero. The model can be approximated to the actual measured value.

- *Mean absolute error (MAE)*

MAE is a method to measure the difference between the actual measured value and the predicted value of the model by calculating the mean for all recorded absolute errors.

$$-\sum|O \quad P|$$

The MAE is always positive. If the MAE is low, the model can predict a value close to the actual collected value.

IV. Results and Discussion

In this section, the proposed model approach is evaluated using the historical data of Bhumibol Dam. To show the superiority of the proposed model, the forecasting performances are also compared with four methods.

Defining the suitable neural network structure for nonlinear data series, the three sets of nodes, 10, 20 and 30 nodes, should be considered. These sets represent the number of days (k), such as 10, 20, and 30 days. Due to the efficiency of the neural network, the number of nodes in the hidden layer should be differently assigned by dividing the number of nodes into 3 levels: 4, 8 and 12 nodes.

The neural network structure with the learning feature will be evaluated by defining the suitable neural network structure with machine learning for adjusting the weight and bias values in the forecasting process. The 70% data is used for the training set the 15% data is used for testing set and the remaining 15% data is used for validating set. The learning cycle needs to be reached 1,000 cycles as a learning condition according to Levenberg-Marquardt algorithm standard configuration [11].

The results of the experiments are finding the number of nodes in the input layer and the number of nodes in the hidden layer for the main model in predicting the amount of inflow water entering the reservoir. The results are measured for the efficiency of the model by R^2, NSE, RMSE, and MAE. From all manipulated data set, the efficiency of the main model predicting the inflow of water into the reservoir at the best performance is a neural network model structure as 30-12-1with input node of 30 daysand number of hidden nodes at 12 nodes.

The best efficiency of inflow forecasting by using the testing data set can be displayed as shown in Figure 3. There is an error remaining between the actual or observed data and the predicted data of the inflow water. Therefore, to develop a model for predicting inflow water to be more accurate, it is necessary to use the error model (See Eq.2) to predict the error associated with the main model.

In the development of the model for predicting the error, the researchers applied the ANN technique as well as developing the main model by setting the number of nodes in the input layer to 30 nodes as the same number of the selected main model. Therefore, the preparation of error information for learning, the data must be prepared in the form of matrix data tables. To train neural networks, data is divided into two parts: Input and Output, for being used in comparison with the results. The error model provides the best performance with the neural network model of 30-8-1.

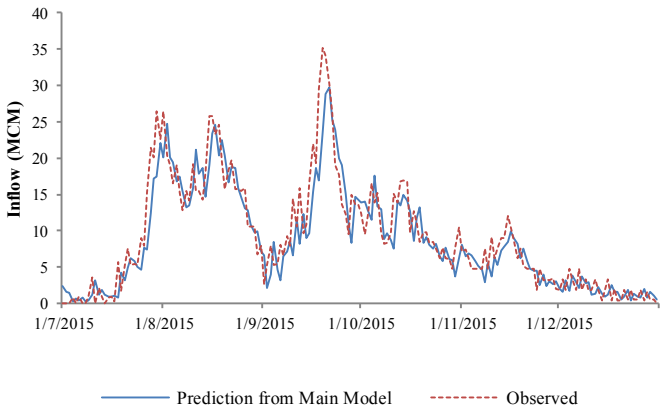

Fig. 3. Comparison of predicted inflow from the main model with observed inflow.

Improvement of the model for predicting inflow water

the water inflow in the reservoir is predicted from the main model while the predicted error values from the predictive error model. These models will be integrated and measured by R^2, NSE, RMSE, and MAE. The performance of the main and modified models is depicted in Table I.

TABLE I. THE PERFORMANCE OF MAIN MODEL AND PROPOSED MODEL.

Model	Model Accuracy Indicators			
	R2	NSE	RMSE	MAE
Main Model	0.916	0.915	7.242	3.652
Proposed Model	0.927	0.925	6.805	3.611

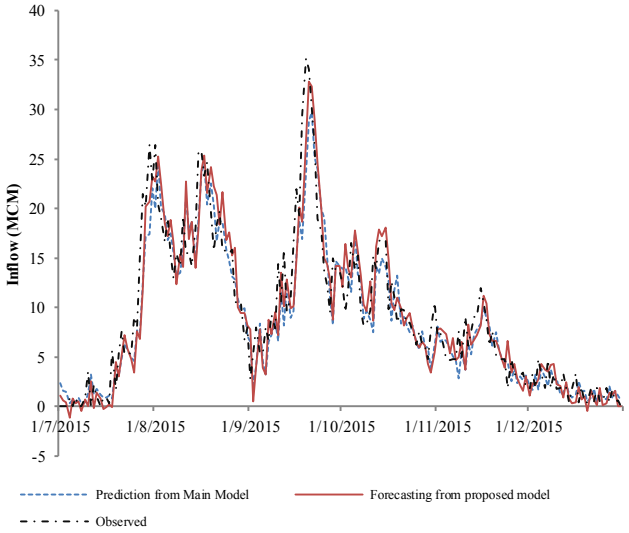

Fig. 4. Comparison of proposed model with main model and observed inflow.

The amount of water entering the reservoir from the predicted main model and proposed forecasting model from testing data set can be depicted with the observed exiting data as presented in Figure 4. It was found that the comparisons gave satisfactory results while the amount of water inflow from the proposed forecasting model was quite in good agreement to the amount of water entering the reservoir. This indicates that the improved model provides more accurate value.

V. CONCLUSION

The results demonstrated that the best predictive efficiency for the main model in predicting water flow in the reservoir, was the model with the neural network architecture 30-12-1, which can be measured the performance of the model as follows: the coefficient of determination was 0.916, the Nash-Sutcliffe efficiency was 0.915 the Root Mean Square Error was 7.242 and the Mean Absolute Error was 3.652. The error forecasting model with the best performance was the model with the architecture of the artificial neural network 30-8-1. When both models were used to improve the inflow model, the volume is formulated from equation 2. It is considered that predicted inflow into the reservoir provides more accurate forecasting. The performance of the model can be evaluated by following measured values: the coefficient of determination was 0.927, the Nash-Sutcliffe efficiency was 0.925, the Root Mean Square Error was 6.805 and the Mean Absolute Error was 3.611. All values provide a significant better predictive efficiency.

This research provides a useful approach for decision making in reservoir operation with more accurate of predicted inflow. Further work will be emphasized on application of machine learning technique for determining the optimal operating policy of reservoirs. However, to improve the accuracy and reliability of inflow predictions from the models, natural and human conditions influencing the reservoir inflow should considered.

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REFERENCES

[1] Lima, L. M., Popova, E., & Damien, P. (2014). Modeling and forecasting of Brazilian reservoir inflows via dynamic linear models. International Journal of Forecasting, 30(3), 464-476.

[2] Cheng, C. T., Feng, Z. K., Niu, W. J., & Liao, S. L. (2015). Heuristic methods for reservoir monthly inflow forecasting: A case study of Xinfengjiang reservoir in Pearl river, China. Water, 7(8), 4477-4495.

[3] Bai, Y., Chen, Z., Xie, J., & Li, C. (2016). Daily reservoir inflow forecasting using multiscale deep feature learning with hybrid models. Journal of hydrology, 532, 193-206.

[4] Valipour, M., Banihabib, M. E., &Behbahani, S. M. R. (2013). Comparison of the ARMA, ARIMA, and the autoregressive artificial neural network models in forecasting the monthly inflow of Dez dam reservoir. Journal of hydrology, 476, 433-441.

[5] Banihabib, M. E., Ahmadian, A., & Jamali, F. S. (2017). Hybrid DARIMA-NARX model for forecasting long-term daily inflow to Dez reservoir using the North Atlantic Oscillation (NAO) and rainfall data. GeoResJ, 13, 9-16.

[6] Moeeni, H., & Bonakdari, H. (2017). Forecasting monthly inflow with extreme seasonal variation using the hybrid SARIMA-ANN model. Stochastic Environmental Research and Risk Assessment, 31(8), 1997-2010.

[7] Othman, F., & Naseri, M. (2011). Reservoir inflow forecasting using artificial neural network. International journal of physical sciences, 6(3), 434-440.

[8] Al-Suhili, R. H., & Karim, R. A. (2015). Daily inflow forecasting for Dukan reservoir in Iraq using artificial neural networks. International Journal of Water, 9(2), 194-208.

[9] Chiamsathit, C., Adeloye, A. J., & Bankaru-Swamy, S. (2016). Inflow forecasting using Artificial Neural Networks for reservoir operation. Proceedings of the International Association of Hydrological Sciences, 373, 209-214.

[10] Sauhats, A., Petrichenko, R., Broka, Z., Baltputnis, K., & Sobolevskis, D. (2016, October). ANN-based forecasting of hydropower reservoir inflow. In Power and Electrical Engineering of Riga Technical University (RTUCON), 2016 57th International Scientific Conference on (pp. 1-6). IEEE.

[11] Marquardt, D. (1963) An Algorithm for Least-Squares Estimation of Nonlinear Parameters. SIAM Journal on Applied Mathematics, 11, 431-44

A Conceptual Framework for an Enhancing Running Motivation by Matching Music and Real-time Training Load

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***Abstract*— Running with music, it can not only capture attention, trigger emotions, adjust or control mood, encourage rhythmic movement, but also achieve higher values of maximal heart rate with music than without music. Moreover, when a runner run with the difference music tempo such as slow-tempo, medium-tempo, and fast-tempo, the runner will achieve differences maximal heart rate and running performance. In general, the training benefit will be separate to 5 target zones by the percent of maximum heart rate range. However, running control without notification and trigger is hard to achieve the benefit in the specific target zones. In this paper, a conceptual framework that facilitates the development for enhancing the running motivation by automatic matching difference music tempo and specific training load in real-time is proposed. Specifically, it provides an essential mechanism that enables the running motivation service to achieve the training benefit for developers and then builds into the corresponding services.**

Keywords— Sport Training, Training Load, Music Tempo

I. INTRODUCTION

Music has positive effect on a variety of physical, psychological and behavioral aspects of human existence [3]. Music can be enhance motor coordination, improve muscular and joint strength, increase endurance, induce relaxation, and improves balance [4], [5]. Running with music, it can capture attention, trigger emotions and enjoyment, adjust or control mood, encourage rhythmic movement, improve running performance and achieve higher values of maximal heart rate with music than without music [1], [6], [7].

Music tempo can be affect running cadence, prevent and treatment for common running-related injuries [8]. For running with the difference music tempo such as slow-tempo, medium-tempo, and fast-tempo, the runner will achieve differences maximal heart rate and running performance [2].

Running with training program will be improve running performance more than running without training program [9]. However, it's hard to control and monitor running to achieve the goal as instructed by the training program. Our proposed a framework for the Enhancing Running Motivation (ERM) aims to support the runner achieves their goal by selecting the suitable music that matches the real-time training load as instructed by the current training program.

The rest of this paper is organized as followed: Section II describes the proposed framework architecture. Each module of the framework is presented in Section A – E. Section III concludes the paper.

II. ERM FRAMEWORK

Our ERM framework uses the music selection for control the training program as shown in Figure 1.

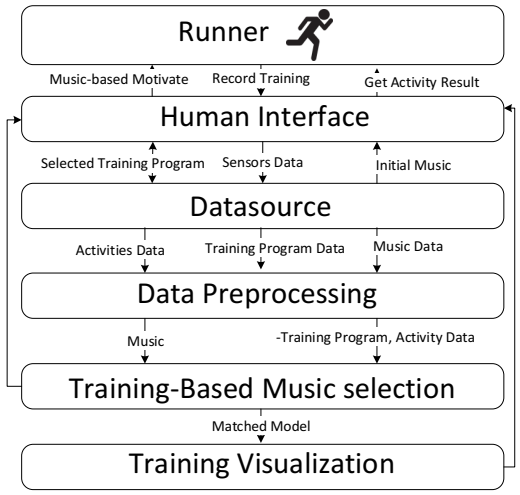

Fig. 1. A framework for the enhancing running motivation

Figure 1 illustrates the ERM architecture. Essentially, it composes of five main components: (A) Human Interface – that connects wearable devices with user; (B) Data Storage – that stores the data which is retrieved from human interface layer and initials training program and music to the user; (C) Data Processing – that is the process of data cleansing, data resampling, data smoothing and preprocessing the raw signal from sensors; (D) Training-based Music Selection – that selects the music by matching between current runner's training load and current training program; and (E) Training Visualization – that analyses and presents the training history for particular runner. Details of these modules are provided in the following sections.

A. Human Interface Layer

In this layer, the main modules are wearable device and smartphone, as illustrated in Figure 2. The wearable devices in this framework are the heart rate monitor (HRM) that used for collecting the signal of heart rate.

This sensor can be divided into 2 categories by the way sensors capture the signal from a human body. The first HRM category is based on the electrocardiograph (ECG) [10]. Sensors in this category consisting of a transmitter and

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a receiver. The transmitter could be attached to the chest using either disposable electrodes or an elastic electrode belt. The captured ECG transforms into data of heartbeat in beat per minute (bpm) unit.

Fig. 2. Human Interface Layer

The second category optical-based HRM which is a wrist-worn device with a light-emitting diode [11], [12]. This type of HRM measures the heart rate from tiny changes in skin blood volume by using light reflected from the skin. Many studies shown that optical-based HRM is very sensitive to the wearing position [11]–[13]. Therefore, User who uses this optical-based HRM may need more attention to keeping the HRM in a stable position when reading heart rate.

When the HRM obtain the heart rate data, HRM will transmit this data to the data storage. The practical method to accomplish this task connect HRM to a smartphone via Bluetooth low energy protocol. After HRM connect to the smartphone successfully, heart rate data can be transmitted to data storage through the wide area network (WAN) such as mobile networking.

This data need to be transmitted real time because heart rate data will be used to quantify the training load in real time. This real time training load [14] is used to determine how different the current effort and training program, then, the music is chosen to minimize the gap between them.

Another task of the smartphone is presenting the real-time training data related to running exercise. For example, current running pace or speed, cadence, elevation gain, decent, total distance, heart rate, etc.

When the exercise finished, the smartphone will present the data visualization for the previous exercise to encourage user by their achievement.

B. Data Storage Layer

The second layer in this ERM framework is Data Storage Layer, as illustrated in Figure 3.

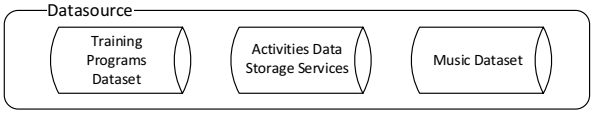

Fig. 3. Data Storage Layer

The main objective of data storage layer is storing the data that retrieved from human interface layer or activities data, training programs, and music. The training program dataset which include predefined instructions for training sessions that chosen by users when they begin to train. The music dataset includes music with different rhythms. The variety of music rhythm will be classified into different music groups which will be discussed in Session D. The activities data contains precise training log data that include biomarker data and geolocation data. In this framework, biomarker data which retrieved by wearable sensor are heart rate and cadence while geolocation data which retrieve by GPS are speed, latitude, longitude, and altitude. These data applied the GPS Exchange Format (GPX) schema [15] which is widely used in many famous on-line exercise services such as Strava[16] and Endomondo[17]. GPX schema is an XML-based schema that records all retrieved data in form of track points which each point contains all data at time interval as the following example code.

```
<?xml version="1.0" encoding="UTF-8"?>
<gpx xmlns="http://www.topografix.com/GPX/1/1"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" … >
 <metadata>
  <time>2012-06-28T13:06:26Z</time>
 </metadata>
 <trk>
  <trkseg>
   <trkpt lat="46.5556800" lon="15.6450590">
    <ele>284.6</ele>
    <time>2012-06-28T13:06:26Z</time>
    <extensions>
     <gpxtpx:TrackPointExtension>
      <gpxtpx:hr>79</gpxtpx:hr>
      <gpxtpx:cad>62</gpxtpx:cad>
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   </trkpt>
      …
  </trkseg>
 </trk>
</gpx>
```

The trkpt or track point periodically records all training data into its node. All track points align into sequence overtime may use to analyses for user training behavior and training load. However, this data contains user's location which may trace back to user accommodation. Therefore, the data privacy mechanism should be concern to ensure user's privacy is not leaking to publish when this data is used in others data analysis service or any actions that share this data publicly.

Data storage layer should be accessible through online services with high level of availability and privacy. Cloud storage is considered as the appropriate platform because of the benefit of scalability and availability. Data privacy needs to be applied to this data storage to ensure that user identity is preserved. The exportabity may perform through Restful API for third party service.

C. Data Preprocessing Layer

The data preprocessing layer is illustrated in Figure 4. This layer consists of several components include data interfacing, data preprocessing, and metadata.

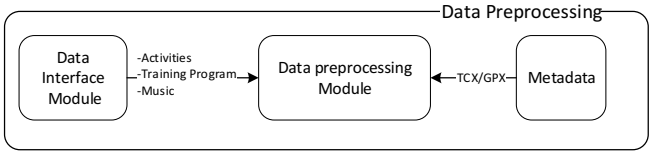

Fig. 4. Data Preprocessing Layer

The data interface account for extract the raw data from different data source and then transform this data in standard data schema for trajectory-based activity data. For heart rate and trajectory data, the consensus data schema such as Garmin's Training Center XML (TCX) and the GPX [15] is used as the HRM and GPS data schema in this framework to ensure the interoperability with third-party in the future.

The data from these sensors usually have missing value and outlier that caused by sensor's bad signal reading and/or uncertain environment condition. For example, some data points may have an altitude data that have null value or have very different value in comparison to nearby data point. This kind of defect is a normal occurrence in GPS sensor data [18]. Therefore, several tasks include data cleansing, data resampling, and data smoothing are needed to be performed on the transformed data in order to improve the quality of matching model in the next layer.

For music data, some data features such as music's rhythm and some useful metadata should be extracted from the music in data source for fulfilling the training load gap between real-time running data and the instruction of the current training program.

D. Training-based Music Selection Layer

This layer accounts for selecting the appropriated music by compares the training load between current runner's training load and the instruction of the current training program, as illustrated in Figure 5.

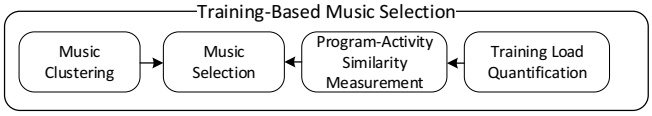

Fig. 5. Training-Based Music Selection Layer

The chosen upcoming music aims to motivate runners to adjust their current exercise effort to match the instruction in the current training program. To achieve that, the first process is the music clustering. The preprocessed music's rhythm and useful music's data feature need to be analyzed and labeled. This music can be classified by the purpose of manipulating the runner training effort. For example, the speed-up music's category may include fast rhythm music to motivate the runner to push more effort while slow-down music's category may include slow rhythm music that relaxes mental to make runner slow their current pace down. The interested techniques were proposed in [19]. These techniques successfully use the deep neural networks to preprocess and classify the music from dataset [20] by using logarithm compression and discrete Fourier transform.

The second process is training load quantification that analyzes the training load of the instruction of the current training program and the real-time training load from the runner. These data will be passed into the training load quantification module which applied by Banister's Training Impulse model (TRIMP) [14]. TRIMP model quantifies the training load by runner's heart rate and running time.

Since the training program normally instructs runner to maintain the training effort level (represented by heart rate) and training duration. Thus, this data can be quantified as the training load. On the other hand, the real-time runner training load is quantified by the current runner's training effort level (represented by runner's heart rate) and their running time.

Once the training load is quantified, the training load of the instruction of the current training program and the training load of real-time training data will be transformed into a vector that suitable for distance measurement. The third module is the program-activity similarity measurement module. This module measures a distance between the training load of the instruction of the current training program and the training load of real-time training data. This module result will be used to establish the training effort adjustment.

The last module in this layer is music selection. This module uses the training effort adjustment to select the upcoming music from the appropriated music category.

E. Training Data Visualization Layer

After the runner has finished their training session, the training history for a particular runner will be analyzed for insight knowledge that supports runner to achieve their goals in the training data visualization layer. This layer for ERM framework is illustrated in Figure 6.

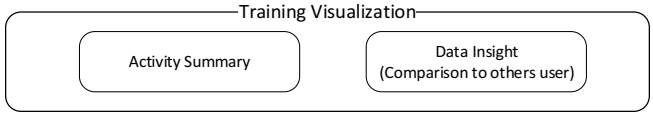

Fig. 6. Training Visualization Layer

The data insight module is a component that analyst the in-depth knowledge from the training history in individual view of point and in comparison against all users in this system. In activity summary module, the individual achievement such as total caloric expenditure, total distance, average speed, average heart rate, and HR zone distribution are presented. In data insight module, all user achievements are analyzed and compared against other users who related to them some data feature such as gender, age, body weight or body mass index (BMI). This module aims to motivate the user to improve their training behavior by recognition of their current physical fitness level in comparison against other people who have the same characteristic.

All analyzed data in this layer will be presented on the mobile application and website to maximize the availability and readiness.

III. Conclusion

This paper proposes the conceptual framework for enhancing the running motivation by matching music and real-time training load. This framework aims to motivate runner by selecting the appropriate music that matches the

desired behavior to training according to the training program instruction. This framework consists of several layers including Human Interface Layer, Data source Layer, Data Preprocessing Layer, Training-based Music Selection Layer and Training Data Visualization Layer.

The future work will be performing experiments this framework on samples consist of recreational runners with different age, gender, body mass index, and running experience. The experimental training data will be analyzed in quantity and quality for optimality in usability and user experience.

REFERENCES

[1] A. E. Thakare, R. Mehrotra, and A. Singh, "Effect of music tempo on exercise performance and heart rate among young adults," vol. 9, no. 2, pp. 35–39, 2017.

[2] C. I. Karageorghis *et al.*, "Revisiting the relationship between exercise heart rate and music tempo preference.," *Research quarterly for exercise and sport*, vol. 82, no. 2, pp. 274–284, Jun. 2011.

[3] M. V Thoma, R. La Marca, R. Brönnimann, L. Finkel, U. Ehlert, and U. M. Nater, "The effect of music on the human stress response," *PloS one*, vol. 8, no. 8, pp. e70156–e70156, Aug. 2013.

[4] M. D. Buffum, C. Sasso, L. P. Sands, E. Lanier, M. Yellen, and A. Hayes, "A music intervention to reduce anxiety before vascular angiography procedures.," *Journal of vascular nursing : official publication of the Society for Peripheral Vascular Nursing*, vol. 24, no. 3, pp. 68–73; quiz 74, Sep. 2006.

[5] J. M. Standley, "The effect of contingent music to increase non-nutritive sucking of premature infants.," *Pediatric nursing*, vol. 26, no. 5, pp. 493-495,498-499, 2000.

[6] M. J. Stork, M. Y. W. Kwan, M. J. Gibala, and K. A. Martin Ginis, "Music enhances performance and perceived enjoyment of sprint interval exercise.," *Medicine and science in sports and exercise*, vol. 47, no. 5, pp. 1052–1060, May 2015.

[7] M. Bigliassi, U. Leon-Dominguez, C. F. Buzzachera, V. Barreto-Silva, and L. R. Altimari, "How does music aid 5 km of running?," *Journal of strength and conditioning research*, vol. 29, no. 2, pp. 305–314, Feb. 2015.

[8] E. Van Dyck *et al.*, "Spontaneous Entrainment of Running Cadence to Music Tempo.," *Sports medicine - open*, vol. 1, no. 1, p. 15, 2015.

[9] M. Altini and O. Amft, "Estimating Running Performance Combining Non-invasive Physiological Measurements and Training Patterns in Free-Living.," *Conference proceedings : ... Annual International Conference of the IEEE Engineering in Medicine and Biology Society. IEEE Engineering in Medicine and Biology Society. Annual Conference*, vol. 2018, pp. 2845–2848, Jul. 2018.

[10] R. M. T. Laukkanen and P. K. Virtanen, "Heart rate monitors: State of the art," *Journal of Sports Sciences*, vol. 16, no. sup1, pp. 3–7, Jan. 1998.

[11] M. A. Case, H. A. Burwick, K. G. Volpp, and M. S. Patel, "Accuracy of smartphone applications and wearable devices for tracking physical activity data," *JAMA*, vol. 313, no. 6, pp. 625–626, Feb. 2015.

[12] H. Murakami *et al.*, "Accuracy of Wearable Devices for Estimating Total Energy Expenditure: Comparison With Metabolic Chamber and Doubly Labeled Water Method," *JAMA Intern Med*, vol. 176, no. 5, pp. 702–703, 01 2016.

[13] L. Cadmus-Bertram, R. Gangnon, E. J. Wirkus, K. M. Thraen-Borowski, and J. Gorzelitz-Liebhauser, "The Accuracy of Heart Rate Monitoring by Some Wrist-Worn Activity Trackers," *Annals of Internal Medicine*, vol. 166, no. 8, p. 610, Apr. 2017.

[14] E. W. Banister, "Modeling elite athletic performance," in *Physiological testing of elite athletes*, Champaign (IL): Human Kinetics, 1991, pp. 403–424.

[15] D. Foster, *GPX 1.1 Schema Documentation*. 2009.

[16] "Running and Cycling GPS Tracker, Performance Analytics, Maps, Clubs and Competition | Strava." [Online]. Available: http://www.strava.com/. [Accessed: 02-Oct-2014].

[17] "Endomondo | Community based on free GPS tracking of sports." [Online]. Available: https://www.endomondo.com/home. [Accessed: 02-Oct-2014].

[18] Y. Zheng, "Trajectory Data Mining: An Overview," *ACM Trans. Intell. Syst. Technol.*, vol. 6, no. 3, pp. 29:1–29:41, May 2015.

[19] K. Choi, G. Fazekas, K. Cho, and M. Sandler, "A Comparison of Audio Signal Preprocessing Methods for Deep Neural Networks on Music Tagging," *arXiv:1709.01922 [cs]*, Sep. 2017.

[20] T. Bertin-Mahieux, D. P. W. Ellis, B. Whitman, and P. Lamere, "The Million Song Dataset," in *Proceedings of the 12th International Conference on Music Information Retrieval (ISMIR 2011)*, 2011.

The Development of an Internet of Things Mobile Application for Tracking an Electric Bus in a Campus

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***Abstract*— To reach the idea of data science for the Internet of Things (IoT) innovation, we believe that if we can collect data from our daily life activities such as our commuting data from a bus system based on IoT. We can add values to this collected data using, for example, machine learning or data analysis and statistics. However, we need to enable the system to be able to measure our daily life's activities. As an example of such a system, this research demonstrates how to apply the IoT technology to track an electrical bus status of a mass transit system in a university. We develop a mobile application to show the information of the bus on a smartphone. The information can be alerted to a user or passenger in real-time. This information includes an estimated waiting time until the bus reaches a user, the number of passengers on board, and the current bus's position on the route in Google Maps. The mobile application can help a passenger to decide and manage the right journeys to travel in the university. The application was developed on the Android platform with many technologies including an Arduino integrated development environment or IDE, Google Maps application programming interface or API, a global positioning system or GPS module, ThingSpeak cloud, and infrared distance sensors. The 30 passengers evaluated the satisfaction survey. The survey mainly includes the accuracy of the tracking and alerting processes. The results are that the passengers were delighted with the processes. The evaluation related values are following. The mean is 4.91, and the standard deviation or SD is 0.29 or representing as 98.20%. To sum up, the application in this research can provide an example of mobile application development with current and available technologies such as IoT and cloud in the disruptive era to enhance applications in a transportation or others domain.**

Keywords—Cloud Computing, Internet of Things, Google Maps API, distance sensor

I. INTRODUCTION

The Internet of Things or IoT is technological innovation as a network of smart devices which can compute and communicate with each other [1, 2]. It is one of the deciding factors for developing applications and some innovational technologies in the digital society. Therefore, many sensors are adapted to IoT concepts and are contributed to the modern things for future life. IoT can lead to change in the better experiences of people, including education, agriculture, healthcare, and tourism. The IoT is compatible with cloud computing in the development of modern applications [24].

[24] states that cloud computing, or for short the cloud, can offer available online computing resources such as storages or processing platforms to customers in pay as you go manner. These cloud resources can communicate with the IoT components such as the sensors via the Internet. [20, 21, 25] argue that the cloud benefits applications in many areas. This paper here leverages IoT and the cloud concepts as also performed in [23].

Recently, people need to use smartphones for getting right and real-time suggestions while traveling. A global positioning system or GPS [3] is the technology which was used to present positions on the earth. Then, it can guide the routes or tracks for transportation systems. It is also an essential technology for IoT application development. The GPS can also be applied to track cars on maps [4].

Almost all GPS applications of transportation systems present the general information such as the route or timetable. However, this general information may be not enough for passengers to make the right decision when traveling. Mainly, the constraint of the number of passengers on a bus in some locations or routes is critical, for example, campuses, or national parks, where the free transportation systems provide to the commuters. The amounts of a service-bus may not be proper for the demand of passengers. This needs to find some solutions for mitigating the problem, or the passengers can decide whether to use the service in real-time.

Apart from the timetable and route information of a bus, the passengers should be informed with enough information to effectively and efficiently decide the right journeys by themselves. Therefore, the notification of the precise information to the passengers is essential. For example, they should get the current travel information of their bus while they are waiting for the bus. Moreover, the data of the number of empty seats on the bus is necessary. The passengers need to know this number before the bus arrives. This information can help the passengers to travel by bus smartly. The information should be presented to the passengers on real-time and on the map on mobile phones. Thus, if a passenger knows that a bus has an empty seat for her/him, the passenger may decide to wait for it. On the other hand, if it is no any seat left for him/her, he/she may change the method of traveling to reach the same destination on time.

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Therefore, this research investigated techniques for developing a mobile application to track the route information and show the number of seats that are remained for an electric bus in a campus, Naresuan University. We believe that the application discussed in this research would be an example of smart journey application of others mass transit systems. This paper is organized as follows. Section two will review the related works. Section three will propose the design and implementation of the electrical bus tracking application. Section four presents the evaluation of this application. The final section, we draw conclusions and future work.

II. Related Works

Development of a tracking electric bus system needs both sensor devices and some technologies. In this section, we review the literature on the Internet of Things (IoT) and the cloud, Google Maps API, and sensor technologies which related to contribution in the development of the bus tracking system in this research. IoT is characterized by a combination of devices and smart components to make innovation for business models [5].

The application development for IoT technologies is numerous. For example, the distinct area of applications is smart farming which is the development of intelligent agricultural production systems. Additionally, the smart-building has the development of intelligent for security systems, and smart energy applications focus on intelligent electricity. IoT [6, 7] can contribute to the application for a digital society; emerging Internet-based information will be exchanged with each other or can commutate devices-to-devices. However, the development of IoT application combines various technologies such as software and hardware for making the intelligent system.

Maps and tracking techniques are mentioned when developing the vehicle tracking system. Google Maps API [8, 9] is a dynamical geocoding address from user input. It provides the mapping tools for a developer to create a maps application to the user. This technology is applied to the various applications and is widely accepted and very reliable for application developers. Our paper applies Google Maps API to the implementation. In addition to the Maps API, the tracking system such as GPS technology is applied to many applications. A GPS tracking system [4] is an approach to get location data of a vehicle in real-time and is widely adopted in vehicles today. The Global Positioning System (GPS) and Global system for mobile communication/General Packet Radio Service (GSM/GPRS) [10] module are used to measure vehicle locations in a transportation system. The GPS module [11, 12] is the main components of a vehicle tracking system, which the location of the vehicle is transmitted to the user's smartphone network.

Some tracking bus systems in our university (Naresuan University) were developed before such as the application in [13]. This application can detect the current bus location on maps. However, it did not show the number of passengers, and not presented the location of the user on the bus in the real-time. A sensor is one of the components which can support smart travels on IoT applications. However, developers need to select the sensor that satisfies missions of developing applications. There are many sensors in the market [14, 15] such as temperature sensors, distance sensors, infrared sensors, voice sensors, or vision sensors. This paper deploys an infrared proximity sensor and an infrared distance sensor to assist in counting the number of passengers. These sensors are not expensive and flexible to be set up.

After the literature review, we found that the IoT technology can be adapted to track an available electric bus on the campus with the real-time manner. Thus, we will apply this IoT technology to the development of a prototype of a vehicle tracking system. The infrared sensors discussed above will be adapted to count the number of passengers in this system. The system overview is shown in Fig. 1. The main tasks of the system are described as following. Firstly, see step 1 in the figure, GPS and sensor data on the bus will be sent to the ThingSpeak cloud [19]. Secondly, in step 2, ThingSpeak receives the user's location from user's mobile for processing with Google Maps API [18]. In step 3, The API produces essential information for the next step. Finally, in step 4, the user gets the travel information for making the decision. This approach is designed to be flexible for both easy implementation and low-cost investment concepts and to suit for the campus areas.

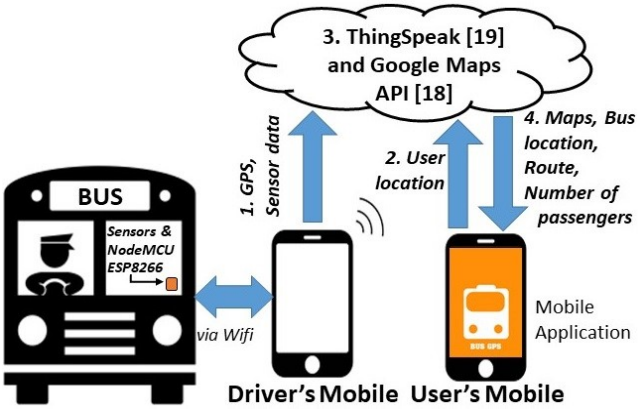

Fig. 1. Overview of the Electric Bus Tracking System

III. Development of The Bus Tracking System

We follow the methodology of development in vehicle tracking systems. Devices and technologies were applied to track the electric bus with its real-time locations. This section mainly discusses the concepts related to the development of the bus tracking system, including hardware, software, the processes of the system, application development, and experiment and evaluation of the system.

A. Hardware

a) NodeMCU ESP8266 V1(for short NodeMCU): it is a printed circuit board or PCB that contains the system on a chip or SoC for IoT platform. This board has the integrated transmission control protocol/Internet protocol or TCP/IP protocol stack that provides access to WiFi network on the bus. Users need to select the modules suitable for their project and create firmware tailored to their requirements.

b) Android smartphone: these smartphones were used for the experiment in this research. The bus driver's smartphone connects to the Internet and is the wireless access point for the NodeMCU board. There are no specific applications on this phone. A user also uses the mobile

application on an Andriod smartphone to check the information of an electric bus and its routes and maps.

c) GPS Module GY-GPS6MV2: it is a GPS sensor for informing the position to the user's mobile application. The sensor can produce precise bus's locations. It is installed on NodeMCU on the bus, which will send data of the locations to the ThingSpeak cloud.

d) Infrared Promoxi Sensor E18-D80NK: this sensor is a high-sensitive photo reflector to measure distance function, ranging from 3 to 80 centimeters. An infrared LED and receiver can manage the presence of things within a specific distance. Best usage on this device is for industrial and automotive, robotics, etc.

e) Infrared Distance Sensor E3F-DS10C4: it is a photoelectric proximity sensor. It can detect all objects that reflect light with the distance of 10 to 15 centimeters. It is widely used for detection, product counting, automatic door, etc.

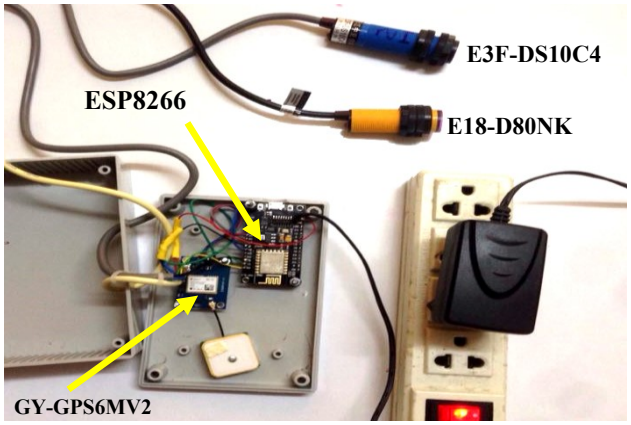

Fig. 2. All sensors on the electric bus

B. Software

a) Android Studio: it is the officially integrated development environment or IDE for applications of Google's Android operating system. It is the rapid tools to build mobile applications that can be run on any Android device [22].

b) ThingSpeak: it can be considered as is the cloud. ThingSpeak cloud provides APIs [16, 17] which is an open source for IoT applications to collect and retrieve data from things using HTTP via the Internet or LAN. ThingSpeak can assist the developer in creating applications which run upon the data received by sensors.

c) Arduino IDE: it is for writing Arduino programming language applications and can upload the written code to the NodeMCU.

Both software and hardware are completely set up, in the computer laboratory for testing. After that, essential sensors and software were installed into the NodeMCU which is on the electric bus for the experiment.

Fig. 3. NodeMCU and infrared sensors on the bus

C. The processes of the bus tracking system

This section provides details of the main processes of our electric bus tracking system.

- The bus driver turns on WIFI spot from his or her smartphone to enable NodeMCU to be able to connect to the Internet.
- The GPS Module sends the data of the longitude and latitude of the current bus location to NodeMCU.
- While the passenger gets on/off the bus, the infrared sensors on the front/back door of the bus will send the on/off-bus values to NodeMCU.
- NodeMCU transfers the data of longitude and latitude of bus position to be stored in ThingSpeak every 15 seconds.
- A bus user/passager can request the tracking service on his/her mobile application. The bus data storing on ThingSpeak will be sent to the user's mobile application, including the current bus position and the current number of passengers, etc. Then, the application will send this bus data and the current user's position to Google Maps API.
- Then, based on the sent data from the previous step above, Google Maps API calculates i) the distance between the bus and the user position and ii) the remaining time which the bus will reach the user's location. Then, the calculated distance and time information will be sent to the user application. Then, the application will be vibrated and will send a message to notify the user, when the bus is far from the user less than and equal to 2 minutes before the bus reaches the user location.

D. Application development

The application development follows the research methodology including, analysis, design, implementation, and evaluation respectively, for solving the problems and supporting the users for bus tracking in the university. The IoT hardware components are set up on the bus. In the part of a mobile application for the user, this research implements an Android application called "BUS GPS" application. The application's abilities are below:

- to show the maps and the current user's position on the smartphone
- to show the current position of the electric bus on maps
- to show the number of a passenger on real-time

- to show the estimated time for waiting for the bus
- to notify to the user on mobile when the electric bus is nearly reaching the current user's location
- to show the distance between the current user and the bus location.

To sum up, this tracking bus application has more functions than other applications which were previously developed at Naresuan University.

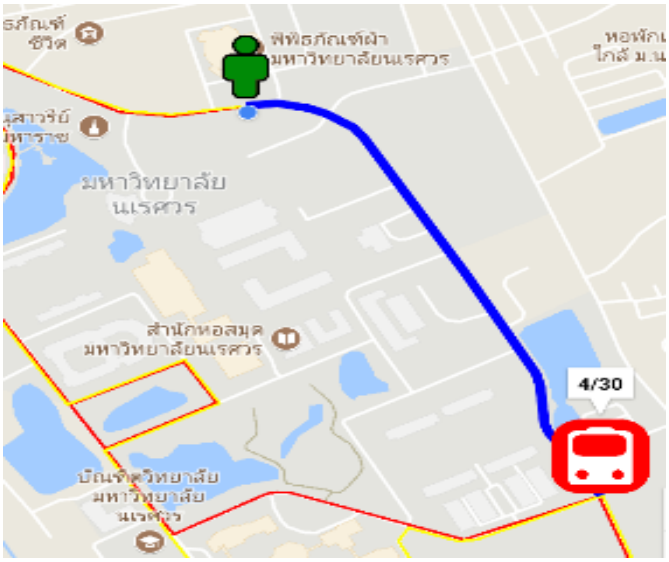

Fig. 4. The shot screen of the application shows the number of passenger and the current user's location on the maps.

E. Experiment and Evaluation

The experiment of the application was set in Naresuan University, where has the electric bus services for students, staffs, or visitors. A passenger can check bus information. The capacity of the bus is thirty people. On the way, there may be more or fewer passengers. It depends on the number of passengers that is on and off the bus. The hardware and sensors were set up on the electric bus for the experiment. We set thirty passengers including students and visitors for testing. Users must download the BUS GPS application to install on their mobiles. Moreover, every user needs to stand on the different location on the bus routes in the campus for realistic simulation.

After that thirty passengers finished their travel, they need to evaluate the satisfaction survey for checking the accuracy of bus's tracks and the notified bus information to them. The survey had five satisfaction questions. Firstly, the mobile application can correctly show the specific number of passengers on the bus. Secondly, the mobile application can accurately explain the waiting time and the distance between the bus and the user's location. Thirdly, the mobile application can correctly show the current user's location. Fourthly, the application can accurately display the route information. Lastly, the mobile application is friendly to a user. A survey scale is consisting of numbering 1 to 5 as follows: 1 not at all satisfied, 2 partly satisfied, 3 satisfied, 4 more than satisfied, 5 very satisfied. The answer of the satisfaction questions by all users was evaluated on the statistic approach for finding the results of the survey including Mean ($\bar{x}$) and the standard deviation (SD) on each issue.

IV. Result and Discussions

A. The result of the evaluation

The result of the evaluation is shown in TABLE I. The question number one, and four were evaluated to being very satisfied, Mean is 5, and the standard deviation is 0. All passengers were satisfied for both questions. They agreed that the application can precisely show in the specific number of passengers and can accurately display the route information. Next, the means of the question number two and three were 4.87 and SD is 0.35. The result of these questions was very satisfying. However, the average of results survey was 4.91 and SD is 0.29; thus, this is a conclusion as very satisfying. To summarize, this bus tracking application is helpful for this group of passengers to assist them in traveling on the campus. They satisfied this mobile application.

TABLE I. The Result of Evaluation by Passengers

Questions	MEAN	SD	Result
1) The mobile application can correctly show the specific number of passengers on the bus	5.00	0	Very satisfied
2) The mobile application can accurately explain the waiting time and distance between the bus and the user's location	4.87	0.35	Very satisfied
3) The mobile application can correctly show the current user's location	4.87	0.35	Very satisfied
4) The mobile application can accurately display the route information	5.00	0.00	Very satisfied
5) The mobile application is friendly to a user	4.80	0.41	Very satisfied
MEAN	4.91	0.29	Very satisfied

B. Discussions

Response time is one of Microsoft Key Performance Indicators (KPIs) that was used in some research [20-21] to evaluate the performance of applications. However, this paper here did not thoroughly discuss the performance of the proposed mobile application against these KPIs. We instead discussed the evaluation of some aspects of the accuracy of the application, as mainly described in Section III-E and IV-A.

We will discuss the detail about data preprocessing that supports excellent user feedback as illustrated in Section IV-A as following. As the mobile application's preprocessing methods on GPS data can accurately produce estimated bus traveling times, as discussed in Section III-E and IV-A, this may be because of that it is with the help of the cooperation of the powerful cloud technologies including ThingSpeak [19] and Google Maps API [18], as discussed at the end of Section II and in Section III-C.

Moreover, for the detail about data analysis that also supports the excellent user feedback as illustrated in Section IV-A, firstly this may be because of that, for example, from

question number one in TABLE I, this may be because of that the sensors precisely measured the number of the passengers in real-time manners. The output from these sensors (as illustrated in Section III-C and D) can be precise compared to counting by, for example, humans. Thus, the users were satisfied with the correct output.

Secondly, this may also be because of that these IoT sensors, and our proposed mobile application can enhance the users' experiences in campus bus commuting. It is because of that these users can feel that they are enjoying new types of bus journeys with our useful and modern application to ease their daily life.

V. Conclusion and Future Work

This research presents the development of a mobile application with the Internet of Things or IoT and the cloud technologies for tracking an electrical bus status of the mass transit system in our campus, Naresuan University. This mobile application has more features than some previous systems which were developed at the university. Our mobile application can show the bus status on a smartphone and inform a passenger to know the real-time waiting period for the bus. The application also shows the number of passengers on board and the current bus position on the route in Google maps. This application was developed on the Android platform with some current technologies, including an Arduino IDE, Google Maps API, GPS module, ThingSpeak cloud, and infrared distance sensors.

We demonstrated the capabilities of an electric bus tracking system through a mobile application in the university. Then we evaluated the satisfaction survey with 30 passengers for checking the accuracy and correctness of the output of the application. The results of the evaluation were very satisfied (Mean = 4.91, SD = 0.29), representing 98.20%. We believe that this application can be one of the approaches that can be applied to the application development with IoT and cloud in the disruptive era for assisting commuters in deciding effective and efficient journeys of transportation. The application can be adapted to work in other types of transportation in other places such as public historical or national parks, or festivals.

For the future work, the application needs to add the function to inform the number of seats which remain on a bus for a disabled person. Also, the application should be contributed to iPhone OS platforms.

References

[1] L. Tan and N. Wang, "Future internet: The internet of things," in *Advanced Computer Theory and Engineering (ICACTE), 2010 3rd International Conference on*, 2010, vol. 5, pp. V5-376-V5-380: IEEE.

[2] I. Lee and K. J. B. H. Lee, "The Internet of Things (IoT): Applications, investments, and challenges for enterprises," vol. 58, no. 4, pp. 431-440, 2015.

[3] B. Hofmann-Wellenhof, H. Lichtenegger, and J. Collins, *Global positioning system: theory and practice*. Springer Science & Business Media, 2012.

[4] N. Chadil, A. Russameesawang, and P. Keeratiwintakorn, "Real-time tracking management system using GPS, GPRS and Google earth," in *Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology, 2008. ECTI-Con 2008. 5th International Conference on*, 2008, vol. 1, pp. 393-396: IEEE.

[5] F. Wortmann and K. Flüchter, "Internet of things," Business InformationSystemsEngineering, vol.57, no.3, pp. 221–224, 2015.

[6] R. H. Weber and R. Weber, *Internet of things*. Springer, 2010.

[7] G. M. Lee, N. Crespi, J. K. Choi, and M. Boussard, "Internet of things," in *Evolution of Telecommunication Services*: Springer, 2013, pp. 257-282.

[8] G. Svennerberg, *Beginning Google Maps API 3*. Apress, 2010.

[9] A. Pejic, S. Pletl, and B. Pejic, "An expert system for tourists using Google Maps API," in *Intelligent Systems and Informatics, 2009. SISY'09. 7th International Symposium on*, 2009, pp. 317-322: IEEE.

[10] S. Lee, G. Tewolde, and J. Kwon, "Design and implementation of vehicle tracking system using GPS/GSM/GPRS technology and smartphone application," in *Internet of Things (WF-IoT), 2014 IEEE World Forum on*, 2014, pp. 353-358: IEEE.

[11] H. D. Pham, M. Drieberg, and C. C. Nguyen, "Development of vehicle tracking system using GPS and GSM modem," in *Open Systems (ICOS), 2013 IEEE Conference on*, 2013, pp. 89-94: IEEE.

[12] R. Jurdak *et al.*, "Camazotz: multimodal activity-based GPS sampling," in *Proceedings of the 12th international conference on Information processing in sensor networks*, 2013, pp. 67-78: ACM.

[13] S. Tangkawanit, C. Termritthikun, and S. Kanprachar, "Electric vehicle tracking and notification application for smart phones," in *Electrical Engineering Congress (iEECON), 2014 International*, 2014, pp. 1-4: IEEE.

[14] A. M. Sabatini, V. Genovese, E. Guglielmelli, A. Mantuano, G. Ratti, and P. Dario, "A low-cost, composite sensor array combining ultrasonic and infrared proximity sensors," in *Intelligent Robots and Systems 95.'Human Robot Interaction and Cooperative Robots', Proceedings. 1995 IEEE/RSJ International Conference on*, 1995, vol. 3, pp. 120-126: IEEE.

[15] J. Gubbi, R. Buyya, S. Marusic, and M. J. F. g. c. s. Palaniswami, "Internet of Things (IoT): A vision, architectural elements, and future directions," vol. 29, no. 7, pp. 1645-1660, 2013.

[16] M. A. G. Maureira, D. Oldenhof, and L. J. R. W. W. Teernstra, "ThingSpeak–an API and Web Service for the Internet of Things," 2011. Available: http://mediatechnology.leiden.edu/images/uploads/docs/wt2014_thingspeak.pdf

[17] C. Doukas and I. Maglogiannis, "Managing wearable sensor data through cloud computing," in *Cloud Computing Technology and Science (CloudCom), 2011 IEEE Third International Conference on*, 2011, pp. 440-445: IEEE.

[18] Google. (2018). Maps. Available: https://cloud.google.com/maps-platform/maps/

[19] ThingSpeak. (2018). Understand Your Things
The open IoT platform with MATLAB analytics. Available: https://thingspeak.com/.

[20] W. Wongthai and A. Van Moorsel, "Performance measurement of logging systems in infrastructure as a service cloud," ICIC Express Letters, 2016.

[21] P. Chan-In and W. Wongthai, "Performance improvement considerations of cloud logging systems," ICIC Express Letters, 2017.

[22] Google. (2018). Android Studio. Available: https://developer.android.com/studio/

[23] W.Runathong, W.Wongthai, and S.Panithansuwan,"A system for classroom environment monitoring using the internet of things and cloud computing," Lecture Notes in Electrical Engineering, 2017

[24] W. Wongthai and A. van Moorsel, "Quality analysis of logging system components in the cloud," Lecture Notes in Electrical Engineering, 2016.

[25] W. Wongthai and A. Van Moorsel, "Logging system architectures for infrastructure as a service cloud," Journal of Telecommunication, Electronic and Computer Engineering, 2017.

A Tax-Map-Based Address Point Data Model for Geocoding Thai addresses

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***Abstract*—With a foreseen of significant geospatial data usage, several providers offer an online geocoding service that allows Internet users to convert a text address to coordinates with ease and no cost. However, the quality of their geocoding results is still uncertain, especially in developing countries like Thailand where the complexity of city plans and address formats are still opened issues. This paper proposes a tax-map based address point data model (TAPDM) which aims to improve geocoding quality of Thai addresses. This study developed a sample reference dataset of the TAPDM from tax map databases acquired from two municipalities in Phitsanulok Province, a study area. An address locator created from the prototype was used to perform geocoding in ArcGIS Desktop. Urban and rural addresses were sampled from the study area with one hundred each. The results were compared with those returned from four geocoding service providers: ArcGIS Online, Google, MapQuest, and Bing. The results revealed that the geocoding results of the TAPDM have the highest match rates in both urban and rural areas with 92% and 100%, respectively, and produced the highest positional accuracy in both urban and rural with the median of distance errors 2.65 meters and 11.68 meters, respectively.**

Keywords—geographic information systems, geocoding, address point, tax map database

I. INTRODUCTION

Geocoding is a process for converting a text address or a place name into geographic coordinates. Two important elements of the geocoding process are a reference database and an algorithm [1]–[3]. The geocoding algorithm includes translation or interpretation of the input text, a process for searching the reference database for the details of the input text, matching the input text to entries found in the reference database, and then selecting the best solution and returning geographic coordinates along with described data back to the user. The reference database consists of data descriptions and geographic coordinates. Thus, selecting an appropriate algorithm for managing the process and choosing the complete reference data are important factors that directly influence the quality of the geocoding results.

The emergence of online geocoding services makes the steps of choosing an algorithm and a reference database transparent to the Internet users. Service providers can make a decision on the geocoding algorithm and the appropriate reference database to be deployed. Nowadays, we can perform geocoding tasks for any place name around the world with ease. In Thailand, several geocoding services are available. Most providers can geocode a place name or point of interest (POI) with a highly accurate location at rooftop level, but many problems arise when geocoding Thai addresses. There are at least three main causes that most geocoding services have difficulties. First, the Thai address format does not use commas to separate address components. The Thai address components are the house number, village number (moo) (assigned for rural addresses), alley (soi) (assigned for urban addresses), street name (thanon) (assigned for urban addresses), sub-district (tambon), district (amphoe), province (changwat), and postcode. Nevertheless, each address component can be extracted using its prefix. Second, the house number is not always a number but it may include letters, hyphens, or slashes; for examples, "169/7-12 ถนนสุริวงศ์ แขวงสุริยวงศ์ เขตบางรัก กรุงเทพฯ 10500" (169/7-12 Thanon Surawong, Suriyawong, Bang Rak, Bangkok 10500), "334/29 ซอยสามัคคี หมู่ 9 ต.อรัญญิก อ.เมือง จ.พิษณุโลก 65000" (334/29 Soi Samukkee, Moo 9, Tambon Arunyik, Amphoe Muang, Phitsanulok, 65000). Last, unlike other countries, each Thai postcode is associated with a geographic location only at a provincial level, identified by the first two digits. The last three digits are used to indicate the country's postal services, which do not always connect with the administrative hierarchy [4]. Thus, to geocode Thai addresses, simply applying the traditional algorithms or the standard reference data models (i.e., street network, parcel boundary, address point) [3][5] cannot achieve high-quality geocoding solutions without completeness of reference data.

To develop a reference database for Thai geocoding, we searched and evaluated many possible data sources with reliable and accurate coordinates reference. The most potential one was the tax map data by the Ministry of Interior. The tax map database consists of information that shows address, address's location, size of the land plot, route, water source and so on. Currently, the Thai government encourages all districts throughout the country to build local taxation databases to support tax collection [6]. Thus, it is possible to utilize the taxation databases for improving the quality of geocoding results. As address data resides in most databases of information systems, many insightful decisions and planning management can be carried out from the analysis of precise locations, such as public health resources management, epidemiological control, city surveillance etc. [7]–[10].

This study aims to design and develop a tax-map based address point data model (TAPDM) for a reference database in the geocoding process. A sample reference database was developed from two tax map databases acquired from two municipalities of Phitsanulok. The efficiency of the TAPDM to geocode Thai addresses was compared with the geocoding

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quality of four online services by ArcGIS Online, Google Maps, MapQuest Maps, and Bing Maps.

II. METHODS

The methodology of this study has four main steps. First, designing a reference address point data model, TAPDM, and creating a sample reference dataset for testing. Second, creating an address locator using ArcGIS Desktop tool from the prepared dataset, referred as the TAPDM geocoder. Third, testing the TAPDM geocoder using a set of sample addresses with its ground truth location. Also, testing the four geocoding services with the same test dataset. Finally, analyzing and comparing the quality of the geocoding results obtained from the five sources. The details in each step are as follows.

A. Tax-map based address point data model (TAPDM)

After we analyzed all patterns of Thai addresses, the reference data model should at least consist of house number, village number, alley, street, sub-district, district, province, and geographic coordinates. We surveyed many possible data sources and searched for the one with the complete address data throughout the country with an accurate geographic reference. It came out that the tax map data is the most potential one. We requested tax map datasets from Phitsanulok municipality and Aranyik municipality, Mueang district, Phitsanulok province, since they claimed for the completeness of house data in their area. In addition, most addresses in Phitsanulok municipality are in the urban format, while those in Aranyik municipality are in the rural format. Table 1 presents the differences between the address components of addresses in urban and rural areas.

TABLE I. THE THAI ADDRESS FORMAT IN URBAN AND RURAL AREAS

Address format	Urban area	Rural area
House number	85/50	911/9
Village number	-	3
Alley	Borommatrailokkanat 19	-
Street	Borommatrailokkanat	-
Sub-district	Nai Mueang	Aranyik
District	Mueang	Mueang
Province	Phitsanulok	Phitsanulok
Postal code	65000	65000

The obtained datasets compose of many data layers for tax collection and land properties purposes and also the building data layer that includes address information such as house number, village number, street, and geographic boundary; an example of building data layer shown in Fig.1. The building layer contains 24,819 addresses in Phitsanulok municipality and 7,231 addresses in Aranyik municipality. However, the address data in the building layer is lack of important address component, which are sub-district, district, and province. Therefore, we performed the spatial overlay operation with the administrative data layer (sub-district, district, and province), to obtain complete information of point addresses. Fig. 2 shows the process of obtaining data for the TAPDM, which requires the building data from a tax map dataset and the administrative information from the administrative datasets.

B. Creating an Address locator

We chose tools in ArcGIS Desktop for creating an address locator and performing geocoding tasks. The address locator was created using the General-Gazetteer locator format. Mapping of fields between the address locator and the TAPDM dataset shows in Table II.

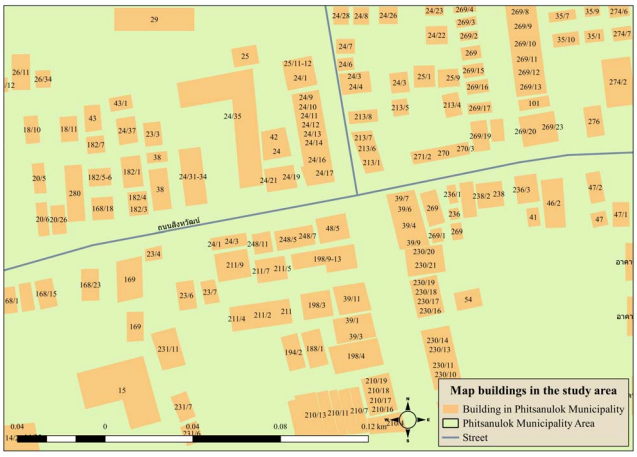

Fig. 1. The building data layer in the tax map dataset

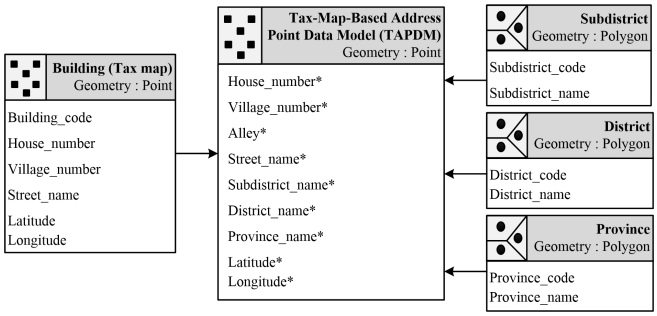

Fig. 2. The components of tax-map-based address point data model

TABLE II. ADDRESS LOCATOR FROM THE TAPDM DATASET

Address locator	Locator format	Reference data	Field name	Fields name of TAPDM
Address locator	General-Gazetteer	TAPDM	*Place name Street Address City State Country	House_number Street_name Sub-district_name District_name Province_name

C. Testing Geocoders

To evaluate the performance of the TAPDM geocoder, one hundred addresses in Phitsanulok municipality and one hundred addresses in Aranyik municipality were randomly sampled from the dataset. Then, we validated the existing of these addresses with a field survey. At each address, we collected geographic coordinates of the address (most are at an entrance of the building) using a GPS handheld device (Garmin eTrex 10) with positional accuracy about 10 m. The collected coordinates of each address were used as ground truth.

The two hundreds of sample addresses were submitted to the TAPDM geocoder and the four online geocoding services. The tests were conducted in September 2018. The geocoding results and other response data were collected for analysis purpose.

D. *Quality Analysis*

We performed two analyses according to address formats: urban and rural. The geocoding quality was measured by match rates and positional accuracy [11][12]. The match rate is a ratio of the number of geocoded addresses returned to the total number of addresses submitted. We also classified the levels of the matched types into three levels: good, ambiguous, and unmatched. Table III shows how we sorted matched types in response messages of each service into confidence levels. Positional accuracy is measured by the error distance between the geocoded point and the ground truth.

TABLE III. MATCHED TYPES OF THE GEOCODING RESULTS

Type of match	TAPDM geocoder	ArcGIS Online	Google Maps	Bing Maps API	MapQuest Maps
Good	Matched	Point Address	Rooftop	High	Point
Ambiguous	Tied	-Street Address -Street Intersection -Distance Marker -Street Name -Locality	-Range interpolated -Geometric center -Approximated	Medium Low	Street Zip City Country
Unmatched	No geocoding result	No geocoding result	No geocoding result	No geocoding result	No geocoding result

III. RESULTS AND ANALYSIS

The match rates of one hundred testing addresses in the urban area, Phitsanulok municipality, produced by the TAPDM geocoder and the four geocoding services were presented in Fig.3. ArcGIS online, Google, MapQuest, and Bing achieved 100% of the overall match rate, while the TAPDM geocoder had 92% of the overall match rate. Further analysis on the level of matched types, the TAPDM geocoder returned the highest 'good' match rate (71%), followed by MapQuest 57%, ArcGIS online 42%, Google 12%, and Bing 7%. Thus, we can see that most online services had low confidence at rooftop or address point level on their results. This is partly due to an incomplete reference address point data in the study area. Conversely, the four services returned high 'ambiguous' match rates at 93%, 88%, 58%, and 43% by Bing, Google, ArcGIS Online, and MapQuest, respectively. At the ambiguous level, all services attempted to give a location for each input address to maintain the overall match rate. But some solutions were at the street location level but some were a centroid of a province. While other services returned no results, the TAPDM geocoder had 8% of the unmatched match rate. The unmatched addresses were those with slashes (/) and hyphens (-) in the house number component; for examples, 268/96-97 and 268/175-176.

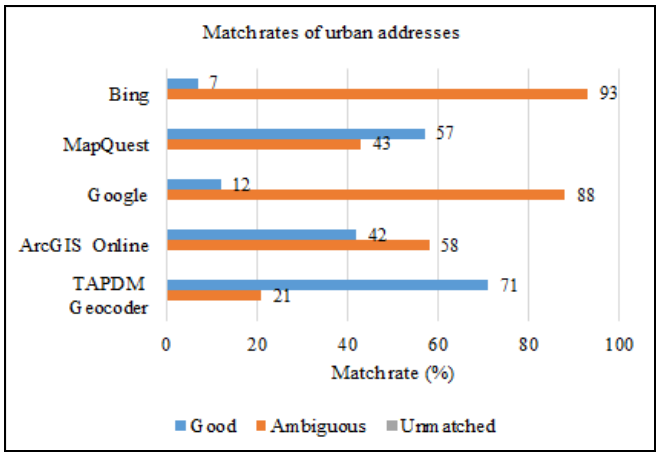

Fig. 3. The match rates of the geocoded results for the urban addresses

With one hundred addresses in the rural area, Aranyik municipality, match rates of all geocoders presented in Fig. 4. All geocoders achieved 100% of the overall match rate. Considering the matched types, ArcGIS online and the TAPDM geocoder returned the highest 'good' match rates at 99% and 89%, respectively. The other three services: Bing, MapQuest, and Google, returned the results at high 'ambiguous' match rates 100%, 96%, and 95%, in that order. It can be interpreted that the ArcGIS Online and the TAPDM geocoder understand the format of Thai rural addresses rather well.

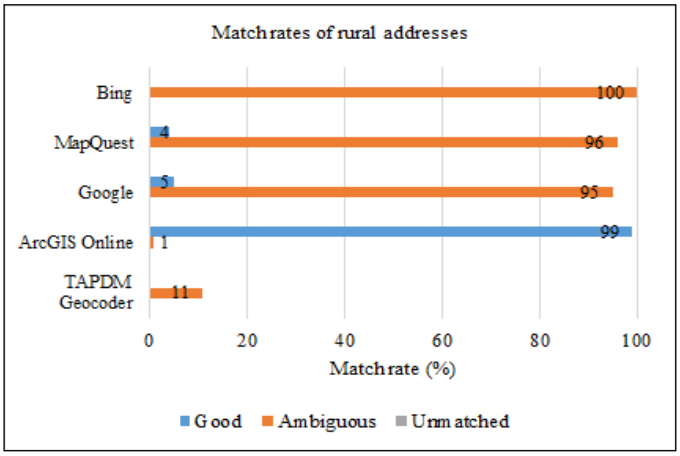

Fig. 4. The match rates of the geocoded results for the rural addresses

For the urban addresses, a statistical summary of error distances produced by each geocoder is presented in Fig.5. It obviously shows that the TAPDM produced, on average, the lowest error distances or the highest positional accuracy with the median of 2.65 m. Bing returned the lowest positional accuracy with the median of 2,591.29 m. 37% of Bing's geocoded points were located in another province, (Tambon Muang, Amphoe Mueang, Nakhon Phanom) which caused mismatched locations further away almost 500 km. ArcGIS Online returned 57% of the results at street level since it could not find the exact match of house numbers causing error distances ranging from 1.04 to 3.51 km.

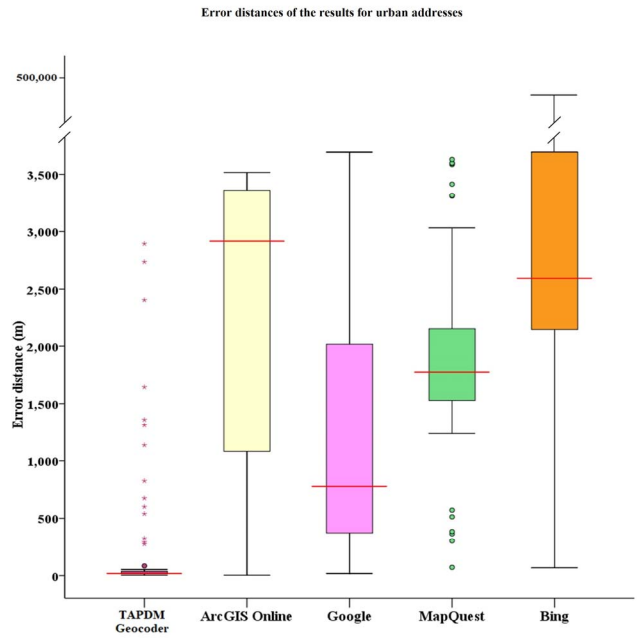

Fig. 5. The error distances of the geocoded results for the urban addresses

The error distances of the geocoded results for the rural addresses present in Fig. 6. The TAPDM geocoder and ArcGIS Online produced the lowest error distance with the median of 11.68 m and 12.15 m, respectively. This confirms that these two geocoders have a good handle of the rural address format. Google returned the geocoded points with the median of 662.50 but the maximum error distance was about 343 km due to mislocating an address in a wrong province. While MapQuest and Bing produced, on average, rather high error distances with a median of 3.56 km, and 5.18 km, correspondingly.

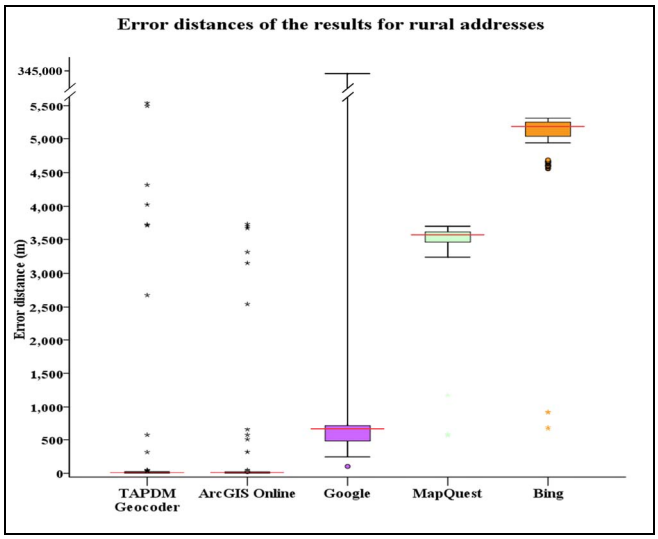

Fig. 6. The error distances of the geocoded results for rural addresses returned by the five geocoders

IV. Discussion and Conclusions

This study proposed a simple address point data model for using as a reference data in any geocoder for Thai addresses. The data source of this model was the tax map datasets, thus we named the model as TAPDM. To test the TAPAM model, we built a reference dataset from the tax map datasets of Phitsanulok and Aranyik municipality, which represent the different formats of urban and rural addresses, then using ArcGIS Desktop's tools to perform geocoding tasks on two hundreds of sample addresses. The geocoding results of the TAPDM geocoder were compared with those of the four online services offered by ArcGIS Online, Google, MapQuest, and Bing. The TAPDM geocoder can achieve the highest match rates at a good level with 71% and 89% for urban and rural addresses, respectively, and produced the highest positional accuracy with the median of error distances 2.65 m and 11.68 m urban and rural addresses, respectively.

With the quality of geocoded results reported previously, the TAPDM can be a potential reference data model for geocoding Thai addresses both in urban and rural areas. Although its overall match rates were lower than other online geocoding services, its positional accuracy was outperformed others. Thus, to increase the overall match rate of the TAPDM geocoder, one should focus on parsing complex house numbers. In addition, this work does not focus on the geocoding algorithm, including the steps of parsing text, normalizing address, matching components with the reference database, and deciding on the returned coordinates. Therefore, misspelling or typos of address components may cause lower match rates when utilizing the TAPDM in a practical geocoder.

In sum, this study has shown the feasibility of using tax map databases for the geocoding purpose. With the availability of the tax map data national wide, it can reduce time and budget significantly to build a national reference database for address points. However, the idea would not be possible without the government's allowance on using the tax map data.

References

[1] H. A. Karimi, M. Durcik, and W. Rasdorf, 'Evaluation of Uncertainties Associated with Geocoding Techniques', *Computer-Aided Civil and Infrastructure Engineering*, vol. 19, no. 3, pp. 170–185, 2004.

[2] D. W. Goldberg, J. P. Wilson, and C. A. Knoblock, 'From Text to Geographic Coordinates: The Current State of Geocoding', *URISA Journal*, vol. 19, no. 1, pp. 33–46, Jan. 2007.

[3] P. A. Zandbergen, 'A comparison of address point, parcel and street geocoding techniques', *Computers, Environment and Urban Systems*, vol. 32, no. 3, pp. 214–232, May 2008.

[4] Thailand Post Co., Ltd, 'The content of postal code Thailand', 07-Oct-2015.

[5] D. W. Goldberg, *A Geocoding Best Practices Guide*. North American Association of Central Cancer Registries,Inc., 2008.

[6] Government Gazette Volume 125, Special section 30 d., 'Ministry of Interior with The Property Registration and Tax Map of The Local Administration in 2007'. 11-Feb-1968.

[7] D. W. Goldberg and M. G. Cockburn, 'The effect of administrative boundaries and geocoding error on cancer rates in California', *Spatial and Spatio-temporal Epidemiology*, vol. 3, no. 1, pp. 39–54, Apr. 2012.

[8] J. S. Sonderman, M. T. Mumma, S. S. Cohen, E. L. Cope, W. J. Blot, and L. B. Signorello, 'A multi-stage approach to maximizing geocoding success in a large population-based cohort study through automated and interactive processes', *Geospat Health*, vol. 6, no. 2, pp. 273–284, May 2012.

[9] D. W. Goldberg, G. M. Jacquez, and N. Mullan, 'Geocoding and Health', in *In Geographic Health Data: Fundamental Techniques for Analysis*, vol. 2013, Eds F Boscoe: CAB International, UK (In Press), 2013, pp. 51–71.

[10] S.-W. Lin, C.-F. Yen, T.-Y. Chiu, W.-C. Chi, and T.-H. Liou, 'New indices for home nursing care resource disparities in rural and urban areas, based on geocoding and geographic distance barriers: a cross-sectional study', *International Journal of Health Geographics*, vol. 14, p. 28, 2015.

[11] P. A. Zandbergen, 'Geocoding quality and implications for spatial analysis', *Geography Compass*, vol. 3, pp. 647–680, Mar. 2009.

[12] D. Roongpiboonsopit and H. A. Karimi, 'Quality Assessment of Online Street and Rooftop Geocoding Services', *Cartography and Geographic Information Science*, vol. 37, no. 4, pp. 301–318, Jan. 2010.

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Entropy-based Attribute Clustering

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***Abstract*—Data clustering techniques have been well-studied for several decades. Different from traditional data, attribute clustering focuses on grouping values of attributes or features instead of grouping similar transactions. Similar attributes will be clustered into the same group and different attributes will be clustered into different groups. Two attributes are considered to be similar if they appear in the similar set of transactions. In this paper, we proposed a new improvement to improve the best-known parameter free attribute clustering algorithm. From our intensive experiments on 10 real-world datasets, the results demonstrate that our proposed method not only achieve higher quality clusters but is also faster than the best-known parameter-free attribute clustering method.**

Keywords— attribute clustering data summarization; minimum description length;

I. INTRODUCTION

Nowadays, big data are all around us and are important for our daily life. However, because of their complicated and large size, their processing and analysis become extremely difficult. One resolution to overcome these difficult problems is to summarize them into more compact, but still informative, version of the entire data. The main objective of data summarization techniques is to produce a good quality of summaries that require less storage and extremely shorten the time needed to process and analyze. For example, a whole book can be summarized into just title and abstract, which will provide a good first impression of what to expect from it.

Many techniques have been proposed for data summarization such as [6][7][8]. Attribute clustering [1] is an efficient data summarization technique for transactional or categorical data in which a summary is given in terms of sets of attributes, which are highly correlated to each other. By showing which attributes are highly correlated or interact most strongly, the summary is able to provide data insight and good first impression of the original entire data. An example of summary forms can be a set of frequent or closed itemsets which are representative of the original datasets [8]. These descriptive frequent patterns can be used as a surrogate to understand and get the insight of the original data.

Many attribute clustering techniques have been proposed to find a good summary of transactional or categorical data [1][2]. The standard approach is to find the frequent patterns first [2]; the result of which quickly grows up too many times of the size of the original dataset. Further, these techniques do not consider interactions between attributes in the data. Several works have been proposed to find the interactions between attributes via the clustering mechanism [1][2]. The output is a set of clusters of attributes that strongly interreact or correlated each other Mampaey and Vreeken [1] proposed the best-known parameter-free algorithm to find the best attribute grouping using Minimum Description Length (MDL). During each merging step, the most two similar attributes will be selected. MDL will be also used to consider when the algorithm would be terminated. This algorithm processes all pairs of attributes, so it may take a long time to find the best grouping and it seems to be too fit to the training data.

The objective of this paper is to improve the performance of the best-known parameter-free attribute clustering proposed in [1]. The attribute selection mechanism of [1] is to select the best pair of attributes to combine by the smallest description length. Our method improves the core selection briefly by finding the most robust candidate attribute, then merge this attribute to one of the best attributes from the rest. As the result, high-quality pairs of attributes have been selected by our method and the clustering can achieve higher performance w.r.t classification measurements such as precision and recall. Our method can also lower the new compression data size. The experiments show that our algorithm generates a smaller number of clusters, gives better compression ratio, and achieves higher accuracy compared to the best-known attribute clustering. Moreover, our method is faster than the best-known algorithm.

The roadmap of this paper is as follows. In Section II, we introduce the best-known attribute clustering algorithm. Then, we introduce our algorithm in Section III. In Section IV, we show the experimental results of our proposed algorithm compared to the best-known algorithm. The conclusion and the discussion are in the last section.

II. THE BEST-KNOWN ATTRIBUTE CLUSTERING

Several methods for attribute clustering have been proposed during the last decades. Although the minimum description length is intractable because of Kolmogorov Complexity [5], its idea has been widely used to remove parameters from the algorithm. The data description length of a given data can be defined as the length of code (i.e., numbers of bits) needed to describe the data.

In this section, we introduce the basic idea of attribute clustering, including its preliminary definitions. Attribute clustering methods [1][6][5] returns groups of attributes, which lead us to achieve more understanding of the data and can be used to summarize the data.

A. Basic Definitions

A dataset D is a set of transactions, $D=\{T_1, T_2, \dots, T_{|D|}\}$. $\mathcal{I}$ be a set of all categorical items in the database, $\mathcal{I} = \{I_1, I_2, \dots, I_n\}$. In a transactional-dataset, a transaction T is a set of items, $T \subseteq \mathcal{I}$. However, in relational-dataset, a transaction is a set of values of attributes. Hence, in this paper, "attribute" will be used interchangeably as "item". To do clustering, all items in $\mathcal{I}$ can be partitioned into smaller groups, called attribute clusters. The attribute cluster A is a set of items (i.e., attributes), $A = \{I_1, I_2, \dots, I_{|A|}\}$.

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Definition 1: An attribute clustering $\mathcal{C}$ is a group of attribute clusters, $\mathcal{C} = \{A_1, A_2, \ldots, A_{|\mathcal{C}|}\}$. All items in $\mathcal{J}$ must be included once and only in an attribute cluster. Then, $\mathcal{J} = \bigcup_i A_i$ and $\forall i \neq j: A_i \cap A_j = \emptyset$.

The minimum description length (MDL) is used as a measurement to select the best pair of clusters to merge. MDL of a cluster A is the minimum number of bits need to reproduce the cluster A, defined as $L(A)$, and MDL of the whole dataset D is the minimum number of bits need to reproduce all members in clusters and the clustering structure. However, MDL is intractable to calculate as it is hard as Kolmogorov complexity [1]. Then, description length has been used in our paper, instead of MDL.

Definition 2: Description length of an attribute cluster A is calculated as an entropy of the attribute cluster.

$$L(A) = -\sum_{I \in A} P(I) \log P(I)$$

where $P(I)$ is the probability that item I appear in the dataset. This entropy has been used to identify the good attribute clusters.

Definition 3: Description length of an attribute clustering $\mathcal{C}$ is the summation of the description length of all clusters in the clustering.

$$L(\mathcal{C}) = \sum_{A \in \mathcal{C}} L(A) + \varepsilon$$

where ε is the number of bits needed to represent elements (i.e., attribute clusters) in the clustering. As we defined in [1], $\varepsilon = \log n + n \log |\mathcal{C}| - \log |\mathcal{C}|!$ where n is the number of items (i.e., attributes) in the dataset.

Definition 4: Description length of the dataset is depended on the attribute clustering. Hence, the description length of the dataset, $L(D, \mathcal{C})$, is defined as:

$$L(D, \mathcal{C}) = L(D|\mathcal{C}) + L(\mathcal{C})$$

Definition 5: The description length of the dataset D encoding by attribute clustering $\mathcal{C}$, $L(D|\mathcal{C})$, is calculated by the summation of description length of all items in each transaction. Each item can be encoded as an index of the attribute cluster in the clustering, so it needs only $\log|\mathcal{C}|$ bits to represent. Moreover, the summation can be calculated from all attribute clusters, instead of the summation from all transactions. Hence, $L(D|\mathcal{C})$ can be formally defined as:

$$L(D|\mathcal{C}) = \sum_{T \in D} \sum_{A \exists I \wedge I \in T} \log|\mathcal{C}| = |D| * \sum_{A \in \mathcal{C}} freq(A) * log|\mathcal{C}|$$

where $freq(A)$ is the total frequency of any attribute (i.e., item) in an attribute cluster A appeared in the whole dataset.

B. MV Algorithm for Attribute Clustering

In this section, we describe the idea of Mampaey and Vreeken algorithm [1], called *MV algorithm* for short, as the best-known parameter-free attribute clustering algorithm. This agglomerative clustering algorithm starts by many clusters containing only one attribute. Then, the algorithm will grow each cluster to cover larger set of attributes. The MDL concept has been applied in [13] to select the best pair of clusters (i.e., groups of attributes) to merge. The key idea of the algorithm is to calculate description length of the clustering after merging any possible pair. Then, the pair of clusters with the smallest description length will be selected to be merged. This process will continue until the description length of the clustering after merging the best pair is worse than (i.e., higher than) the description length of the clustering without merging.

TABLE I MV ALGORITHM

Algorithm: MV Algorithm for attribute clustering

Input: Transactional dataset *D*, Set of All Attributes
Output: The best minimum attribute clustering $\mathcal{C}$

```
1.  C ← All Attributes
2.  while |C| > 1 do
3.  min_sim = ∞
4.      C_min = C
5.      for i = 1 to |C|
6.          for j = i+1 to |C|
7.              C_min ← C − {A_i, A_j} ∪ {A_i ∪ A_j}
8.              if L(D, C_min) < min_sim
9.                  min_sim = L(D, C_min)
10.                 C_min ← C_min
11.             end if
12          end for
13.     end for
14.     if L(D, C) ≤ min_sim
15.         break;
16.     end if
17.     C ← C_min
18. end while
19. return C
```

As shown in TABLE I, The MV algorithm is the summarizing data by using description length to select the best attribute clustering. Here we show the process. First, the attribute clustering $\mathcal{C}$ will be initialized by setting every single attribute as an attribute cluster (line 1). Then, two clusters will be merged to create a larger cluster until there is only one cluster left (line 2). In this process, all possible pairs of clusters will be temporarily merged (line 7) and the description length of the clustering which contains the new cluster will be calculated (line 8). After trying all possible pairs to merge, the best pair will be selected and merged before starting the next iteration (line 17). If the description length after merging cannot decrease any further, the algorithm will be terminated (line 14-15).

The running time to select the best pair of attribute clusters in each iteration is large as $O(n^2)$ time, where n is the number of attributes. Moreover, selecting the best pair is not only time-consuming but also seems to be too fit to the training data.

III. ENTROPY-BASED ATTRIBUTE CLUSTERING

In this section, we propose a new algorithm for attribute clustering algorithm. Our method can achieve higher performance in term of smaller execution time and higher accuracy compared to the best-known algorithm.

Our algorithm, named *Entropy-based Attribute Clustering*, will be brief as the following steps. First, we select the attribute cluster that has the finest entropy among all attribute clusters, called selected attribute cluster. Then we use this selected attribute cluster to pair with another attribute cluster to minimize the description length after merge.

TABLE II ENTROPY-BASED ATTRIBUTE CLUSTERING ALGORITHM.

Algorithm :Entropy-based Attribute Clustering

Input :A transactional dataset D, Set of All Attributes
Output :The best minimum attribute clustering $\mathcal{C}_{\min}$.

```
1.  C ← All Attributes
2.  max_entropy =−∞
3.  while |C| > 1 do
4.     for i=1 to |C|
5.        if L(A_i) > max_entropy
6.           max_entropy = L(A_i)
7.           A_s = A_i
8.        end if
9.     end for
10.    min_sim =∞
11.    C_min = C
12.    for j=1 to |C|
13.       C_min ← C − {A_s, A_j} ∪ {A_s ∪ A_j}
14.       if L(D, C') < min_sim
15.          min_sim = L(D, C')
16.          C_min ← C_min
17.       end if
18.    end for
19.    if L(D, C)) ≤ min_sim
20.       break;
21.    end if
22.    C ← C_min
23. end while
24. return C
```

Our algorithm is shown in TABLE II, First, as in [1], each attribute will be treated as an attribute cluster in the clustering $\mathcal{C}$ (line 1). Then, the most robust cluster among all clusters in $\mathcal{C}$ will be selected (line 4-9). In this step, the entropy of each attribute cluster will be calculated and the attribute with *maximum entropy* will be selected (line 5-6).

After the most robust cluster, A_s, has been selected, all other clusters will be temporally paired with the selected cluster (line 13) and the description length after merging these two attribute clusters will be calculated (line 14). The cluster that achieves the smallest description length after pairing to A_s will be selected and merged together in next iteration (line 16-15). The algorithm will be terminated when the whole clustering contains only one cluster (line 3) or when merging the best pair of clusters cannot decrease the description length any further (line 19-21).

The running time of our method to select the best pair reduces from O(n^2) comparisons in the previous algorithm to O(n) comparisons. Moreover, because the cluster selection has been modifiedour proposed algorithm seems to select the more robust attributes to merge.

IV. EXPERIMENTAL RESULTS

In this section we demonstrate the results on 10 real-world datasets in term of execution time and clustering quality. Two algorithms which are the best-known attribute clustering algorithm [1], called *MV algorithm*, and our proposed algorithm, called *Entropy-based Attribute Clustering*, have been compared.

A. Experimental Setup

The algorithms have been written in C++ on Ubuntu. The experiments are measured on 2.6 GHz Intel Core i5 with 8GB of memory. TABLE III shows the characteristics of all 10 datasets used in our experiments. The performance will be given in terms of compression rate and accuracy.

TABLE III CHARACTERISTICS OF DATASETS

Dataset	# Attributes	# Rows	# Class
adult	97	48842	2
anneal	71	989	5
auto	135	205	6
breast	17	699	2
connect4	129	67557	3
ecoli	34	336	8
flare	38	1389	8
mushroom	90	8124	2
pageBlocks	44	5473	5
pima	38	768	2

B. Quality in terms of Compression Rate

In TABLE IV, both algorithms, MV algorithm and our Entropy-based Attribute Clustering, have been compared in term of execution time. we represent execution time between MV algorithm and our Entropy-based algorithm. The execution time of our algorithm better on 8 datasets.

TABLE IV QUALITY IN TERMS OF COMPRESSION RATE

Dataset	MV algorithm		Our algorithm	
	$\lvert\mathcal{C}\rvert$	*Time (s)*	$\lvert\mathcal{C}\rvert$	*Time (s)*
adult	9	32.65	5	12.38
anneal	12	0.20	6	0.08
auto	22	0.20	19	0.12
breast	3	0.01	2	0.01
connect4	7	84.32	7	44.76
ecoli	6	0.02	3	0.02
flare	6	0.07	5	0.04
mushroom	5	5.16	3	1.94
pageBlocks	7	0.27	6	0.18
pima	8	0.03	7	0.02

From TABLE IV, our proposed algorithm can achieve smaller clusters on 9 out of 10 datasets, the better compression algorithm. The experiments demonstrate that the proposed attribute process can select better pairs of attributes to merge. Moreover, because in each selection process, the number of comparison reduce from $O(n^2)$ to $O(n)$, our proposed methods can run twice faster than MV algorithm.

C. Quality in terms of accuracy

In this section, we compare the performance between our Entropy-based Attributing Clustering algorithm and MV algorithm in term of *precision* and *recall*. Different from traditional data clustering, attribute clustering focus on grouping attributes instead of grouping transactions. Hence, decision tree classification has been used to test the model accuracy .The results show that our algorithm obtains higher accuracy on 4 datasets, comparable accuracy for 6 datasets, and with no loss. Our algorithm has been resolving the process of selection for grouping the attribute clusters. This result of accuracy show that our algorithm can achieve the better results of attribute clustering as shown in TABLE V.

TABLE V QUALITY IN TERMS OF ACCURACY

Dataset	MV algorithm		Our algorithm	
	Precision	*Recall*	*Precision*	*Recall*
adult	0.58	0.76	0.58	0.76
anneal	0.69	0.79	**0.86**	**0.90**
auto	0.49	0.50	**0.54**	**0.55**
breast	0.43	0.66	0.43	0.66
connect4	0.43	0.66	0.43	0.66
ecoli	0.18	0.43	0.18	0.43
flare	0.71	0.84	0.71	0.84
mushroom	0.82	0.73	**0.94**	**0.93**
pageBlocks	0.81	0.90	0.81	0.90
pima	0.42	0.65	**0.75**	**0.74**
		Win	4 datasets	
		Equal	6 datasets	
		Lose	0 datasets	

V. CONCLUSIONS

In this paper, a new parameter-free algorithm for attribute clustering has been proposed. Similar to the best-known attribute clustering algorithm proposed in [1], our clustering algorithm is an agglomerative clustering, and the MDL concept has been applied to make the algorithm parameter-free. In contrast, our proposed algorithm has improved the process of selecting the best pairs of attribute clusters to merge. This improvement not only reduces the running time but also increases the quality of the clustering.

Our intensive experiments on 10 real-world datasets demonstrate that our proposed algorithm is better than the best-known algorithm in term of accuracy, evaluated by precision and recall. Our proposed algorithm is about twice faster than the best-known algorithm. Higher compression ratio shows that our algorithm will return smaller number of clusters while obtaining the higher accuracy, compared to the best-known algorithm.

REFERENCES

[1] Michael Mampaey and Jilles Vreeken. Summarising Data by Clustering Items. In *Proc. of* ECML PKDD'10 , pp. 130–173, 2010.

[2] Wang J, Karypis G SUMMARY: efficiently summarizing transactions for clustering. In: Proc. of the IEEE international conference on data mining (ICDM'04), IEEE, pp 241–248.

[3] Siebes, J. Vreeken, and M. van Leeuwen. Item sets that compress. In Proc. of SDM·06, pages 393-404, 2006.

[4] JB. Bringmann and A. Zimmermann. The chosen few: On identifying valuable patterns. In *Proc. of* ICDM·07, pp. 63-72, 2007.

[5] N. Kolmogorov, "Three approaches to the quantitative definition of information", *Problemy Peredachi Informats*, vol. 1, no. 1, pp. 3-11, 1965.

[6] Chandola and V. Kumar. Summarization – compressing data into an informative representation. In Proc. of ICDM·05, pp. 98–105, 2005.

[7] Wang C, Parthasarathy S Summarizing itemset patterns using probabilistic models. In: Proc. of the ACM SIGKDD international conference on knowledge discovery and data mining (KDD'06). ACM, New York, pp 730–735.

[8] X. Yan, H. Cheng, J. Han, and D. Xin. Summarizing itemset patterns: A profile-based approach. In Proc. of KDD·05, pp 314–323, 2005.

[9] T. Calders and B. Goethals. Mining all non-derivable frequent itemsets. In Proc. of ECML PKDD·02, pp. 74–85, 2002.

[10] T. M. Cover and J. A. Thomas. Elements of Information Theory, 2nd ed. John Wiley and Sons, 2006.

[11] G. C. Garriga, E. Junttila, and H. Mannila. Banded structure in binary matrices. In Proc. of KDD·08, pages 292–300, 2008.

[12] Gionis, H. Mannila, T. Mielika¨inen, and P. Tsaparas. Assessing data mining results via swap randomization. TKDD, 1(3), 2007.

[13] P. D. Gru¨nwald. The Minimum Description Length Principle. MIT Press, 2007.

[14] J. Han, H. Cheng, D. Xin, and X. Yan. Frequent pattern mining: Current status and future directions. Data Mining and Knowledge Discovery, 15(1), 55–86, 2007.

[15] H. Heikinheimo, E. Hinkkanen, H. Mannila, T. Mielika¨inen, and J. K. Seppa¨nen. Finding low-entropy sets and trees from binary data. In Proc. of KDD·07, pp 350–359, 2007.

[16] H. Heikinheimo, J. Vreeken, A. Siebes, and H. Mannila. Low-entropy set selection. In Proc. of SDM·09, pp 569–579, 2009.

[17] J. Knobbe and E. K. Y. Ho. Maximally informative k-itemsets and their e cient discovery. In Proc. of KDD·06, pp 237–244, 2006.

[18] J. MacQueen. Some methods for classification and analysis of multivariate ob- servations. In Proc. of the 5th Symposium on Mathematical Statistics and Probability, 1967.

[19] J. Wang and G. Karypis. SUMMARY: E ciently summarizing transactions for clustering. In Proc. of ICDM·04, pp 241–248, 20

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Outliers Detection in Time Series Data

Case study: Provincial Waterworks Authority

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***Abstract*— One main cause of inaccurate forecasts is that data may contain noises and outliers. In the case of the Provincial Waterworks Authority (PWA), the inaccuracy of analyzing and forecasting the number of water users is due to outliers contained in data sources. Some branches of PWA collected errors such as the very high or very low number of water users. This has a direct impact on the quality and reliability of the predictive accuracy output. The removal of the "outliers" is thus critical for accurate interpretation of the data. The purpose of this paper is to detect outliers in water consumption time series data. We examined two techniques: (1) a method based on autoregressive integrated moving average (ARIMA) time series modeling and (2) median absolute deviation (MAD). A clustering technique (K-Mean) is used as a pre-processing step in order to identify appropriate parameters for the two outliers detection techniques. The results showed that, with the precise parameter values obtained from K-Mean, both ARIMA and MAD performed very well on water consumption time series data. The two techniques are able to generate high sensitivity and specificity outputs.**

Keywords— Outliers Detection, Time Series Data, Clustering

I. INTRODUCTION

Nowadays, forecasting is recognized to be very useful with today's unpredictable business environment. Especially for the executives, they can use the forecasting result to plan appropriate strategy to the organization. One main cause of inaccurate forecasts is that data may contain noises and outliers. Outliers are data having lower or higher value than normal. Outliers may affect the distribution of data or cause the average data to change. They have a direct impact on business forecasting and affect the quality and reliability of predictive values. The removal of the outliers is important before the data is forecasted.

The objective of the Provincial Waterworks Authority (PWA) is to forecast the number of water users increased monthly. The inaccuracy of forecasting the number of water users is due to outliers contained in data sources. Some branches of PWA collected errors such as very high or very low number of water users. From the 234 branches, and for each month, invalid and very high number of water users are noticed for a large number of branches. In order to remove outliers, traditional detecting methods are used. Data are collected from the employees through the PWA 's operation information system on a monthly basis. Then, for the 234 branches in Excel format, the investigators detect outliers by comparing current data with the past three years using naked eye. With only one investigator and without statistical methods to help check, this is very time consuming. Mistakes and errors frequently happen, and result in very inaccurate forecasting results.

Many techniques have proposed for detecting outliers in time series data. Among the proposed techniques, the most popular are Autoregressive Integrated Moving Average (ARIMA) [2][6] and the Median Absolute Deviation (MAD) [4]. The two techniques are designed for forecasting time series data and are able to detect outliers in time series data with very high precision in terms of sensitivity and specificity. In [3], the authors compared the two methods in detecting outliers in time series data. They noticed that, the best outlier detection accuracy can be obtained, by setting appropriate parameters such as critical value (ARIMA) and acceptable tolerance (MAD). The same parameters values cannot be used for PWA case. With its 234 branches, different parameters should be appropriate determined for each branch and method.

The objective of this paper is to apply ARIMA and MAD for detecting outliers in WTA water consumption time series data. In order to determine appropriate parameters values for the two methods, a clustering mechanism based on K-mean is proposed. We are using similar frequencies and widths data outliers of the PWA branches. Divided into 3 groups are high frequency, medium frequency and low frequency. To determined appropriate parameters for the both methods in each PWA branches. Experimental results show that a clustering parameter is sensitivity lower than a non-clustering parameter, but a clustering parameter is more specificity than a non-clustering parameter. It is concluded that a clustering parameter are complete outliers detected and accuracy is very high.

II. OUTLIERS AND OUTLIERS DETECTION IN TIME SERIES DATA

In this section, outliers are defined, and different types of outliers are described. Then, two main outliers detection outliers techniques in time series data are explained which are ARIMA and MAD [2][3][4].

A. Outliers in time series

Outlier is a major impact on forecasting data if we use forecasting methods such as ARIMA, ARMA, and others [6]. Outlier in time series data is an observation, which so much deviates from the other observations. Some data may be lower or higher value than normal. In [9], six types of outliers are defined.

- Additive Outlier (AO)
- Innovation Outlier (IO)
- Level Shift (LS)
- Temporary change (TC)
- Seasonal Additive Outlier (SA)

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- Local Trend Outlier (LT)

In this paper, we focus only on outliers of type additive outlier (AO) and innovation outlier (IO).

B. *Detecting Outliers in Time Series data using ARIMA methods*

Autoregressive Integrated Moving Average (ARIMA) A popular model for time series prediction. The ARIMA model was introduced by Box and Jenkins (1976). It was requires three parameters in the model as ARIMA(p, d, q) [10], where

p is the order of the autoregressive part
d is the order of the differencing
q is the order of the moving-average process

If no differencing is done (d = 0), the models are usually referred to as ARMA(p,q) models[9]. The underlying process that generate the time series has the form [10]:

$$y_t = \theta_0 + \emptyset_1 y_1 + \emptyset_2 y_{t-2} + \cdots + \emptyset_p y_{t-p} + \varepsilon_t - \theta_1 \varepsilon_t - \theta_2 \varepsilon_{t-2} - \cdots - \theta_q \varepsilon_{t-q,} \quad (1)$$

Where y_t and ε_t are the original value and random error at time period t ,respectively; $\emptyset_i (i = 1,2 \ldots, p)$ and $\theta_j (j = 0,1,2, \ldots, q)$ are model parameter. p and q are integers and often referred to as orders of the model. Randiom error, ε_t, are assumed to be independently and identically distributed with a mean of zero and a constant variance of σ^2[10].

The Automatic ARIMA. Analyze time, especially forecasts in large data analysis. This is a popular auto forecast. The algorithm was developed based on the ARIMA model proposed by Hyndman & Khandakar [5]. The R language is used in the detection with the tsoutliers package [3].

C. *Outlier Detection in Time Series data using MAD Methods*

Median Absolute Deviation (MAD) is one of the most common methods used to find anomalies on single-variable time series data. Median is used because median is not sensitive to outliers compared to mean [3][4][7]. The MAD formula is defined as follows:

$$MAD = b\, M_i(|x_i - M_i(x_j)|)$$

M = median of dataset
x = data
b = constant (1.4826)
xj = the j original observation

In order to use and evaluate the MAD formula, the acceptable values for the parameters are needed. The most popular parameter values are 3, 2.5 and 2, respectively. In [4], the equation using MAD is given as follows:

$$M - 2.5*MAD \leqslant xj \leqslant M + 2.5*MAD$$

where the xj is the observation number j. After, then create the upper and lower lines to detect outliers.

III. OUR METHODOLOGY

In this section, our methodology for detecting outliers in time series data is explained. It is composed of three steps: data-preparation step, data-clustering step and outliers-detection steps. In the data-preparation step, the original water usage accumulative data is transformed to monthly data. In the data-clustering step, K-mean clustering algorithm is combined with MAD to determine appropriate parameter values for the next step. Finally, in the outliers-detection step, the two techniques (1) autoregressive integrated moving average (ARIMA) time series modeling and (2) median absolute deviation (MAD) are applied to detect outliers. The overview of our methodology is given in Fig. 1.

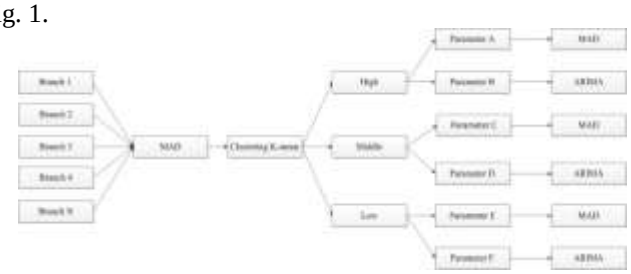

Fig. 1. Overview of our methodology based on combing K-mean & MAD.

A. *Data pre-paration step*

The objective of the Provincial Waterworks Authority (PWA) is to forecast the number of water users increased monthly. Data are collected from 234 branches. The input data is number of users increased monthly of the past 5 years. Thus, the total number of rows is 14040 (12 x 5 x 234). In this paper, as a preliminary study, only 39 PWA branches will be used to detect outliers. Thus, the total number of rows is 2340 (12 x 5 x 39).

The data in each branch is in the form of cumulative, difficult to detect. It is necessary to convert from the accumulated data into monthly-based data. Fig. 2 shows the original water usage accumulative data. Fig. 3 shows the transformed water usage monthly data.

Fig. 2. Original accumulated data.

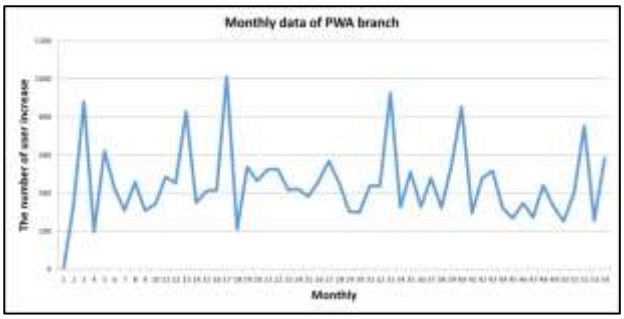

Fig. 3. Monthly converted to data.

B. Data clustering step

The best outlier detection accuracy can be obtained, by setting appropriate parameters such as critical value (ARIMA) and acceptable tolerance (MAD).

From the preliminary results, we notice that the parameters used in both ARIMA and MAD methods affect the sensitivity and specificity of the outliers. In our case study, the water usage level is very different for each PWA branch. The parameters that are appropriate for the respective PWA should be specified. Thus, our idea is to group those PWA branches based on their level of water usage in terms of "outlier frequency" and "outlier range".

Thus, the PWA branches are grouped based on their frequency and range of outliers. As a preliminary study, 3 groups of similar frequency and range are selected: high frequency, medium frequency and low frequency. The grouping details are shown as follows.

- Use the MAD method to generate outlier frequencies from the formula.

$$M - 2.5*MAD \leqslant xj \leqslant M + 2.5*MAD \quad (1)$$

- Then create upper and lower lines. (2.5 is Acceptable tolerances [4])
- Create middle and high lines from upper and lower lines in Fig. 4. (Calculated from upper and lower lines, plus 66% and 99%, respectively.)

Fig. 4. Preview using of MAD in the PWA Chiang Mai branch.

- The result is high frequency, medium and low frequencies to segment in R studio program. Using K-means method for define 5 groups in Fig. 5 (so that each group is clearly separated). The results of grouping can be grouped 83.9%, but only 3 groups are needed. Based on graph and cluster mean, groups 2, 4 and 5 can be grouped into low frequencies. Group 3 is intermediate and group 1 is high frequency group.

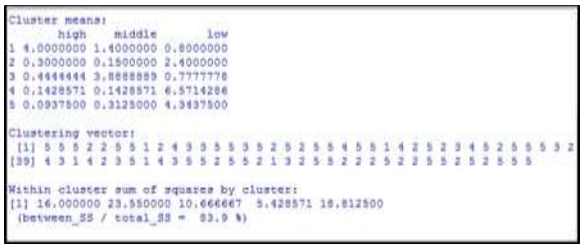

Fig. 5. Clustering K-mean.

- When the group has 3 groups needed. Each parameter is defined as follows in table I.

TABLE I. SETTING PARAMETER FOR IMPREMENT ALGORUTHMS.

Group frequency	**MAD** tolerances value (to)	**ARIMA** critical value (C)
low	2	2.5
middle	2.5	3
high	3	3.5

C. Outlier detection using MAD method

From the previous step, appropriate values for MAD can be applied.

$$M - 2.5*MAD \leqslant xj \leqslant M + 2.5*MAD$$

In the following, the acceptable tolerance parameter is set to 2 the formula, in the case of PWA Chiang Mai branch.

$$M - 2*MAD \leqslant xj \leqslant M + 2*MAD$$

In Fig. 6, the acceptable tolerance parameter value is set to 2.5.

Fig. 6. Outlier results using MAD with acceptable tolerances 2.5

In Fig. 7, the acceptable tolerance parameter value is set to 2.

Fig. 7. Outlier results using MAD with acceptable tolerances 2

Based on Fig. 6 and Fig. 7, we notice that, when using the acceptable tolerance parameters values 2, outlier points are correctly detected. Thus, the detection accuracy is very high.

D. Outlier detection using ARIMA method

Using the ARIMA method, it is necessary to check whether the information is white noise and whether it is stationary or not. Based on the experimental data has been converted the non-stationary accumulate data to stationary [1].For define the most accurate modeling in ARIMA method with Packet tsoutliers of the R language to find out data outliers.

Parameters for ARIMA (p, d, q) are defined as "auto.arima" and the parameters of the tolerance values (Critical value) are grouped according to the data of each branch apply in the function. Coding are:

```
Data <- ts(Dataset[,3], start=c(0,1))
o <- tso(Data,cval = 3,types = c("AO","IO"),tsmethod =
      c("auto.arima"),args.tsmethod=NULL)
plot(o)
```

where tso is function in the R language, cval is critical valuem, types are type of outliers and tsmethod using “auto.arima”

Example PWA Chiang Mai branch is in group low frequency. Take 2.5 acceptable values into the function.

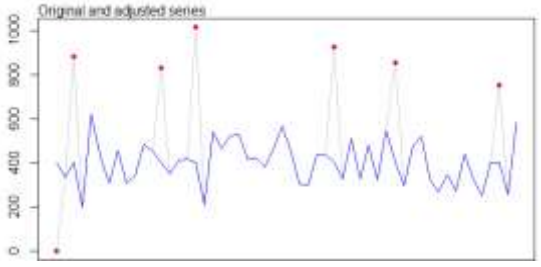

Fig. 8. Show outlier results with ARIMA method with acceptable tolerances 2.5

If the tolerance is set to 3, it is not the value obtained from the segmentation. The result is that values cannot properly detect outlier for this data

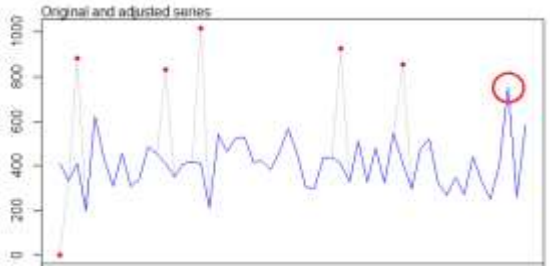

Fig. 9. Show outlier results with ARIMA method with acceptable tolerances 3.

IV. RESULTS AND DISCUSSION

In the experiments, the clustering parameters is set to 3 based on frequency and range of the groups. To set the parameters for acceptable tolerance, 2, 2.5, 3 and 2.5, 3, 3.5 are respectively set of MAD and ARIMA. In Fig. 6 we used non-clustering (TO) parameter is values 2.5 [4], but in Fig. 7 we used from clustering (TO) parameter is values 2 to detection outliers of the PWA Chiangmai branch dataset for MAD method. Observe that when using the (TO) parameters values 2, outlier points are correctly detected. Thus, the detection accuracy is very high. And in Fig.8 we used non-clustering (C) parameter is 3 and in Fig. 9 we used clustering (C) parameter is 2.5 for ARIMA method by the same dataset. The results show that Fig. 8 can detect outlier points are correctly and accuracy than Fig. 9.

In Table II, the outlier detection results shows that, with MAD method, the clustering parameters are less sensitive than a non-clustering parameter at 83% and 89% respectively, but specificity are higher at 90% and 88%. With ARIMA method, the clustering parameters are sensitivity lower than the non-clustering parameter at 79% and 95% respectively, but specificity are higher at 82% and 75%.

TABLE II. THE RESULT OF OUTLIER DETECTION

Methods	***Sensitivity***	***Specificity***
Clustering with MAD	83%	90%
Clustering with ARIMA	79%	82%
Non-Clustering with MAD	89%	88%
Non-Clustering with ARIMA	95%	75%

V. CONCLUSION AND FUTURE WORK

Experimental results show that the appropriate parameters setting has very high effect to the outlier detection results of the two methods MAD and ARIMA. In this paper, we proposed a k-mean clustering-based technique for determining appropriate parameter values. The experimental results show that, with appropriate parameter values, the outlier detection result is complete with very high accuracy. The proposed approach is suitable for organizations with large number of branches for which there is high difference in data distribution.

REFERENCES

[1] Jindamas Sutthichaimethee, "Application of ARIMA Model for Research" , Ministry of Science and Technology (2011).

[2] Hermine N. Akouemo and Richard J. Povinelli. "Time series outlier detection and imputation", epartment of Electrical and Computer Engineering, Marquette University (2014).

[3] Saeed Mehrang, Elina Helander, Misha Pavelt, Angela Chieh and Ilkka Korhonen. "Outlier Detection in Weight Time Series data of Connected Scales". College of Computer and Information Science and Bouve College of Health Sciences, Northeastern University (2015).

[4] Brilian Surya Budi. "Outlier Detection Framework for Extreme Fluctuation Time Series Data", Badan Pusat Statitik, Sorong, Indonesia (2017).

[5] Suhartono, Salafiyah Isnawati, Novi Ajeng Salehah, Dedy Dwi Prastyo, Heri Kuswanto, Muhammad Hisyam Lee. "Hybrid SSA-TSR-ARIMA for Water Demand". A Department of Statistics, Institut Teknologi Sepuluh Nopember Kampus ITS Sukolilo, Surabaya, 60111, Indonesia (2018).

[6] Ansari Saleh Ahmar , Suryo Guritno , Abdurakhman , Abdul Rahman , Awi , Alimuddin , Ilham Minggi , M Arif Tiro , M Kasim Aidid , Suwardi Annas , Dian Utami Sutiksno , Dewi S Ahmar , Kurniawan H Ahmar , A Abqary Ahmar , Ahmad Zaki , Dahlan Abdullah , Robbi Rahim , Heri Nurdiyanto , Rahmat Hidayat , Darmawan Napitupulu9 , Janner Simarmata, Nuning Kurniasih , Leon Andretti Abdillah , Andri Pranolo , Haviluddin , Wahyudin Albra, A Nurani M Arifin. "Modeling Data Containing Outliers using ARIMA Additive Outlier (ARIMA-AO)", IOP Conf. Series: Journal of Physics: Conf. Series 954 (2018) 012010.

[7] Christophe Leys , Christophe Ley , Olivier Klein , Philippe Bernard , Laurent Licata. "Detecting outliers: Do not use standard deviation around the mean, use absolute deviation around the median", Université Libre de Bruxelles, Unité de Psychologie Sociale, Belgium Université Libre de Bruxelles, Département de Mathématique and ECARES, Belgium (2013).

[8] Rogue Wave Software. "Advanced Time Series Analysis", Rogue Wave Software 5500 Flatiron Parkway, Suite 200 Boulder, CO 80301, USA (2014).

[9] Manoj, K. "Outlier detection in datamining", Manonmaniam Sundaranar University (2015).

[10] G. Peter Zhang." Time series forecasting using a hybrid ARIMA and neural network model", Neurocomputing 50 (2003) 159 – 175.

EBITDA Time Series Forecasting

Case study: Provincial Waterworks Authority

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***Abstract*— EBITDA is a measure of a company's financial performance. It can determine the direction of business decisions for the organization, can be used to analyze and compare profitability among companies. By its linear and non-linear combination, appropriate forecasting technique must be determined. The aim of this paper is to propose a methodology for forecasting EBITDA. We propose a three-steps methodology which is composed of data preparation, forecasting model comparison and evaluation steps. The results from using 10 years monthly data of the Provincial Waterworks Authority (PWA) reveal that the best model is ARIMA-ANN hybrid model. Thus, this model can be used to forecast the other time series data such as Selling Expenses, Operating Expense, General and Administrative Expenses in the future.**

Keywords— Time Series Forecasting, Linear approach, Non-linear approach, ARIMA, ANN, ARIMA-ANN hybrid forecasting

I. INTRODUCTION

Earnings before interest, tax, depreciation and amortization (EBITDA) is a measure of a company's operating performance. Essentially, it's a way to evaluate a company's performance without having to factor in financing decisions, accounting decisions or tax environments [7]. Thus, forecasting EBIDATA is very essential for evaluating company's operating performance, and compares its profitability with other companies.

The aim of the Provincial Waterworks Authority (PWA) is to forecast yearly EBITDA. Based on yearly EBIDA, and the moving average (MA) linear approach, the obtained forecasting result is very inaccurate. This can be explained by the distribution of the input data which combine both linear and non-linear. Thus, appropriate technique for forecasting EBITDA must be determined.

The aim of this paper is to propose a methodology for forecasting EBITDA. We propose a three-steps methodology which is composed of data preparation, forecasting model comparison and evaluation steps. The results from using 10 years monthly data of the Provincial Waterworks Authority (PWA) reveal that the best model is ARIMA-ANN hybrid model. Thus, this model can be used to forecast the other time series data such as Selling Expenses, Operating Expense, General and Administrative Expenses in the future.

II. EARNING BEFORE INTEREST, TAX, DEPRECIATION, AMORTIZATION (EBITDA)

Earnings before interest, tax, depreciation and amortization (EBITDA) is an accounting measure calculated using a company's net earnings, before interest expenses, taxes, depreciation, and amortization are subtracted, as a proxy for a company's current operating profitability [1].

Although EBITDA is not a financial measure recognized in generally accepted accounting principles, it is widely used in many areas of finance when assessing the performance of a company, such as securities analysis. It is intended to allow a comparison of profitability between different companies, by discounting the effects of interest payments from different forms of financing (by ignoring interest payments), political jurisdictions (by ignoring tax), collections of assets (by ignoring depreciation of assets), and different takeover histories (by ignoring amortization often stemming from goodwill). EBITDA is a financial measurement of cash flow from operations that is widely used in mergers and acquisitions of small businesses and businesses in the middle market. It is not unusual for adjustments to be made to EBITDA to normalize the measurement allowing buyers to compare the performance of one business to another [2].

In Provincial Waterworks Authority (PWA), EBITDA is recorded for 10 years, monthly. PWA's EBITDA is composed of a variety of information, such as revenue from water sales, operating expenses. It has a unique style. Thus, in this paper, the monthly EBITDA data is used. Fig. 1 gives example.

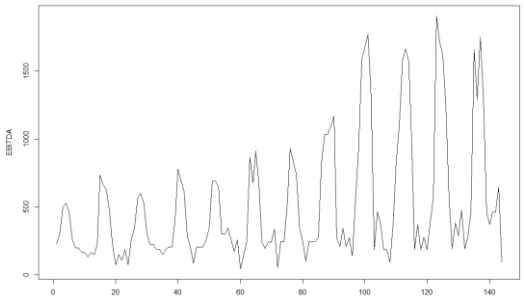

Fig. 1. Example of monthly EBITDA data.

III. OUR METHODLOGY

In this section, our methodology for forecasting EBITDA is explained. It is composed of three steps: data-preparation step, data-forecasting step and evaluation steps. In the data-preparation step, yearly EBIDA data is transformed to monthly EBIDA data. In the data-forecasting step, the three techniques (1) autoregressive integrated moving average model (ARIMA) time series modeling and (2) artificial neural network model (ANN) (3) ARIMA-ANN hybrid model are implemented. Finally, in the evaluation step, the three techniques are compared based on RMSE and MAE. The overview of our methodology is given in Fig. 2.

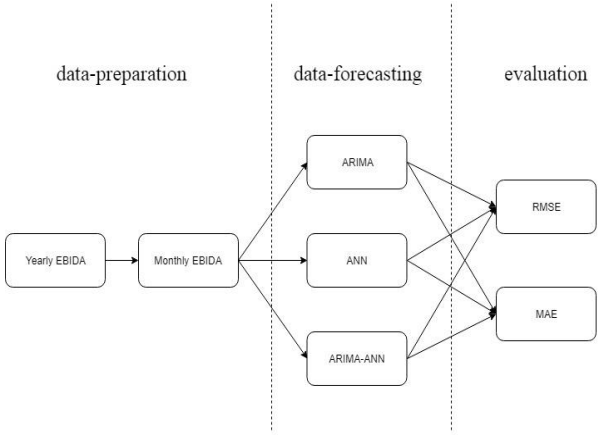

Fig. 2. Forecasting EBITDA using ARIMA, ANN and ARIMA-ANN

IV. HYBRID ARIMA AND ANN IN TIME SERIES DATA

There are many popular techniques for time series forecasting. In this paper, we focused on ARIMA Model, ANN Model and ARIMA-ANN hybrid Model.

A. AutoRegressive Integrated Moving Average model (ARIMA)

In an ARIMA Model, the future value of a variable is assumed to be a linear function of several past observations and random errors [3]. The form is

$$y_t = \theta_0 + \emptyset_1 y_{t-1} + \emptyset_2 y_{t-2} + \dots + \emptyset_p y_{t-p} + \varepsilon_t - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \cdots - \theta_q \varepsilon_{t-q}, \quad (1)$$

Where y_t and ε_t are the actual value and random error at time period t, respectively; $\emptyset_i$ (i = 1, 2, …, p) and θ_j (j = 0, 1, …, q) are model parameters. p and q are integers and often referred to as orders of the model. Random errors,ε_t are assumed to be independently and identically distributed with a mean of zero and a constant variance of σ^2.

Eq. (1) entails several important special cases of the ARIMA family of models. If q = 0, then (1) becomes an AR model of order p. When p = 0, the model reduces to an MA model of order q. One central task of the ARIMA model building is to determine the appropriate model order (p, q). Based on the earlier work of Yule [9] and Wold [8], Box and Jenkins [3] developed a practical approach to building ARIMA models, which has the fundamental impact on the time series analysis and forecasting applications. The Box–Jenkins methodology includes three iterative steps of model identification, parameter estimation and diagnostic checking. The basic idea of model identification is that if a time series is generated from an ARIMA process, it should have some theoretical autocorrelation patterns with the theoretical ones, it is often possible to identify one or several potential models for the given time series. Box and Jenkins [3] proposed to use the autocorrelation function and the partial autocorrelation function of the sample data as the basic tools to identify the order of the ARIMA model.

In the identification step, data transformation is often needed to make the time series stationary. Stationarity is a necessary condition in building an ARIMA model that is useful for forecasting. A stationary time series has the property that its statistical characteristics such as the mean and the autocorrelation structure are constant over time. When the observed time series presents trend and heteroscedasticity, differencing and power transformation are often applied to the data to remove the trend and stabilize the variance before an ARIMA model can be fitted.

Once a tentative model is specified, estimation of the model parameters is straightforward. The parameters are estimated such that an overall measure of errors is minimized. This can be done with a nonlinear optimization procedure.

The last step of model building is the diagnostic checking of model adequacy. This is basically to check if the model assumptions about the errors, ε_t , are satisfied. Several diagnostic statistics and plots of the residuals can be used to examine the goodness of fit of the tentatively entertained model to the historical data. If the model is not adequate, a new tentative model should be identified, which is again followed by the steps of parameter estimation and model verification. Diagnostic information may help suggest alternative model(s).

This three-step model building process is typically repeated several times until a satisfactory model is finally selected. The final selected model can then be used for prediction purposes.

B. Artificial Neural Network model (ANN)

When the linear restriction of the model form is relaxed, the possible number of nonlinear structures that can be used to describe and forecasting a time series is enormous. A good nonlinear model should be "general enough to capture some of the nonlinear phenomena in the data" [10]. Artificial neural networks are one of such models that are able to approximate various nonlinearities in the data.

ANNs are flexible computing frameworks for modeling a broad range of nonlinear problems. One significant advantage of the ANN models over other classes of nonlinear model is that ANNs are universal approximators which can approximate a large class of functions with a high degree of accuracy. Their power comes from the parallel processing of the information from the data. No prior assumption of the model form is required in the model building process. Instead, the network model is largely determined by the characteristics of the data [4].

Single hidden layer feed-forward network is the most widely used model form for time series modeling and

forecasting [43]. The model is characterized by a network of three layers of simple processing units connected by acyclic links. The relationship between the output (y_t) and the inputs ($y_{t-1}, y_{t-2}, \ldots, y_{t-p}$) has the following mathematical representation:

$$y_t = \alpha_0 + \sum_{j=1}^{q} \alpha_j g\left(\beta_{0j} + \sum_{i=1}^{p} \beta_{ij}\, y_{t-i}\right) + \varepsilon_t\,, \qquad (2)$$

where α_j (j = 0, 1, …, q) and β_{ij} (i = 0, 1, …, p; j = 0, 1, …, q) are the model parameters often called the connection weights; p is the number of input nodes and q is the number of hidden nodes. The logistic function is often used as the hidden layer transfer function, that is,

$$g(x) = \frac{1}{1+\exp(-x)} \qquad (3)$$

Hence, the ANN model of (2) in fact performs a nonlinear functional mapping from the past observations ($y_{t-1}, y_{t-2}, \ldots, y_{t-p}$) to the future value y_t, i.e.,

$$y_t = f\left(y_{t-1}, y_{t-2}, \ldots, y_{t-p}, w\right) + \varepsilon_t\,, \qquad (4)$$

where w is a vector of all parameters and f is a function determined by the network structure and connection weights. Thus, the neural network is equivalent to a nonlinear autoregressive model. Note that expression (2) implies one output node in the output layer which is typically used for one-step-ahead forecasting.

The simple network given by (2) is surprisingly powerful in that it is able to approximate arbitrary function as the number of hidden nodes q is sufficiently large [14]. In practice, simple network structure that has a small number of hidden nodes often works well in out-of-sample forecasting. This may be due to the overfitting effect typically found in neural network modeling process. An overfitted model has a good fit to the sample used for model building but has poor generalization ability for data out of the sample. The choice of q is data dependent and there is no systematic rule in deciding this parameter.

In addition to choosing an appropriate number of hidden nodes, another important task of ANN modeling of a time series is the selection of the number of lagged observations, p, the dimension of the input vector. This is perhaps the most important parameter to be estimated in an ANN model because it plays a major role in determining the (nonlinear) autocorrelation structure of the time series. However, there is no theory that can be used to guide the selection of p. Hence, experiments are often conducted to select an appropriate p as well as q.

Once a network structure (p; q) is specified, the network is ready for training—a process of parameter estimation. As in ARIMA model building, the parameters are estimated such that an overall accuracy criterion such as the mean squared error is minimized. This is again done with some efficient nonlinear optimization algorithms other than the basic backpropagation training algorithm. One of these is generalized reduced gradient (GRG2), a general purpose nonlinear optimizer [11]. A GRG2-based training system is used in this study [12].

The estimated model is usually evaluated using a separate hold-out sample that is not exposed to the training process. This practice is different from that in ARIMA model building where one sample is typically used for model identification, estimation and evaluation. The reason lies in the fact that the general (linear) form of the ARIMA model is pre-specified and then the order of the model is estimated from the data. The standard statistical paradigm assumes that under stationary condition, the model best fitted to the historical data is also the optimum model for forecasting [13]. With ANNs, the (nonlinear) model form as well as the order of the model must be estimated from the data. It is, therefore, more likely for an ANN model to overfit the data.

There are some similarities between ARIMA and ANN models. Both of them include a rich class of different models with different model orders. Data transformation is often necessary to get best results. A relatively large sample is required in order to build a successful model. The iterative experimental nature is common to their modeling processes and the subjective judgment is sometimes needed in implementing the model. Because of the potential overfitting effect with both models, parsimony is often a guiding principle in choosing an appropriate model for forecasting.

C. ARIMA – ANN Hybrid Model

Both ARIMA and ANN models have achieved successes in their own linear or nonlinear domains. However, none of them is a universal model that is suitable for all circumstances. The approximation of ARIMA models to complex nonlinear problems may not be adequate. On the other hand, using ANNs to model linear problems have yielded mixed results. For example, using simulated data, Denton [15] showed that when there are outliers or multicollinearity in the data, neural networks can significantly outperform linear regression models. Markham and Rakes [18] also found that the performance of ANNs for linear regression problems depends on the sample size and noise level. Hence, it is not wise to apply ANNs blindly to any type of data. Since it is difficult to completely know the characteristics of the data in a real problem, hybrid methodology that has both linear and nonlinear modeling capabilities can be a good strategy for practical use. By combining different models, di5erent aspects of the underlying patterns may be captured.

It may be reasonable to consider a time series to be composed of a linear autocorrelation structure and a nonlinear component. That is,

$$y_t = L_t + N_t\,, \qquad (5)$$

where L_t denotes the linear component and N_t denotes the nonlinear component. These two components have to be estimated from the data. First, we let ARIMA to model the linear component, then the residuals from the linear model will contain only the nonlinear relationship. Let e_t denote the residual at time t from the linear model, then

$$e_t = y_t - \hat{L}_t \,, \tag{6}$$

Where $\hat{L}_t$ is the forecast value for time *t* from the estimated relationship (2). Residuals are important in diagnosis of the sufficiency of linear models. A linear model is not sufficient if there are still linear correlation structures left in the residuals. However, residual analysis is not able to detect any nonlinear patterns in the data. In fact, there is currently no general diagnostic statistics for nonlinear autocorrelation relationships. Therefore, even if a model has passed diagnostic checking, the model may still not be adequate in that nonlinear relationships have not been appropriately modeled. Any significant nonlinear pattern in the residuals will indicate the limitation of the ARIMA. By modeling residuals using ANNs, nonlinear relationships can be discovered. With *n* input nodes, the ANN model for the residuals will be

$$e_t = f(e_{t-1}, e_{t-2}, \dots, e_{t-n}) + \varepsilon_t \,, \tag{7}$$

where f is a nonlinear function determined by the neural network and ε_t is the random error. Note that if the model f is not an appropriate one, the error term is not necessarily random. Therefore, the correct model identification is critical. Denote the forecast from (7) as $\widehat{N}_t$, the combined forecast will be

$$\hat{y}_t = \hat{L}_t + \widehat{N}_t, \tag{8}$$

In summary, the proposed methodology of the hybrid system consists of two steps. In the first step, an ARIMA model is used to analyze the linear part of the problem. In the second step, a neural network model is developed to model the residuals from the ARIMA model. Since the ARIMA model cannot capture the nonlinear structure of the data, the residuals of linear model will contain information about the nonlinearity. The results from the neural network can be used as predictions of the error terms for the ARIMA model. The hybrid model exploits the unique feature and strength of ARIMA model as well as ANN model in determining different patterns. Thus, it could
be advantageous to model linear and nonlinear patterns separately by using di5erent models and then combine the forecasts to improve the overall modeling and forecasting performance.

As previously mentioned, in building ARIMA as well as ANN models, subjective judgment of the model order as well as the model adequacy is often needed. It is possible that suboptimal models may be used in the hybrid method. For example, the current practice of Box–Jenkins methodology focuses on the low order autocorrelation. A model is considered adequate if low order autocorrelations are not significant even though significant autocorrelations of higher order still exist. This sub-optimality may not affect the usefulness of the hybrid model. Granger [16] has pointed out that for a hybrid model to produce superior forecasts, the component model should be suboptimal. In general, it has been observed that it is more effective to combine individual forecasts that are based on different information sets [16, 17].

V. Implementation and Forrecasting Results

R language is used in the experimental evaluation step. The package "Rcmdr" is used for supporting data management and data preparation.

R-Code for forecasting using ARIMA is shown as follows, in Fig 3.

```
require(forecast)
ARIMA_Model = auto.arima(EBITDA_Train_TS)
ARIMA_Forecast = forecast(ARIMA_Model,h=24)

plot(ARIMA_Forecast, xlab='', ylab = 'EBITDA')
lines(EBITDA_TS,type="l",col="black")
```

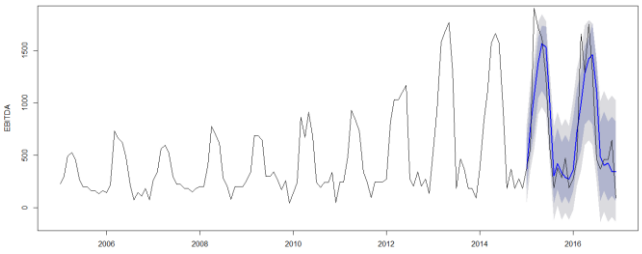

Fig. 3. Forecasting EBITDA using ARIMA Model

R-Code for forecasting using ANN is shown as follows, in Fig 4.

```
require(caret)
ANN_Model = nnetar(EBITDA_Train_TS)
ANN_Forecast = forecast(ANN_Model,h=24)

plot(ANN_Forecast, xlab='', ylab = 'EBITDA')
lines(EBITDA_TS,type="l",col="black")
```

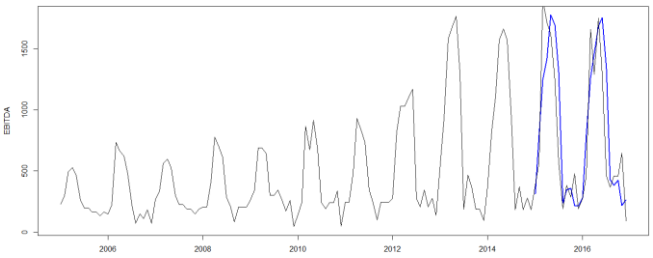

Fig. 4. Forecasting EBITDA using ANN Model

R-Code for forecasting using ARIMA-ANN hybrid is shown as follows, in Fig 5.

```
require(forecastHybrid)
HYBRID_Model <- hybridModel(EBITDA_Train_TS,model="an")
HYBRID_Forecast = forecast(HYBRID_Model,h=24)

plot(HYBRID_Forecast, xlab='', ylab = 'EBITDA')
lines(EBITDA_TS,type="l",col="black")
```

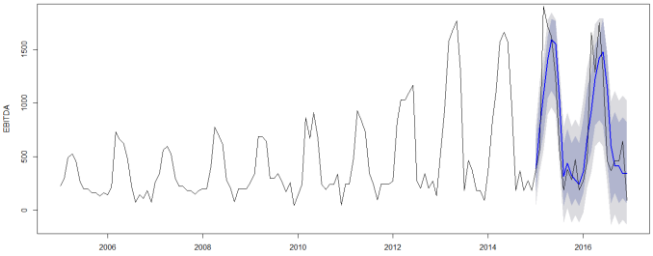

Fig. 5. Forecasting EBITDA using ARIMA-ANN Model

In Fig. 6., the results of the three techniques are compared. The error is calculated based on RMSE and MAE by using the following commands:

```
accuracy(ARIMA_Forecast, EBITDA_Test_TS)
accuracy(ANN_Forecast, EBITDA_Test_TS)
accuracy(HYBRID_Forecast, EBITDA_Test_TS)
```

	RMSE	MAE
ARIMA	324.6005	240.0283
ANN	382.3196	286.4868
ARIMA-ANN	318.4571	231.7333

Fig. 6 Results comparison of the 3-models based on RMSE and MAE

VI. CONCLUSION AND FUTURE WORKS

The results from using 10 years monthly data of the Provincial Waterworks Authority (PWA) reveal that the best model is ARIMA-ANN hybrid model [5, 6]. Thus, this model can be used for forecasting EBITDA. From these results, the other time series of PWA data such as Selling Expenses, Operating Expense, General and Administrative Expenses, using ARIMA-ANN hybrid model in the future.

REFERENCES

[1] en.wikipedia.org/wiki/Earnings_before_interest,_taxes,_depreciation,_and_amortization, (2018)

[2] Exitpromise - Adjusted EBITDA Definition - exitpromise.com/adjusted-ebitda/, (2018)

[3] G.E.P. Box, G. Jenkins, Time Series Analysis, Forecasting and Control, Holden-Day, San Francisco, CA, 1970

[4] G. Peter Zhang. Time series forecasting using a hybrid ARIMA and neural network model. Neurocomputing 50 (2003) 159-175.

[5] R. M. Kapila Taranga Ratnayaka, D.M.K.N Seneviratne, Wei Jianguo and Hasitha Indika Arumawadu. A Hybrid Statistical Approach for Stock Market Forcasting Based on Artificial Neural Network and ARIMA Time Series Models. International Conference on Behavioral, Economic, and Socio-Cultural Computing (BESC 2015).

[6] Ping-Feng Pai, Chih-Sheng Lin, A Hybrid ARIMA and support vector machines model in stock price forecast. Omega 33 (2005) 497-505.

[7] Chih-Fong Tsai, Combining cluster analysis with classifier ensembles to predict financial distress. Information Fusion 16 (2014) 46-58

[8] G.U. Yule, Why do we sometimes get nonsense-correlations between time series? A study in sampling and the nature of time series, J. R. Statist. Soc. 89 (1926) 1–64.

[9] H. Wold, A Study in the Analysis of Stationary Time Series, Almgrist & Wiksell, Stockholm, 1938.

[10] J.G. De Gooijer, K. Kumar, Some recent developments in non-linear time series modelling, testing, and forecasting, Int. J. Forecasting 8 (1992) 135–156.

[11] M.S. Hung, J.W. Denton, Training neural networks withth e GRG2 nonlinear optimizer, Eur. J. Oper.Res. 69 (1993) 83–91.

[12] V. Subramanian, M.S. Hung, A GRG2-based system for training neural networks: design and computational experience, ORSA J. Comput. 5 (1993) 386–394.

[13] R. Fildes, S. Makridakis, The impact of empirical accuracy studies on time series analysis and forecasting, Int. Statist. Rev. 63 (1995) 289–308.

[14] K. Hornik, M. Stinchicombe, H. White, Using multi-layer feedforward networks for universal approximation, Neural Networks 3 (1990) 551–560.

[15] J.W. Denton, How good are neural networks for causal forecasting? J. Bus. Forecasting 14 (1995) 17–20.

[16] C.W.J. Granger, Combining forecasts—Twenty years later, J. Forecasting 8 (1989) 167–173.

[17] M.P. Perrone, L. Cooper, When networks disagree: ensemble method for hybrid neural networks, in: R.J. Mammone (Ed.), Neural Networks for Speechand Image Processing, Chapman & Hall, London, 1993, pp. 126–142.

[18] I.S. Markham, T.R. Rakes, The e5ect of sample size and variability of data on the comparative performance of arti/cial neural networks and regression, Comput. Oper. Res. 25 (1998) 251–263.

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How mental imagery helps robot learning

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***Abstract*—This work presents a computational model underlying learning in robots. It demonstrates the way in which motor skills and mental imagery can be acquired by robots through exploration. The target experiment involves permitting a humanoid robot to learn how to retrieve an out-of-reach object using a tool (action sequencing). Exhibiting exploratory behavior in the robot is possible through the help of a reinforcement learning technique and the dynamic movement primitive framework. The results show that the robot can complete a given action sequencing task in a reasonable period of times. In addition, by mean of planning, mental imagery can be used as an alternative resource replacing overt movements that could help reducing times and power consumption. Furthermore, this work conducts two experiments which might be identical to the infant's age and might be used to explain the characteristic of tool use development found in humans.**

Keywords—robotic controller, mental imagery, action sequencing

I. INTRODUCTION

A simple tool use scenario, such as using a rake-like tool to retrieve an out-of-reach toy, has been proven that too difficult for infants aged younger than 18 months to accomplish [1]. As shown in their empirical data, tool use performance is increased functions to the infants' age. At the aged younger than 18 months, the infants' tool use performance remains invariance and contingent. This kind of task post difficulty to the younger infants might be because it requires the use of mental imagery. For instance, given a demonstration of how to use a tool to retrieve a toy can help infants that previously failed in the test to be able to succeed spontaneously when they encounter that task again. Again, it was the age of 18 months that the infants can gain benefit from the demonstration session.

According to Piaget's theory of child development, the age of 18 months is the beginning of the sensorimotor stage 6 that infants begin to have an ability of using mental imagery [2]. Thus, the demonstration (i.e., [1]) might provide missing information about actions-outcomes effects of how to solve the task to the infants. The infants might fulfill and correct their understanding of how to solve the task through the use of mental imagery. When they encounter the task again, only recalling a suitable action that produces a proper outcome is required to complete the task.

The infants' tool use capability can be viewed as highly connected to the existing motor skills [3, 4]. This capability gradually increases function to the experience the infants have on the exploration on object manipulation [5]. In agreement with these views, the capability of using tools of younger infants seems inefficient and varied comparing to the older ones. Due to their age, younger infants should have less sensorimotor experience which limits the number of skills that can be acquired directly. Some researchers assumed that, at the beginning, infants can exhibit simple tool use competence using only simple sensorimotor knowledge such as action and perception [3]. While in the later stage, tool use required more precise knowledge about object-object interactions and the ability to manipulate an internal representation of that knowledge [6]. In this line, affordances play a central role linking together perception, action, and cognition [7]. In which, infants are not endowed with an ability to perceive affordance of objects at birth. To understand the world around them, through affordances, the infants have to explore this capability [8].

Although literature regarding tool use in human infants suggests the use of mental imagery, the work on robots suggested the important role of affordances [9, 10], there are no computational models that addressed these issues so far. This study is the first attempt to reveal the role of both mental imagery and affordances in action sequencing competence.

The present model targets at permitting the robot to acquire tool use capability through the help of affordances and mental imagery. In addition, the model will be able to reproduce a characteristic of tool use development found in infants. The key idea is that the development could be characterized by a number of motor skills the infants have acquired. Young infants should have a small number of motor skills due to the period of time (their age) they had in the sensorimotor learning stage. Therefore, their tool use performance should be very limited. In contrast, older infants performed the task better because they have acquired more number of motor skills. The reason why more numbers of skills results in better performance is that it gives more chance that suitable skills for solving a given tool use task consist in a higher set. In this setting, if there are no suitable skills, tool use competence will not be possible. In addition, we also introduce another hypothesis that difference periods of time (training trials) the infants used to familiarize with a tool use scenario would result in differences in tool use performance. Similar to the case of skills, young infants will have a small number of training trials while older infants will have higher number trials. In term of development, gradually increasing of these numbers, i.e., skills, training trials, should result in an increase of tool use performance.

In this study, the ability to use a tool in robots is possible through affordances, while the developmental characteristic is constrained by a number of motor skills acquired by the robots. Importantly, mental imagery can be used to replace overt movements in the problem-solving processes, i.e., action sequencing. The next two sections, settings and methods, will give more details on mechanisms underlying this framework including some definitions of components used. Section IV reports results obtained by the model. The last section draws a discussion and conclusion.

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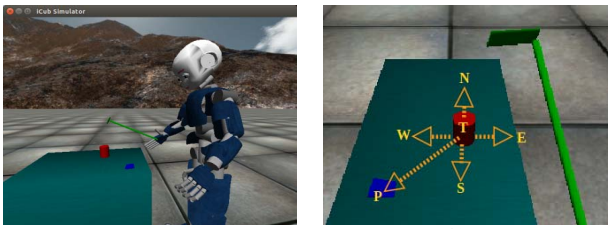
II. SETTINGS

A. Robotic tool use scenario

There is a table, a rigid box, placed in front of the robot (see Fig. 1a). Tool use scenarios will be set on top of this table. There will be a toy placed on the table at a location that too far away from the robot's reach. The iCub simulator [11] was set to hold a rake-like tool permanently with its right hand. Tool use competence will require only the right arm of the robot. The tool is colored in green, consists of a long stick handle and a flat rectangle tip. The tool was used to extend the length of reach of the robot. Movements caused by the right arm will cause change on the tool directly.



(a) (b)

Fig. 1. Tool use settings: (a) The iCub simulator and sample tool use scenario, (b) 6 interesting events.

B. Initial postures and tool use situations

In fact, demonstrating the processes of action acquisition of all possible actions, or even focusing on one arm that move with a tool, can be a daunting task. Thus, only two types of actions that the robot exhibits with the tool will be considered as mandatory for our initial tool use scenarios. They are “Pulling” and “Interaction” actions. What makes each action different is its outcome. For example, pulling is an action that make the toy moves to a reachable area while the interaction actions refer to the effects when the tool interacts with the toy e.g., touching, moving left.

Initial postures refer to the configuration of the right arm of the robot. Differentiation on the joints' value results in changing the robot's posture. There are 4 initial postures, which varied the spatial gap between the tool’s tip and the toy. The first posture is the case that the tool’s tip located behind the toy. The second will have a little spatial gap, while the third and fourth post a bigger gap. To simplify sensorimotor exploration and an acquisition of tool use competence, we assumed that the robots already hold the rake tool in its right hand permanently, and will be facing (start) with only four different situations during their sensorimotor period. From the robot's view, movements on its arm will directly affect its visual perception. This causes the different spatial gap between the tool's tip and the toy.

C. Interesting Events

In order to demonstrate that tool use ability can be acquired by robots in a reasonable amount of time, we have set a scheme that the change of the toy caused by the interaction with the tool is suitable to make a simple tool use scenario. From this interaction, 6 types of event are assumed to happen during exploration (movements of the robot's arm with tool, see Fig. 1b). In infants, they might get surprised or distracted when these events happen because the object of desire (a toy) was moved. The interesting events are Pulling, Touching, and movements of the toy in 4 directions: North, South, East, and West.

III. METHODS

A. Model Architecture

Based on our previous neurorobotic model accounts for mental rotation in robots [12]. The present model (Fig. 2) includes four parts of the cortical area. We believe that, by means of information/cognitive processing, these brain areas might involve during learning action sequencing in human. The model also consists of an intrinsic motivation mechanism that plays a key role shaping what the system can learn and determining when the learning should be started.

The focused components are primary visual cortex (V1), parietal cortex (PC), premotor cortex (PMC), primary motor cortex (M1) and prefrontal cortex (PFC). The role of motivations is introduced to the system through the motivation activation and Hippocampus (HIP) components. The HIP serves as mechanisms that monitor coming events and evaluate specific rewards to the system.

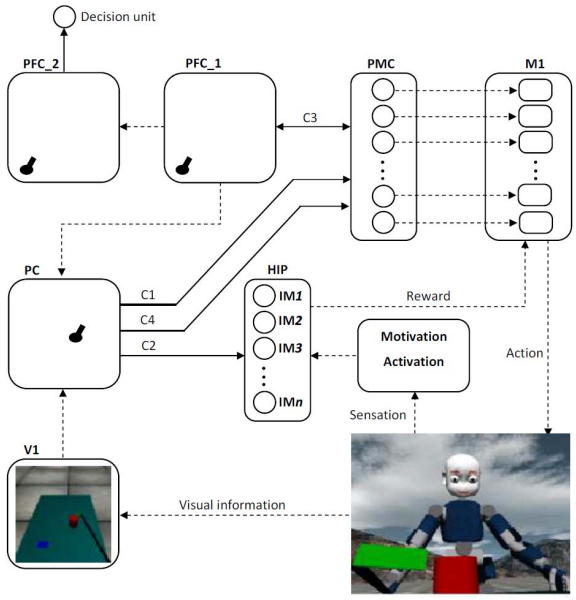


Fig. 2. The neurorobotic model for learning action sequencing

The V1 is formed by a 320 x 240 neural map. It is used to store visual information captured directly from the robot's camera. PC is responsible for storing spatial information on the tool and the toy that represents tool use situation. It is formed by 320x240 neurons, the same size as of V1. Note that information from V1 is passed through color filtering processes before using as neural activation of the PC. The PMC is formed by 10 neurons responsible for affordance interpretation. M1 is also formed by 10 units. Each neuron in the PMC has a direct link to one unit in M1. This means that activation of the PMC's neurons causes execution of the M1's unit directly. The PFC consists of two components which will be used for storing and manipulating mental images. HIP is formed by 6 neurons corresponding to 6 different interesting events.

The term motivation activation used here refers to a mechanism that guides the process of skill acquisition in infant robots. In humans, by means of motivation activation, infants might get surprised when something that they are paying attention to has changed. However, in robots, it is of interest how they can be interested in the occurrence of an unexpected event, and how they can distinguish some events as interesting and other events as not. To simplify this, we use the change of the environment as a source of attraction. As a critic, the motivation activation mechanism was applied to detect the change of the environment caused by movements of the robot. Thus, the reward of 1 will be given to the system when movements of the robot have revealed a focus goal, otherwise the reward will be 0. This mechanism is assumed to work as dopamine neurons which are fired when an agent encounters novel/unpredicted situations.

PMC was used as motor preparation while M1 serves as motor execution. The direct link between them was constructed manually in a sense that one motor preparation (i.e., affordances) activates one corresponding motor command (i.e., action). Note that this link is not a connection. Ten neurons of this map were used to represent affordance interpretation of the tool use situation.

Six neurons of the HIP were used to indicate whether or not the system can achieve a particular goal from a being perceived tool use situation. As distal goals, one of these neurons (corresponding to one specific goal) will be activated if the system has mastered suitable actions to do so. This ensures that the system will not learn to acquire the same action (using different PMC neuron) to achieve the same goal. Ideally, high activation of these neurons means that a being perceived tool use situation is not new to the robot.

B. Model Learning

The model starts the learning processes by capturing the current tool use situation via the robot's camera. The visual input consists of two objects, the toy and the tool. In order to easier distinction between the two objects, they were set with a different color. The toy was colored in red while the tool was colored in green. The model uses a color based detection and focuses only on the two colors. Therefore, only changing of these two objects will affect the visual input or tool use scenarios. Thus, the tool is moved by movements of the robot right arm, while the toy will be moved only when it was touched by the tool. Tool use scenarios are variations between actions exhibited by movements of the robot's arm with the tool and the interaction with the toy. Furthermore, some movements might cause the situation that the toy is moved in a certain direction when touching with the tool, which will be considered as intrinsically motivated events.

Information propagates among neural maps through connections. There are 4 connections and 3 types of learning algorithms involved in this study. C1 and C2 are Hebbian connections, which is responsible for affordance encoding. C3 is a special type of Kohonen learning which is learned in a supervised fashion. Furthermore, this connection can propagate information in both ways, i.e., form PFC_1 to PMC, and also from PMC back to PFC_1. A mental image creation is possible through this connection. The C4 is a Q-learning connection; it is responsible for accumulating knowledge about tool use competence exhibited during training.

Affordances (through the connection C1, C2) are an association between tool use situations and their suitable actions. The perceived situation activates suitable actions that lead the robots to achieve a particular goal. This association will be formed during skill acquisition. Note that one tool use situation is able to activate more than one action, because it is possible that from one tool use situation can lead to an achievement of different goals. The Hebbian learning rule is defined as follows:

$$\Delta w_{ij} = \eta \; a_i \, (a_j - w_{ij}) \tag{1}$$

where Δw_{ij} denotes the weight's change from input neuron i to output neuron j, a_i and a_j denote activation potential of neuron i and j respectively, η denotes the learning rate which is set to 0.15, and w_{ij} is a current weight value.

Mental imagery (through the connection C3) refers to the ability to predict next state of the intended action constraints by a being perceived situation. It will be used to anticipate the planning of the robots. Ideally, the ability of using mental imagery will be used to replace the processes of action-perception in which the robot does not have to exhibit overt action instead it can use mental imagery to fulfill the outcome of the intend action. The supervised Kohonen learning rule is as below.

$$\Delta w_{i\,win} = \eta \; a_{win} \, (a_i - w_{i\,win}) \tag{2}$$

where $\Delta w_{i\,win}$ is the change of the connection weight between input unit i and a winning unit win of the output, the learning rate η is set to 2.0.

Q-Learning is a reinforcement learning technique invented specifically for learning of action sequencing [13]. Like traditional reinforcement learning, the q-learning process involves action, state, and reward to accumulate the knowledge regards an encountering task. The reward is used as guidance for selection of the next action. Through iteration processes of rewarding and updating mechanisms, the q-learning can lead the system to achieve an optimal solution (obtain maximum reward). In this work, the processes that underlie Q-learning were adapted to train the connection C4 of the model as below.

$$\Delta w_{i\,win} = \eta \, ((reward_t - \gamma \, qMax_t) - Qwin_{t-1}) \, x_{i\,t-1} \tag{3}$$

where $\Delta w_{i\,win}$ is the change of the connection weight between unit i and a winning unit win, η is a learning rate (η = 0.0001), $reward_t$ is a reward that was given to the system at time step t, $qMax_t$ is a highest activation of output unit at time t, $qWin_t$ is an activation of output unit at time t that was selected using softmax function, γ is a discount factor which is set to 0.8, and $x_{i\,t-1}$ is the activation of input unit i at the previous time step $t-1$.

C. Skill Acquisition

This work applied DMPs framework [14] to form motor primitives for the robots. Motor primitives or movements of the robots will be encoded using a set of linear and non-linear dynamic functions. When rolled out, DMPs can generate a series of joint angles that can be used directly to control actuators of a robotic system. Three core equations of this framework are given as follows:

$$y''_t = \alpha_y(\beta_y \, (g - y_t) - y'_t) + f_t \tag{4}$$

$$\psi_i = \exp(-h_i (x - c_i)^2) \quad (5)$$

$$x' = -\alpha_x x \quad (6)$$

The first part of (4) represents linear dynamical system which is perturbed by the forcing term f. This equation generates trajectory values (y_t) which, at any particular point in time, can be used directly to control an actuator. The forcing term f is responsible for shaping the trajectory. It consists of a number of basis functions (ψ). The calculation for this forcing term was done by normalizing the weight values and multiply by the canonical value x, which was decreased to zero over time by the factor -α, as stated in (6). The basis function (5) was defined as a Gaussian function. It activates around x with variance h and centre c.

The DMPs was applied to control movements of the iCub simulator, i.e., the right arm. Since the iCub has 7 joints on the right arm to control (excluded the fingers), the DMPs were designed to have 7 goal parameters corresponding to the number of the joints, and 28 shape parameters (4 for each joint) to modify movement's trajectory of the arm. Each joint can be controlled independently by changing these two parameter sets.

We propose a scheme that an interesting event leads the system to search for proper parameters of a DMP that can constantly cause that event happened through practice. Therefore, any new intrinsically motivated event will lead the system to the acquisition of a new motor skill. Ideally, after training, each DMP (if assigned) will be able to exhibit one useful movement as a skill. The term 'useful' means that the movement can make one of the interesting events happen. The system can detect 6 events as it was designed to have 10 (6+4) DMPs. The 4 extra DMPs are dedicated to the case whereby only 1 DMP cannot meet the constraint of initial postures. Initially, all DMPs will be assigned with random values to their shape and goal parameters. One DMP will be selected randomly and rolled out to generate series of the joint's values it encoded. At this state, the visual information does not take any effect to the action selection.

Fig. 3 illustrates two examples of the network connections formed by the system. During the processes of skill acquisition, all robots will encounter all initial tool use situations. Both examples (Fig. 3a and 3b) refer to the robots that acquired all skills.

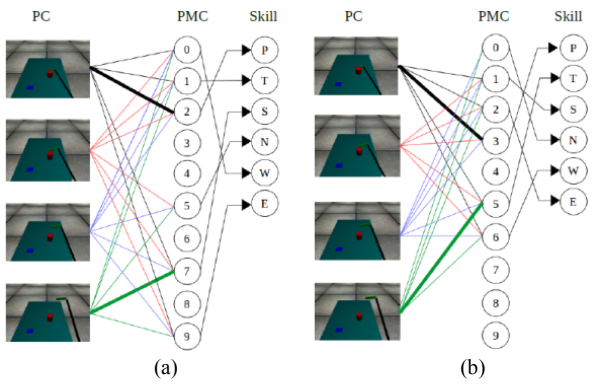


Fig. 3. Examples of the network connection of the model after passing through the learning processes. Note that the initial postures (the 4 images on the left) are represented in PC only one at a time. Their images are used for clarification. (a) example 1, (b) example 2.

The difference between the two networks is indicated by the different connections between PC and PMC. In addition, activation of the PMC's neurons, as affordance interpretation, should be differed, however it is not shown in the figure. The thick arrows refer to the connections which are strengthened by the Q-learning and depending on the initial posture stored in the PC.

In the example 1 (Fig. 3a), during testing, when the robot encounter with initial tool use situation-1 the PMC neuron number 2 will be activated with high activation. This means that the robot will be more likely to select action-P (due to the selection of the softmax function). Similarly, when the robot sees tool use situation number 4, PMC's neuron number 7 will be active with highest activation, which should lead the system to exhibit action-S. Considering that if the outcome of action-S is similar to the tool use situation 1, the system should exhibit action-P after this which should result in the success of retrieving the toy.

In contrast, if the system is formed as example 2 (Fig. 3b), it will not be able to succeed in the case of tool far from toy. This is because, in the initial tool use situation 4, PMC's neuron number 5 will be active; however, it was mapped to the action-T which is normally not similar with the tool use situation 1. Thus, this system should fail in the test.

D. *Experiment Settings*

According to [1], tool use performance is constrained by an infant's' age, whereby an increase in age results in a better performance in the test. To simulate this finding in robots through computational modeling, we interpret the age in motor skills and training trials.

• Exp.1: In the first experiment, the number of IM-detectors was varied from 2 to 6 (i.e., 2, 3, 4, 5 and 6) referred to the simulated infant robots aged 14 to 22 months (i.e., 14, 16, 18, 20 and 22). The acquisition of any new motor skill based on interesting events discovered by the robots, thus using a different number of IM-detectors directly affects the number of motor skills the robots can obtain. Note that all robots in this simulation had been initialized with two basic skills, i.e., pulling and touching, and used a fixed number of training trials i.e., 10, in the processes of action sequencing.

• Exp.2: The number of training trials will be varied on the number of IM-detector instead. Using the number of training of 0 and 2 refers to the infants robot aged 14 months, while 4, 6, 8 and 10 refer to the robots aged 16, 18, 20 and 22 months, respectively. Note that infant robots in this simulation are able to detect all interesting events, which means all motor skills can be acquired and exhibited by these robots.

IV. RESULTS

Each infant robot will encounter only one tool use situation (either tool-behind-toy or tool-far-from-toy) and solves the task using both "Reactive" and "Planning" strategies. Reactive system refers to the case that the robot exhibits overt movements during learning, while Planning system is the case of using mental images instead. The test of each tool use situation of each group will be repeated 30 times; thus, each group consists of 60 individuals (30 repetitions x 2 tool use situations).

Fig. 4 illustrates the results obtained from the first experiment. The top line of the two graphs (Fig. 4a and 4b) indicates the performance of tool use in the situation that the tool located behind the toy. In this case, the performance of tool use of all age groups is similar with high success rate about 90%. The youngest group appears to be able to retrieve the toy at the highest success rate, 100%. This is because they have only two skills in their action repertoire, i.e., pulling and touching, and due to the affordance interpretation, the situation that tool-behind-toy was more likely to cause high activation on the skill-P. Thus, this benefits the first group, and leaves no space for improvement. So, increasing of the number of skills will not result in better performance.

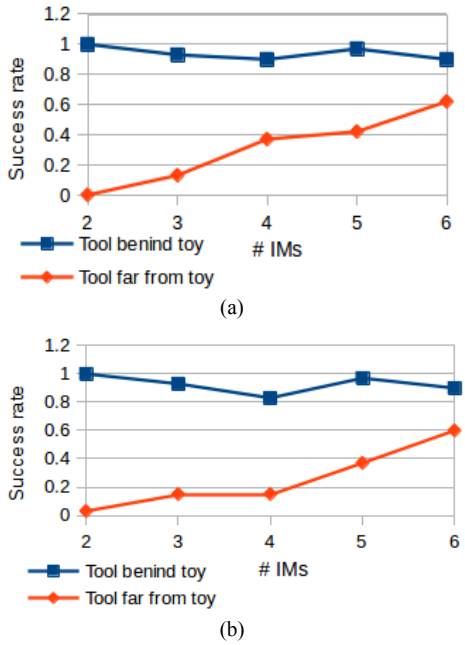


Fig. 4. Tool use performance when varying the number of skills: (a) Reactive, (b) Planning.

In contrast, the bottom line of both graphs in Fig. 4 show the increase in tool use performance when the number of skills is increased. Unlike the situation that tool-behind-toy, skill-P is not suitable to retrieve the toy from the case of large spatial gap, tool-far-from-toy. In the youngest group that only have the skills of pulling and touching, obviously cannot solve the case of large spatial gap. However, it is possible that, sometimes, performing pulling after touching can succeed in this case. Thus, performance of solving the case of tool-far-from-toy starts from about 0% at the youngest group and increases to 10, 40, 45 and 60 corresponding to the increasing of the number of skills.

Fig. 5 shows the results obtained from the second experiment. In this test, the youngest group, which has no training period, can solve the case of tool-behind-toy at about 60%. In contrast to the first hypothesis, approximately 20% of individuals in this group, of this simulation can have an ability to solve the case of tool-far-from-toy. Although, increasing of the number of training trials results in increasing of the performance in both tests, the performance characteristic is not in a linear fashion. It appears that, in the case of tool-behind-toy, using the number of training trials of 6 results in the highest performance.

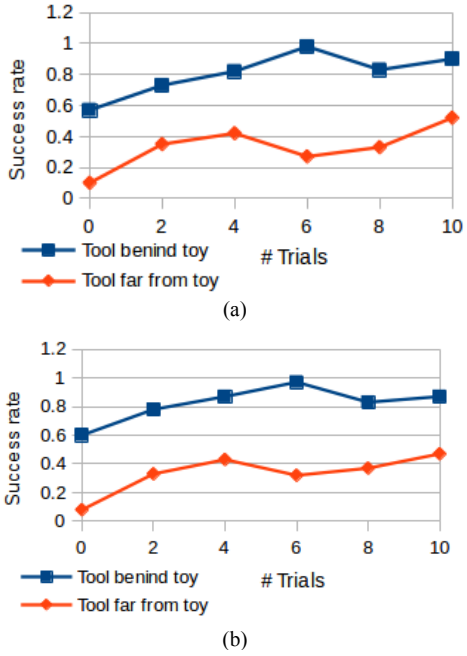


Fig. 5. Tool use performance when varying the number of training trials: (a) Reactive, (b) Planning.

In both tests, the results obtained by the two systems, "reactive" and "planning", seem identical. This confirms that mental imagery can be used efficiently in replacing the use of overt movements. However, comparing to the infant data reported in [1], the first hypothesis seems to capture the main characteristic of tool use development better than the second. Thus, from these results, we suggest that the development of tool use found in human infants might be caused by differences in the number of motor skills they have mastered.

V. Conclusion

This study simulates the infants' ages based on two different interpretations on their tool use performance. The first experiment interprets the age as the number of acquired motor skills while the latter differentiates the age as a period of experience/practice on tool use scenarios before testing. Even the results reported in the previous section showed a comparable characteristic of tool use performance (qualitatively) as exhibited by our infant robots and the human infants [1]). However, we still lack evidence that addresses a relationship between the number of acquired motor skills or a period of experience and the infants' age. What actually underlies the performance of tool use in human infants is still unknown.

Tool use scenarios, captured through the robot's eye, are varied subject to the movements of the right arm of the robot. However, this does not simply mean that the number of different tool use situations equals the number of actions the robot had such as 2 to 6. Because the effect of physical interactions between the tool and the toy is sometimes unpredictable, it is possible that two outcomes caused by the same action can differ from time to time. Therefore, the Q-learning processes accumulate knowledge on solving the tool use task from a variation of inputs, not from a static set.

This work also demonstrates that mental imagery (an expectation of the actions' outcome) can be used to replace overt movements in the acquisition of tool use ability. Since,

using mental images allows the robots to do planning to solve the task in mind, this might be interpreted as an understanding of how to use tools. In such cases, the infants can exhibit movements for solving a being perceived tool use scenarios spontaneously.

REFERENCES

[1] L. Rat-Fischer, J. K. O'Regan and J. Fagard, "The emergence of tool use during the second year of life", *Journal of experimental child psychology*, vol. 113(3), 2012, pp. 440-446.

[2] J. Piaget, and M. Cook, *The origins of intelligence in children*, New York: International Universities Press, vol. 8(5), 1952.

[3] J. J. Lockman, "A perception–action perspective on tool use development", *Child development*, vol. 71(1), 2000, pp. 137-144.

[4] B. A. Kahrs and J. J. Lockman, "Building tool use from object manipulation: A perception–action perspective", *Ecological Psychology*, vol. 26(1-2), 2014, pp. 88-97.

[5] E. J. Gibson and A. D. Pick, *An ecological approach to perceptual learning and development*, Oxford University Press, USA. 2000.

[6] F. Guerin, N. Kruger and D. Kraft, "A survey of the ontogeny of tool use: from sensorimotor experience to planning", *IEEE Transactions on Autonomous Mental Development*, vol. 5(1), 2013, pp. 18-45.

[7] J. J. Gibson, *The ecological approach to visual perception: classic edition*, Psychology Press, 2014.

[8] E. J. Gibson, "Exploratory behavior in the development of perceiving, acting, and the acquiring of knowledge", *Annual review of psychology*, vol. 39(1), 1988, pp. 1-42.

[9] A. Stoytchev, "Behavior-grounded representation of tool affordances", in *Robotics and Automation, 2005. ICRA 2005. Proceedings of the 2005 IEEE International Conference on*, (April. 2005), 2005, pp. 3060-3065.

[10] V. Tikhanoff, U. Pattacini, L. Natale and G. Metta, "Exploring affordances and tool use on the iCub", in *Humanoid Robots (Humanoids), 2013 13th IEEE-RAS International Conference on*, (October. 2013), 2013, pp. 130-137.

[11] V. Tikhanoff, A. Cangelosi, P. Fitzpatrick, G. Metta, L. Natale and F. Nori, "An open-source simulator for cognitive robotics research: the prototype of the iCub humanoid robot simulator", in *Proceedings of the 8th workshop on performance metrics for intelligent systems*, (August. 2008), 2008, pp. 57-61.

[12] K. Seepanomwan, D. Caligiore, A. Cangelosi and G. Baldassarre, "Generalisation, decision making, and embodiment effects in mental rotation: a neurorobotic architecture tested with a humanoid robot", *Neural Networks*, vol. 72, 2015, pp. 31-47.

[13] C. Watkins and P. Dayan, "Q-learning", *Machine learning*, vol. 8(3-4), 1992, pp. 279-292.

[14] S. Schaal, "Dynamic movement primitives-a framework for motor control in humans and humanoid robotics", in *Adaptive motion of animals and machines*, Springer Tokyo, 2006, pp. 261-280.

Clustering of Leaf Characteristics in Secondary Dry Dipterocarp Forest based on Particle Swarm Optimization

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***Abstract*—The study of the relationship between forest and environment especially in climate change is needed for forest management. Seasonally dry tropical forest is one type of the tropical forests that is a home of biodiversity hotspots. The species in the deciduous forest has the various response to climate variables. The optimization approach called Particle Swarm Optimization (PSO) is a technique that has been recognized in a lot of research as an effective approach to analyze data. This approach has been applied to solve many problems. In this research, we applied PSO to cluster the leaf characteristic patterns in secondary dry dipterocarp forest. The results showed the main patterns of leaf characteristics in the forest can be extracted by PSO. Nevertheless, it cannot separate the small different characteristics of leaf phenology as complete and incomplete in shorten period during the usual dry season.**

Keywords— unsupervised classification, particle swarm optimization, dry dipterocarp forest, leaf phenology, leaf characteristics

I. INTRODUCTION

Forest is strongly linked to climate change. This has been affecting and being an important factor of climate mitigation by removed atmospheric carbon in process of leaf photosynthesis [1]. The seasonally tropical dry forest is a type of tropical forests that has great biodiversity. Tree species in this forest also has various leaf characteristics responding to the climate variability [2]. The change in leaf characteristic or phenology is one of the indicators for understanding forest and climate interaction and has an influence on carbon and water cycle [3]–[6]. However, the challenges of the study in leaf characteristics are the complexity of the data. Thus, the clustering of leaf characteristics is the primarily important step for understanding forest adaptation as a species level.

The metaheuristic approach called Particle Swarm Optimization (PSO) [7] is the optimization technique that has high performance and has a short time to analyze data. PSO has been applied in many application [8]. The algorithm was proved that it has a high performance than the Genetic Algorithm (GA) which is one of state-of-the-arts in some problems [9]. However, the single PSO technique has not been used in unsupervised clustering the complex data too much.

In this research, we proposed to study the performance of PSO by applying it to with the clustering of the complex leaf characteristics pattern in secondary dry dipterocarp forest.

II. METHODOLOGY

In order to analyze the pattern of leaf characteristics by PSO. The proper adjustment of its parameters is needed for the algorithm to be able to work appropriately with the specific problem.

TABLE I. LIST OF SPECIES THAT WERE USED AS DATA FOR LEAF CHARACTERISTICS ANALYSIS

No.	Species Name
1	*Litsea glutinosa* (Lour.) C.B.Rob
2	*Croton oblongifolius* Roxb.
3	*Lannea coromandelica* (Houtt.) Merr.
4	*Erythrophleum succirubrum* Gagnep
5	*Dipterocarpus obtusifolius* Teijsm. ex Miq
6	*Shorea roxburghii* G.Don
7	*Shorea siamensis* Miq
8	*Sindora siamensis*
9	*Phyllanthus emblica*
10	*Shorea obtuse* Wall. ex Blume
11	*Xylia xylocarpa* (Roxb.) Taub. var. kerrii
12	*Ellipanthus tomentosus*
13	*Dipterocarpus tuberculatus* Roxb.

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(a) (b)

Fig. 1. The figure of leaf characteristics which has 0 score (a) and 4 score (b).

In this research, we divided the proposed methodology into three main parts. First part is the description of data that was used in this research. The second part describes how to apply PSO in the leaf characteristics analysis problem. The last part is the description of the clustering of leaf characteristics techniques based on PSO.

A. Study area and data collection

The leaf characteristics inside secondary dry dipterocarp forest (a type of tropical dry forest) located in western, Thailand (13° 35' 13.3" N: 99° 30' 3.9" E, elevation of 118 m) was observed. The mature leaf phenology of 888 trees covering 13 species was observed and scored into the 0-4 range [10] as shown in figure 1 for three years (from March 2015 to April 2018). The list of 13 species was shown in table I.

B. Application of PSO in leaf characteristics analysis

The Particle Swarm Optimization (PSO) is one of the optimization techniques that was created by [7]. Figure 2 shows the concept of PSO. PSO was inspired from the finding food of bird or fish and the velocity theory that rely on the group's movement and the space between each bird or fish. In this case "Particle" is used to represent each bird or fish in the PSO algorithm. In each iteration, the velocity and position of each particle were updated by using equation (1) and (2).

$$V_i^{(k+1)} = W*V_i^{(k)} + C_1*R_1*(P_BEST_i^{(k)} - X_i^{(k)}) + C_2*R_2*(G_BEST^{(k)} - X_i^{(k)}) \quad (1)$$

$$X_i^{(k+1)} = X_i^{(k)} + V_i^{(k+1)} \quad (2)$$

Where $V_i^{(k+1)}$ is the updated velocity of each particle. $X_i^{(k)}$ is the location of each particle. W is the weight that effects the velocity in the next iteration. C_1 and C_2 are parameters to control the direction of each particle and swarm respectively in each iteration. R_1 and R_2 are random parameters from 0 to 1 that help each particle reach the global optimal solution. $P_BEST_i^{(k)}$ and $G_BEST^{(k)}$ are the best food location that was found from particle and swarm.

Due to the ease of implementation of PSO while it still provides good performance, there are many works used PSO to solve real-world problems. For example, [11] applied PSO to classify wheat area. They compared the performance with K-mean approach which is one of state-of-the-arts machine learning technique. The results showed that PSO provides better accuracy than K-mean. PSO also used for unsupervised classification of multispectral Landsat images by applying with the Fractional Global Best Formation (FGBF) technique in [12]

Although PSO is easy to implement and evidently using few parameters than other optimization techniques, it still has some limitation. The main problem of PSO is the uncertainty to reach the global optimal solution. The results of PSO are sometimes stuck in the local optimal solution. This problem cause PSO has worse performance. Nowadays, there is some research such as [13] that can solve this problem.

To apply PSO in the leaf characteristics analysis problem, there are some parameters need to set properly as follow.

- Due to the score of the mature leaf of each tree in secondary dry dipterocarp forest was observed and collected for 38 months to study the leaf characteristics, PSO's dimension was set to 38.
- To cluster the group of leaf characteristics pattern, we calculated the distance between the representative of each group. In this research, we define the parameter

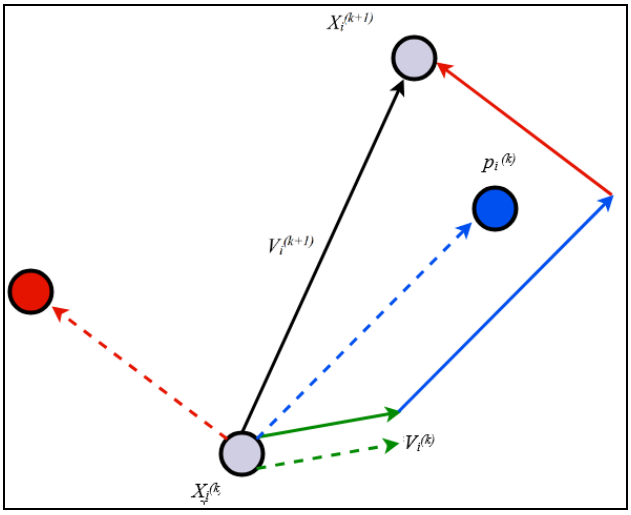

Fig. 2. The concept of PSO.

name "centroid" to represent the pattern of each group. Based on the assumption of the expertise, the pattern of leaf characteristics in secondary dry dipterocarp forest could be divided into 5 groups including:

- Incomplete deciduousness species
- Incomplete deciduousness in the usual dry season but complete deciduousness appearance during severe drought
- Complete deciduousness species
- Complete deciduousness with prolonged shedding
- Complete deciduousness appearance only prolonged drought with always late shedding and flushing

Therefore, the 5*38 matrix was defined to consist the solution of 5 groups.

- To find the location of each particle in PSO, the initial centroid was generally set by random. The random value helps the swarm break the local optimal solution. However, the pattern of leaf characteristics in each group are closed with each other and has a high dimension. Thus, the random value cannot help the swarm reach the global optimal solution in this research. To solve this problem, the initial centroid of every group were defined to reduce the diversity of the solution.
- In addition, we also define the penalty to the particle that stuck in one group. This technique was also used to solve the local optimal solution problem by using (3).

$$Penalty = weight*(N - Number_of_Class_Count) \quad (3)$$

Where *weight* is a constant to clarify the penalty. *N* is a number of classes and *Number_of_Class_Count* is the number of class counted in the solution.

C. Clustering pattern of leaf characteristics based on PSO

In this research, we applied PSO in the pattern of leaf characteristics clustering. The optimal solution that was used in PSO is the minimum value of Euclidean distance. The Euclidean distance is used to find how similarity of the leaf characteristics pattern in each species. The Euclidean distance was calculated by using (4) and (5).

$$F(G_1, G_2, G_3, ..., G_N) = \sum_{i=1}^{N} \left(\sum_{p_j \in Z_i} \| Z_i - p_j \| \right) - Penalty \quad (4)$$

$$Obj = \arg\min(F) \quad (5)$$

Where *G1, G2, G3, ..., GN* represent N groups of leaf characteristics pattern. p_j is the selected tree data. Z_i represents the centroid in each group. *F* is the fitness function.

III. Experimental Results

Figure 3 shows the results of the leaf characteristics pattern that was clustered by PSO. From the result, the leaf characteristics of *Lannea coromandelica.* has complete deciduousness with prolonged shedding pattern. *Erythrophleum succirubrum* is complete deciduousness appearance only prolonged drought with always late shedding and flushing type. The leaf characteristics of *Dipterocarpus obtusifolius* and *Ellipanthus tomentosus* can be put into the incomplete deciduousness species pattern. However, PSO could not separate the small different characteristic of leaf phenology as complete and incomplete in shorten period during the usual dry season. Therefore, each tree species in secondary dry dipterocarp forest can be divided into 4 groups in this experiment. The matching group of 13 species was shown in Table II

| Group | Species Name | Leaf Characteristics | | |

TABLE II. THE MATCHING GROUP OF 13 SPECIES IN SECONDARY DRY DIPTEROCARP FOREST.

No.	Group of leaf characteristics	Species Name
1	*Incomplete deciduousness species*	*Dipterocarpus obtusifolius* Teijsm. ex Miq
		Ellipanthus tomentosus
2	*Incomplete deciduousness in the usual dry season but complete deciduousness appearance during severe drought or Complete deciduousness species*	*Litsea glutinosa (Lour.) C.B.Rob*
		Croton oblongifolius Roxb.
		Shorea roxburghii G.Don
		Shorea siamensis Miq
		Sindora siamensis
		Phyllanthus emblica
		Shorea obtuse Wall. ex Blume
		Xylia xylocarpa (Roxb.) Taub. var. kerrii
		Dipterocarpus tuberculatus Roxb.
3	*Complete deciduousness with prolonged shedding*.	*Lannea coromandelica* (Houtt.) Merr.
4	*Complete deciduousness appearance only prolonged drought with always late shedding and flushing*	*Erythrophleum succirubrum* Gagnep

IV. CONCLUSION

The study of leaf characteristics patterns in secondary dry dipterocarp forest that has great biodiversity is important to explore the relationship between forest and climate change. In this research, we applied the mathematical optimization technique namely Particle Swarm Optimization (PSO) with leaf characteristics pattern analysis in secondary dry dipterocarp forest. Based on expertise assumption, PSO was used to cluster the pattern of leaf characteristics from 13 tree species into 5 groups. The results have shown that the main pattern of leaf characteristics can be extracted. However, PSO cannot separate the different between incomplete and complete deciduousness during the usual dry season because both patterns have very similar characteristics. Therefore, PSO can extract only 4 groups of the leaf characteristic patterns in secondary dry dipterocarp forest. In future work, we will develop an algorithm that can detect this non-trivial characteristic. We hope the results of this research will be useful for analyzing the relationship between dipterocarp forests and climate change in the future.

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REFERENCES

[1] A. D. Richardson, T. F. Keenan, M. Migliavacca, Y. Ryu, O. Sonnentag, and M. Toomey, "Climate change, phenology, and phenological control of vegetation feedbacks to the climate system," *Agric. For. Meteorol.*, vol. 169, pp. 156–173, 2013.

[2] R. Blackie *et al.*, "Tropical dry forests The state of global knowledge and recommendations for future research," *Cifor*, p. 38, 2014.

[3] X. Xiao, S. Hagen, Q. Zhang, M. Keller, and B. Moore, "Detecting leaf phenology of seasonally moist tropical forests in South America with multi-temporal MODIS images," *Remotfile///D/Ph.D/P_Pik/Research/pheno_3.pdfe Sens. Environ.*, vol. 103, no. 4, pp. 465–473, 2006.

[4] C. E. Doughty and M. L. Goulden, "Seasonal patterns of tropical forest leaf area index and CO2exchange," *J. Geophys. Res. Biogeosciences*, vol. 114, no. 1, pp. 0–12, 2009.

[5] P. K. Diem, U. Pimple, A. Sitthi, P. Varnakovida, R. Kaewthongrach, and A. Chidthaisong, "Responses of tropical deciduous forest phenology to climate variation in Northern Thailand," *Int. Conf. Environ. Res. Technol. (ICERT 2017)*, no. September, pp. 340–345, 2017.

[6] M. Zalamea and G. González, "Leaffall phenology in a subtropical wet forest in Puerto Rico: From species to community patterns," *Biotropica*, vol. 40, no. 3, pp. 295–304, 2008.

[7] J. Kennedy and R. Eberhart, "{P}article swarm optimization," *IEEE Int. Conf. Neural Networks*, pp. 1942–1948, 1995.

[8] Y. Zhang, S. Wang, and G. Ji, "A Comprehensive Survey on Particle Swarm Optimization Algorithm and Its Applications," vol. 2015, 2015.

[9] M. Systems, "F. Hoffmann La Roche AG: The ultra fast track to innovative cancer drugs," *Pharm. Eng.*, vol. 28, no. 2 SUPPL., pp. 22–24, 2008.

[10] C. Kuaraksa, S. Elliott, and M. Hossaert-Mckey, "The phenology of dioecious Ficus spp. tree species and its importance for forest restoration projects," *For. Ecol. Manage.*, vol. 265, pp. 82–93, 2012.

[11] S. Dehuri, C. Mohapatra, A. Ghosh, and R. Mall, "A Comparative Study of Clustering Algorithms," pp. 238–241, 2006.

[12] A. Yildirim, "Unsupervised classification of multispectral Landsat images with multidimensional particle swarm optimization," *Int. J. Remote Sens.*, vol. 35, no. 4, pp. 1217–1243, 2014.

[13] N. Netjinda, T. Achalakul, and B. Sirinaovakul, "Particle Swarm Optimization inspired by starling flock behavior," *Appl. Soft Comput. J.*, vol. 35, pp. 411–422, 2015.

Change Management Model to Improve Antibiotic Prescribing in a Small Chinese Hospital

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***Abstract*—Nowadays, China suffers from serious overuse of antibiotics. Although the Health Ministry has launched a nationwide campaign over the past few years to regulate the use of antibiotics, the government still faces great challenges as some public hospitals have loosened supervision on prescription safety under heavy pressure from patients. Therefore, it is of great significance for such hospitals to facilitate the reduction of unnecessary antibiotics through change management. The research is to build a change management model to change the doctors' prescribing behaviour to give less antibiotics in a small public Chinese hospital.**

***Keywords*—Overuse of antibiotics, Root cause analysis, Change Management, After Action Review**

I. INTRODUCTION

Since the World Health Organization (WHO) introduced the issue of antimicrobial resistance in 2001 [1-3], Chinese medical experts have come to realize that antibiotics have been "heavily overused" at hospitals, which might cause serious side-effects for the health of an entire generation [4]. Therefore, the Health Ministry of China issued a Guideline for Antibacterial Use in Clinical Practice in 2004 to regulate the use of antibiotics in hospitals [5]. Although progress has been made, in 2011, Vice Health Minister Ma Xiaowei admitted that the government faces great challenges as some public hospitals have loosened supervision on prescription safety under heavy pressure from patients.

Consequently, China still suffers from serious overuse of antibiotics. In a systematic review of 57 eligible studies with a total of 556435 outpatient encounters between 2000 and 2012, the overall percentage of outpatients prescribed antibiotics was 50.3%, far above the recommended level [6]. Particularly, antibiotics are overused in the treatment of children. A nationwide study of prescriptions for outpatient children between 2004 and 2015 showed that 55.37 % of them were prescribed antibiotics, which is much higher than the standard level in the Guideline for Antibacterial Use in Clinical Practice [7].

Besides, most of the Chinese researchers have given the suggestions to hospitals like "strengthen its supervision on antibiotic prescriptions" or "give more education to doctors" after they analyzed the situation of antibiotic overuse over the last decade [8-9]. However, the antibiotic utilization rate is still much higher than the national standard in some hospitals. It is time to find effective ways for hospitals to push the doctors to change antibiotic over-prescribing.

A township public maternity and child health care hospital with only 31 employees which is located in the north of Jiangsu province was chosen to collect data, analyse the problem and conduct change management in pediatric outpatient clinic in this research. The hospital has a problem of antibiotic over-prescribing in outpatient pediatric, as the pharmacist claimed that nearly 65.3% of the prescription contains antibiotics, which is even higher the national level mentioned above.

This study is to analyze the reason why the doctors still give unnecessary antibiotics and explore a change management model to help them reduce antibiotic overuse.

II. LITERATURE REVIEW

A. Root Cause Analysis

Root cause analysis (RCA) is a methodology for finding and correcting the most important reasons when there is a

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gap between actual and desired performance. It can provide critical information on what to change and how to change it and usually be the first step of problem solving [10]. There are many tools that can be used in RCA, including the Five Whys technique, barrier analysis, change analysis, causal factor tree analysis, and the Ishikawa (or fishbone) diagram [11]. Among them, the Five Whys technique is a simple but powerful way to troubleshoot problems, since the nature of the problem and its solution becomes clear by asking "Why" for five times. Nowadays, root cause analysis is widely used in health care to deal with medical errors and clinical incidents [12-13].

B. Change Management

Change management is the process, tools and techniques to manage the people side of change to achieve the required business outcome. It includes methods that redirect or redefine the use of resources, business process, budget allocations, or other modes of operation that significantly change a company or organization. Change is a constant issue in healthcare, and change management has been applied by some organizations to maintain a competitive edge in the health care market [14-15]. In fact, change management is an essential work to be done in health care industry, since one of the key concerns in health care management is management of change and health care professionals are obligated both to acquire and to maintain the expertise needed to undertake their professional tasks [16].

There are many famous models in change management, here three popular models which focus on people's action and aim to deal with the people side of change were chosen—The ADKAR model, Kotter's 8-step model and Lewin's 3-stage model [17-23]. All of them have been used successfully in different cases. Each of them may have different point of focus and can be suitable for different situations, so it is critical to choose the most appropriate one for a specific organization [24].

C. After Action Review (AAR)

The AAR process was firstly developed by the military as a method of providing feedback after unit collective training exercises for everyone to learn quickly from soldiers' experiences in the field [25]. It is a professional discussion of an event, focused on performance standards, that enables a group of people to discover for themselves what happened, why it happened, and how to sustain strengths and improve weaknesses. After the discussion, the knowledge was shared and each member got the lesson learned, which is one of the characteristics of learning organization [26]. AAR is now widely used by non-military organizations, which involves a systematic debriefing after every mission, project, or critical activity. It can also play an important role in health care industry. Some researchers use AAR method to conduct health care education like post-simulation debriefing and medical curriculum [27-28].

III. Research Methodology

Qualitative methods were used in this research to firstly analyze the root cause, then create the change management model and finally improve the model after the test.

A. Participants

The problem was found by the pharmacist who analyzed the prescriptions and give suggestions to doctors; the focus group in this research is 4 doctors who have the right to give prescriptions in outpatient pediatric; the manager and all of the employees were involved to make collaboration to help reduce antibiotic overuse.

B. Data collection

Firstly, an interview with the pharmacist was conducted to analyze the situation of the problem. Some questions like "What do you meaning by using the phrase overuse of antibiotics", "Is there any evidence to show the overuse", "Why did it happen" and "What can be done to solve the problem in your opinion" were asked to get more explanation about the issue.

Then a focus group discussion was organized, gathering the 4 doctors together to talk about the root cause of antibiotic over-prescribing. The questions during the discussion were developed with "5 Whys" technique, just kept asking "why" begin with "why did you overuse antibiotics when prescribing?" until the root cause was conveyed. After that, the solutions were asked according to the cause.

Three popular models (the ADKAR model, Kotter's 8-step model and Lewin's 3-stage model) which focus on people's action and have been used successfully in different cases were chosen to do a comparative analysis in this research. The similarities were found through analyzing the strengths and weaknesses of each model. After that, a new

model which is suitable for the hospital was built combined with the root cause.

C. *Data validation and evaluation*

Participant validation, also known as member checking, is a technique for exploring the credibility of results in a qualitative research [29]. The interview and discussion results were returned to the participants to check back for the accuracy. Besides, the model was tested by the hospital after an action plan was made. Finally, after action review was conducted through a facilitated discussion with members of the team responsible for the change management to evaluate and improve the model.

IV. Research Findings

A. *The root cause of antibiotic overuse*

Actually, although the doctors already know that they should stop over-prescribing antibiotics, they haven't made a change and kept giving unnecessary antibiotics. According to this, the root cause analysis was conducted among the doctors to asked "why did you still give unnecessary antibiotics" by 5 Whys tool as the figure below, and finally get 2 critical cause—poor collaboration and parents' wrong cognition to antibiotics. Based on the two cause, the change management process will get all of the doctors, pharmacists and nurses involved to work together in giving education to parents, so that the parents will understand doctors if they refuse to give antibiotics to their children.

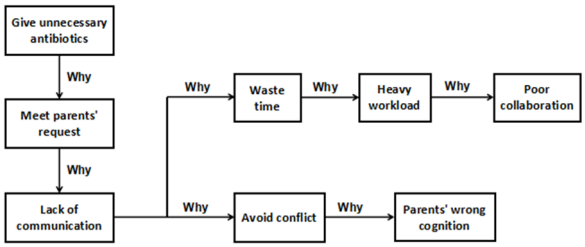

Fig.1. Results of 5-whys analysis

B. *Creation of the change management model*

TABLE I. Comparative Analysis of Three Models

Model	Pros	Cons	Similarity
The ADKAR Model	Key elements for successful change	An individual change management model	1. Stressing the need to raise people's awareness for change. 2. Including some suggestion for preparing, managing and reinforcing a change. 3. Emphasizing overcoming resistance to change.
Kotter's 8-step Model	Specific steps for leading change	Too many steps and may be time-consuming	
Lewin's 3-stage Model	Other two models match in the three stage of change	Too simple to help plan the details of the change	

After analyzing the features of each model in the literature review part, the comparative analysis was made to see what similarities and differences exist. The result was shown in the table above. According to the table, each model has its strengths and weaknesses, that is why we needed to create a new model according to the situation of the hospital, instead of just choosing one of them. The similarities of the three models were some indispensable part of the change management model, including raising awareness for change through make people know that a change must be made and why it is important; preparing, managing and reinforcing the change; and overcoming the resistance to change.

Finally, a primary 6-step change management model was made to deal with the root causes of antibiotic overuse. As to the poor collaboration, they need to get all of the employees (nurses, pharmacists, doctors) involved and work as a team to discuss what do they need (knowledge, skills) and how to acquire them (learn). In order to correct parents' wrong cognition, they need to get the parents involved through education and communication.

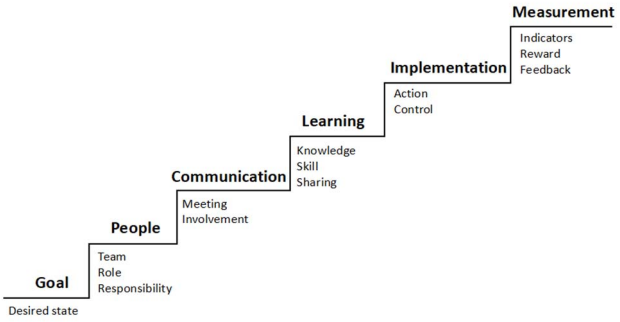

Fig.2. A primary 6-step change management model

The model gives six simple steps to manage an organizational change, which include "Goal, People, Communication, Learning, Implementation and Measurement". The first step is to set up the goal of change, then people with different roles like the target group, the manager and the change leader team are chosen and responsibilities were arranged to them. The third step is communication, which means the people involved need to communicate with each other to get an understanding of the change and discuss about the knowledge and skills that needed for change. Next is the learning part, during this step, the employees will learn and share about how to communicate with parents and the knowledge needed to convey to parents. After that, the implementation part is needed to give more communication and less antibiotics to children and parents. Last but not the least, the measurement part was created to measure and evaluate the change, with some measurable indicators to show whether the change is successful or not. And finally, the one who does the best should be given rewards and the feedback from employees needs to be collected to improve the change management.

C. After action review

The hospital organized a campaign to conduct the model following the action plan presented in the Appendix. The action plan gives specific information about what, how, when and who to do in each period of the model. After the action plan was made, the manager has adjusted it to be more feasible to apply for the hospital. The successful indicators are given in each step of the action plan to ensure that progresses were made to achieve the objective.

After the campaign was finished, there's a meeting for the change management team members to discuss about what happened, why it happened and how it can be done better during this process. The manager set up the goal to reduce antibiotic utilization rate from 65.3% to 50%, but they only reduced it to 52.6%. Although it failed, we can see the possibility that change management can help to reduce antibiotic overuse in the hospital. According to the leading team, the main reason why they didn't achieve the goal is the limited time and communication. Besides, the doctors said that they need the demonstration in a real scenario to learn some practical communication skills.

As to the suggestions to improve the model, they said each stage should involve the communication part, especially for the "Implementation" stage, they need some communication opportunities like the weekly meetings to summarize the performance and experience of each doctors so that they can learn from others and make improvements during this stage. Furthermore, the manager suggested that the model can be a circular one, since if the goal is not achieved, they need to come back to the first stage "Goal" to reset a goal and conduct the following stages again, so that the change can be continued and sustained.

Finally, according to the suggestions, the model was changed into a circular one as the image shown below, with the "Communication" stage in the center to make sure that each step must involve some communication parts.

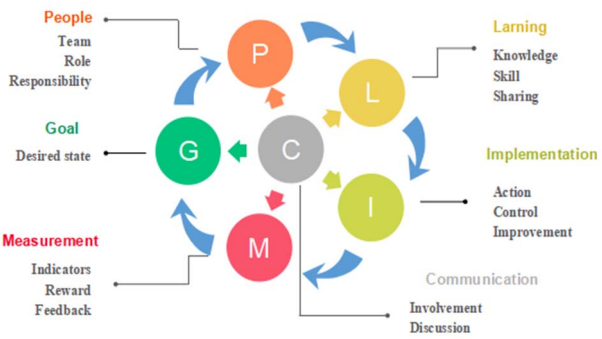

Fig.3. An improved change management circle model

□. DISCUSSION

This study explored an appropriate change management model for the hospital to help the doctors reduce unnecessary antibiotic prescriptions. The main component of the research is the process of creating, implementing and improving the model. At first, the primary 6-step model was created based on the similarities of other three popular models and the root causes of antibiotic over-prescribing in

outpatient pediatrics. And then, the model was put in use by organizing a campaign with the action plan. After that, we conducted after action review to evaluate the organizational performance during the campaign and finally adjusted the model according to the suggestions for improvement.

According to the discussion in after action review, the doctors said that they need the demonstration in a real scenario to learn some effective communication skills to deal with the real situation. During the last period of the campaign, the doctor who made the most reduction on antibiotics has been found and rewarded. Future research is needed to capture the experience and knowledge of this doctor and transfer the knowledge to the other doctors in pediatrics.

Future researches are needed to interview the best performer about some talking skills like technique, attitude or materials and record the dialogue between parents and the doctor in the real situation. A video of the dialogue can be made to be a demonstration and teaching material for both doctors and parents, so that the doctors will learn more efficiently and the parents can be educated and acquire some useful knowledge of antibiotic usage. Moreover, the improved model for change management still needs to be tested in the hospital.

The model can give a reference for such small hospitals to plan an organizational change management for the new policies, such as the changing standard of antibiotic utilization rate. The 5 stages in the circle “Goal, People, Learning, Implementation, Measurement” are necessary for organizing a change management activity, and the central element “Communication” is vital for each stage. If the result did not match with the goal, the organization needs to go back to the “Goal” stage and finish the loop again.

The main problem of change management is that some of the employees are unwilling to change, which may be called defensive routine. Many change management models are focused on dealing with defensive routine by building awareness of the need and desire for change. In this case, reason why the doctors didn’t want to change their prescribing habit was found by root cause analysis in advance and helped them solve the problems during change management process, so that they have no excuse to refuse the change.

The limitation of the study is that the method of analysis and the change management model may be difficult to implement for large organizations with hundreds or thousands of employees. It may take too much time to cope with the defensive routine and get everyone involved to make joint effort to make the change.

. CONCLUSION

In summary, this study provides a new model for managing change of prescribing behavior in a small hospital. The model was proved to be effective for the reduction of antibiotic utilization in the first trial and has been improved after the implementation. Although the second trial is still needed to prove the validity of the model, it could give possibilities that other hospitals can use change management to deal with the overuse of antibiotics. Besides, other small-scale organizations can take this model as reference to manage organizational change to achieve their goals.

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REFERENCES

[1] WHO global strategy for containment of antimicrobial resistance Geneva: World Health Organization; 2001

[2] World Health Organization. World Health Day 2011—Combat drug resistance: no action today means no cure tomorrow. http://www.who.int/mediacentre/news/statements/2011/whd_20110407/en/

[3] World Health Organization . The World Medicines Situation 2011—Rational Use of Medicines. WHO; Geneva, Switzerland: 2011.

[4] Xinhua.(2011,October 20). Antibiotics 'heavily overused' in China. http://www.china.org.cn/china/2011-10/20/Content_23675875.htm

[5] Wang, L., Zhang, X., Liang, X., & Bloom, G. (2016). Addressing antimicrobial resistance in China: policy implementation in a complex context. Globalization and health, 12(1), 30.

[6] Yin X., Song F., Gong Y., Tu X., Wang Y., Cao S., Liu J., Lu Z. A systematic review of antibiotic utilization in China. J. Antimicrob. Chemother. 2013;68:2445–2452.

[7] Xinxin Xie, Qingting Yang, Manhua Kuang, Yang Liu, Tao Zhang, Gangqiang Li, Weiqing Rang. Analysis of the Status of Antibiotics Use of Children in China From 2004 to 2015[J]. Central South Journal of Medical Science, 2016, 44(02): 130-134.

[8] Wei F., Yi S., Junan S., Zuxun L. Analysis of rational use of drugs and management measures in rural township hospitals. Chin. Health Econ. 2004;23:25–2

[9] Ding D, Pan Q, Shan L, Liu C, Gao L, Hao Y, et al. . Prescribing patterns in outpatient clinics of township hospitals in China: a

comparative study before and after the 2009 health system reform. Int J Environ Res Public Health (2016)

[10] Connelly L M. Root cause analysis[J]. Medsurg Nursing, 2012, 21(5): 316.

[11] Serrat, O. (2017). The five whys technique. In Knowledge solutions (pp. 307-310). Springer, Singapore.

[12] Uberoi R S, Swati E, Gupta U, et al. Root cause analysis in healthcare[J]. Apollo Medicine, 2007, 4(1): 72-75.

[13] Nicolini, D., Waring1, J., & Mengis2, J. (2011). The challenges of undertaking root cause analysis in health care: a qualitative study. Journal of health services research & policy, 16(1_suppl), 34-41.

[14] Campbell, R. J. (2008). Change management in health care. Health Care Manager, 27(1), 23-39.

[15] Free C, Phillips G, Galli L, et al. The effectiveness of mobile-health technology-based health behaviour change or disease management interventions for health care consumers: a systematic review[J]. PLoS medicine, 2013, 10(1): e1001362.

[16] Al-Abri R. Managing change in healthcare[J]. Oman medical journal, 2007, 22(3): 9.

[17] Hiatt, Jeffrey M. (2006). ADKAR: a model for change in business, government and our community. Loveland, CO: Prosci Research.

[18] Calder, Ashley May, "Organizational Change: Models for Successfully Implementing Change" (2013). Undergraduate Honors Theses. Paper 144.

[19] Auguste J. (2013) Applying Kotter's 8-Step Process for Leading Change to the Digital Transformation of an Orthopedic Surgical Practice Group in Toronto, Canada. J Health Med Informat 4: 129. doi:10.4172/2157-7420.1000129

[20] Kotter, J. P. (2012). Leading change. Harvard business press.

[21] Lewin K. Group decision and social change[J]. Readings in social psychology, 1947, 3(1): 197-211.

[22] Burnes B. Kurt Lewin and the planned approach to change: a re□ appraisal[J]. Journal of Management studies, 2004, 41(6): 977-1002.

[23] Lorenzi N M, Riley R T. Managing change: an overview[J]. Journal of the American Medical Informatics Association, 2000, 7(2): 116-124.

[24] Todnem By, R. (2005). Organisational change management: A critical review. Journal of change management, 5(4), 369-380.

[25] Morrison J E, Meliza L L. Foundations of the after action review process[R]. INSTITUTE FOR DEFENSE ANALYSES ALEXANDRIA VA, 1999.

[26] Garvin D A, Edmondson A C, Gino F. Is yours a learning organization?[J]. Harvard business review, 2008, 86(3): 109.

[27] Sawyer T L, Deering S. Adaptation of the US Army's after-action review for simulation debriefing in healthcare[J]. Simulation in Healthcare, 2013, 8(6): 388-397.

[28] Jennings, B., Killeen, T., & Miles, S. (2018). Applying the After Action Review (AAR) method to undergraduate medical curriculum development. In AMEE International Conference(p. 509).

[29] Birt, L., Scott, S., Cavers, D., Campbell, C., & Walter, F. (2016). Member checking: A tool to enhance trustworthiness or merely a nod to validation? Qualitative Health Research, 26, 1802–1811.

Knowledge Model Based on Destination Management System Framework For Chinese Gay Tourist in Bangkok by Using Knowledge Engineering

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***Abstract*—This study is to describe how the knowledge model based on the Destination Management System framework by using Knowledge Engineering can develop the Chinese gay tourist's travelling efficiency when they carry the gay-leisure aspect at the Bangkok. Knowledge engineering methodology provides the process to identify the problem and elicit the knowledge from the experts' experience, research articles, and documents. The knowledge model based on the Destination Management System(DMS) framework matches the needs and requirements of the knowledge worker. The ontology identification and development to organize, distribute and utilize the knowledge were followed by the knowledge worker and expert needs which under the framework of the DMS.**

Keywords—DMS, knowledge engineering, ontology, CommonKadS

I. INTRODUCTION

Over the past decades, tourism has experienced continued growth and diversification to become one of the faster-growing economic sectors in the world, accounting for 7 % of worldwide exports, one in every eleven jobs and 10% of the world's GDP[1]. For nowadays, the industry of tourism in China is booming than before. Chinese tourist made 130 million overseas trips in 2017, with total spending amounting to $115 billion[2]. China has maintained the status of the world's largest source of outbound tourism tourists for many years. China is considered to the world's fastest-growing tourism market. Thailand is one top destination for Chinese outbound tourists in 2017[3]. According to a recent report by Juwai.com, Thailand is perhaps the most tolerant country in Asia, and Bangkok is known as Asia's gay capital, viewed as a gay-friendly haven for Chinese tourists.[4] But after doing the questionnaire for the Chinese gay tourist who has traveling experience at Bangkok, then it shows that most of the Chinese gay tourist are having a lower traveling efficiency due to the information fragmentation of gay-related aspect.

Information & Communication Technologies (ICTs) have transformed the tourism industry into the new chapter. The fast development of information and communication technology have set a brand new competitive environment for the tourism industry. Destination Management System(DMS) is developed by the technological innovation of ICTs. The DMS is the inter-organizational information systems used for the collect, the storage, the manipulation and the distribution of all kind of information in all its forms. Aims to support the development and management of tourism destinations through the facilitation and fostering of collaboration practices among the numerous destination stakeholders. It means the DMS can collect and distribute the gay-related information to the Chinese gay tourist which Based on the framework of the Destination Management framework by using the knowledge engineering methodology for design the knowledge model. The applicable ontology is based on the framework of the DMS that offering the information about Hotel, Restaurant, Gay spot, Event concept so as to efficiently characterize knowledge of the effective gay-related information as an appropriate knowledge. Consequently, the Destination Management System is designed using ontology as knowledge representation to support and distribute the gay-related information to Chinese gay tourist who wants to travel at Bangkok.

II. LITERATURE REVIEW

2.1. Destination Management System Concept

Even though there has no universal definition about DMS. But there is still have some view and opinion from different researchers about what is their understanding of DMS. Destination Management Systems (DMS) stands for a personalized communication network between tourism organization, guest and service providers on the spot. It is a collection of computerized information, interactively accessible, about a destination; an integrated local information system which enables to gather information on services, events, tourism-related and non-tourism products[5]. DMS can be described as the IT infrastructure of the DM0 and should be an enabling mechanism to integrate the different services and products from the tourism industry[6]. The DMS also can be involved with commercial and marketing activities. "DMS is the IT infrastructure used by a destination organization for the collection, storage, manipulation and distribution of information in all its forms, and for the transaction of reservations and other commercial activities" by the definition of Pollock[7]. It explains the DMS is not only focused on the information collection and distribution. It also focuses on the function of e-business, the DMS should be able to do the reservation and other commercial activities. Therefore, the accessibility of DMS should be open to the world.

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In addition, the framework of the DMS should be comprised provide complete and up-to-date information a particular destination. They should be capable of handling both the pre-trip and post-arrival information, as well as of integrating availability and booking service too.

2.2. Ontology as Ontological Commitment

" ontology is an explicit specification of a shared conceptualization that holds in a particular context[8]." Ontology can be used to elicit the construction of knowledge. The specification of a conceptualization explains approaching the domain knowledge, not specifically the formal of associations in the knowledge. Therefore, ontology is used for developing the specific terms and modelling linguistic to indicating the conceptualization.

Basically, in the Knowledge Engineering methodology. The function of the ontology is to enable the structure of the domain knowledge. And ontology distributes a terminology of terminologies and relationships by which to structure the knowledge. Ontologies are fundamental facilitating equipment aimed at to construct the knowledge model and Semantic Web[9]. Ontologies were established in the Artificial Intelligence(AI) to enable knowledge distribution and utilization.

In information systems and artificial intelligence, where an ontology refers to a specific vocabulary and a set of explicit assumptions about the meaning and usage of these words, then an ontological commitment is an agreement to use the shared vocabulary in a coherent and consistent manner within a specific context[10]. In other words, an ontological commitment is a decision to adhere to a certain interpretation of a language in some domain; it is a mechanism to help ensure that a given model written in a given language communicates exactly and only what was intended by the model developer. Sometimes the domain knowledge is difficult in representing "common sense" knowledge held by the average individual, which is often incomplete, inconsistent, or even incorrect. Then the ontological commitment can help the robustness, complexity.

2.3. Knowledge Engineering and CommomKADS

Knowledge engineering (KE) developing and keeping knowledgeable assets[11] is associated for the purposes of knowledge engineering that provides knowledge modelling, continue storing and reuse knowledge. The early stage of knowledge engineering was the constructing of knowledge with the structure of the knowledge-based systems(KBS). This is not the circumstance in process of KM, as the consequence of a KM approach may not be a knowledge management system or not even a computer-based system. Notwithstanding, information technology plays a significant role in knowledge management.[12]

KE declare the complex of the construction but will define the process that the clarification of expressing the process is to express in the knowledge management system the knowledge will associate with the development surely. The knowledge engineering methodology is to allow the knowledge worker and expert to decide the needs and approaches to complete the needed task and deliberate the task the knowledge level.

In this research, the knowledge from Chinese gay tourist who had the rich gay-related tourism experience in Bangkok is an appropriate source for gay-related tourism in Bangkok domain knowledge that trusts on the specialist knowledge. KE approach is a method of extracting and capturing and experience from the specialist. Also the approach of KA process, modelling, representation, and utilization[13]. This study focuses on CommonKADS as a tool for KE methodology to capture, construct and utilize the knowledge.

The CommomKADS methodology is served for the approach to organized KE. It focuses on the allocates and uses their experience assets, and consequently provides tools for sharing knowledge management process. CommonKADS also offers the development of knowledge-based systems which offer designated segments of the business process[14].

The CommonKADS model has various parts, for example, the organization model, task model, agent model, knowledge model, the communication model, and design model. In this study, we emphases on the knowledge model to construct appropriate knowledge of gay-related tourism in Bangkok for Chinese gay tourist and ontology development based on the concept of DMS framework.

III. METHODOLOGY

This study aims to use the DMS framework based on the knowledge model using the knowledge engineering to help the Chinese gay tourist's traveling efficiency when they travel at Bangkok with the gay-leisure aspect. The ontological commitment can facilitate the design of the DMS also were utilized as knowledge representation (KR) to design Semantic Web as DMS for disseminating knowledge to the Chinese gay tourist. The conceptual framework of this research is shown in *Fig. 1*.

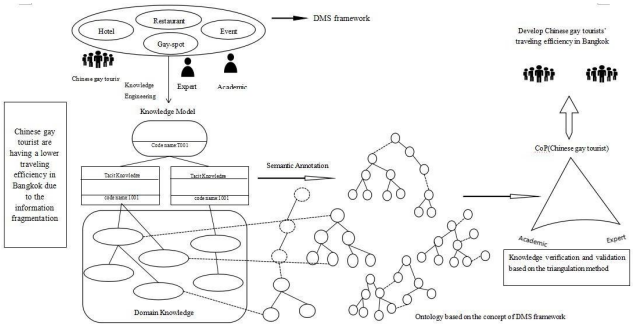

Fig.1. The conceptual framework

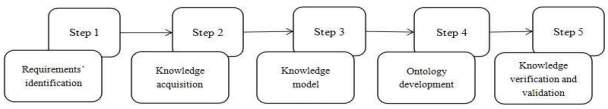

Fig.2. The research framework

3.1. Requirements' Identification: Step 1

This stage describes the online interview with the questionnaire method through the platform of the Blued with the Chinese gay tourist who has experienced before to analyze the problem they were facing when they travel at Bangkok. After identifying the problem will use the more in-depth interview to analyze the difference of the requirements from the Chinese gay tourist. Those requirements will include what the different choice of the hotel, restaurant, gay-spot, and also the event they will prefer to book or visit

which based in Bangkok. Destination Management System(DMS) is the IT infrastructure used by a destination organization for the collection, storage, manipulation and distribution of information in all its forms, and for the transaction of reservations and other commercial activities. The function of DMS like information collection and distribution about the gay-related hotel, restaurant and spot can achieve their needs for this aspect. And for the function of reservation and other commercial activities, the Chinese gay tourist can use DMS to book the hotel which they prefer after receiving the information of the hotel within the DMS. Then the framework of the DMS can perfectly match their requirements.

3.2. Knowledge Acquisition: Step 2

Knowledge acquisition is the process of identifying and eliciting knowledge from existing source. Normally it ' s come from the domain expert. The domain expert in my case is the Chinese gay tourist who has the traveling experience in Bangkok before. Because they know a lot about the domain knowledge of how to travel in Bangkok when they carry the gay-related leisure aspect. It also means that they are reliable on this domain knowledge. Those people who are has experienced before will be formed as a group on the platform of Blued as the Community of Practice(Cop) to share the information and experience. They are the expert who comes to Bangkok at least three times already with carrying the gay-leisure aspect. And they will be interview within this group. As stage 1, after identifying their actual requirements for the travel guide information in Bangkok. The next step is will give them a more in-depth interview about the difference of the requirements, also the useful gay-related information they can provide when they travel in Bangkok before. Then analyze the information they give within the interview, then identify and extract relevant items of knowledge. The effective information will be able to turn into action. But all the knowledge acquisition process will be under the framework of the DMS.

3.3. Knowledge Model: Step 3

CommonKADS offers methods to create descriptions of knowledge-intensive tasks within the overall process as well as techniques for detailed knowledge analysis, knowledge development and knowledge storage. And the knowledge model within the CommonKADS will give an implementation-independent description of knowledge involved in a task. The knowledge will be categories into three parts: Domain knowledge; Inference knowledge; Task knowledge. In this research, the task is to design the DMS for the Chinese gay tourist, and the framework of the DMS will match the needs of the requirements from them. The inference knowledge will be divided into 4 aspects: Design the structure of the DMS; Elicit the useful gay-related information and add the commercial activity within the DMS; Choose the appropriate communication channel; The design elements for the DMS. The domain part will provide the relevant information and knowledge based on the inference. The ontology will be developed after based on the knowledge model as the knowledge representation (KR) to design the DMS.

3.4. Ontology Development: Step 4

This stage of the method developed the specific vocabulary and a set of explicit assumptions about the meaning and usage of these words via ontological commitment with Chinese gay tourists and the expert in tourism, also the academic in KM. This study recognized the Chinese gay tourists' jargon that specific terminology and particular conceptualization in their domain knowledge, subsequently the ontology knowledge construction to acquire the knowledge of the Chinese gay tourist. The ontological commitment is to building the shared vocabulary to make the three-party(Chinese gay tourist; Expert; Academic) all understandable and agreed with.

3.5. Knowledge Validation and Verification: Step 5

Verification and validation can be regarded as a collection of methods and a related procedure. And the triangulation method will be the method to verify and validate the knowledge. Triangulation method involves using more than one observer, interviewer, coder, or data analyst in the study. Confirmation of data among investigators, without prior discussion or collaboration with one another, lends greater credibility to the observation. The investigators of this case will be involved with three parts: Cop(a group of Chinese gay tourist who has the traveling experience in Bangkok); The expert who is expertise in knowledge engineering and tourism part; The last part is the academic who read about this research. This three-party will decrease the potential of bias in gathering, reporting, coding, or analyzing of the data and contribute to internal validity, also add to reliability.

IV. RESEARCH RESULTS

4.1. Requirement identification from the Chinese gay tourist who has multiple travel experiences in Bangkok.

For the Chinese gay tourist who has multiple travel experiences in Bangkok will be treated as the expert in this case. The requirements identification is based on their feedback through questionnaire and in-depth interview. From the first step of the questionnaire is to find the evidence show that the Chinese gay tourist having a lower traveling efficiency with the gay-leisure aspect is due to the information fragmentation when the plan to travel first. The result from the questionnaire is proving this problem is really exit. Then the next step of the in-depth interview through the platform of the most popular gay application of Blued is to get the specific requirements for what are their specific requirements for the travel information guidance. The result from the in-depth interview shows that they want to know more information about the accommodation who are gay-friendly, the restaurant who are gay friendly also, and the gay-spot information and the different type of the event around Thailand. Furthermore, it will have more details to provide in each subject.

4.2. Destination Management System can match the needs of the Chinese gay tourist.

After the process of identifying the problem and figure out what is their actual needs in gay-related tourism in Bangkok. It shows that the function of the Destination management system will match the needs of the Chinese gay tourist. Because the DMS stands for a personalized communication network between tourism organization, guest and service providers on the spot. An integrated local information system which enables to gather information on services, events, tourism-related and non-tourism products

and also provide the commercial and marketing activities. It means that the DMS can be a platform to distribute the effectiveness information to the people who want to get the gay-related information in Bangkok. And the people who access the DMS also can link to the booking website which is suitable for the Chinese gay tourist payment habit to book the gay-friendly hotel to what they are like. So, the function of DMS are surely matching the needs of the Chinese gay tourist who are want to travel to Bangkok.

4.3. Knowledge modelling based on the framework of DMS.

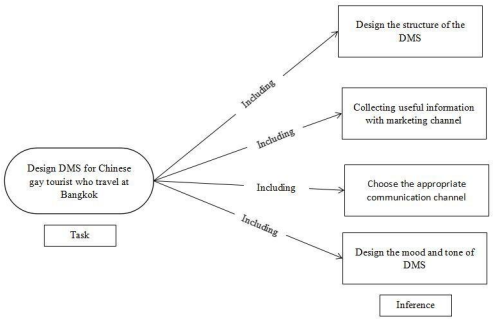

Fig.3. The knowledge-intensive task, inference structure based on the DMS framework

The knowledge elicitation from the expert of Chinese gay tourist who has the experience in Bangkok and for the expert who has the knowledge of tourism. In this study has one task for design the structure of DMS for Chinese gay tourist who travel at Bangkok. This task was modeled into task, inference, domain knowledge from the expert who are expertise in tourism.

The inference of the knowledge model will include four aspects: Hotel, Restaurant, Gay-spot and Event. This knowledge model results came from interviewing experts to capture the accuracy gay-related information within Bangkok with reviewing, capturing and collecting existing knowledge on the academic researches to elicited knowledge of gay-related tourism based on the framework ofDMS.

4.4. Ontology identification and development based on the DMS framework.

When tacit knowledge of experts in tourism of gay-leisure aspect on Bangkok was elicited by means of CommonKADS as knowledge engineering methodology, this ontology recognition stage concentrates on the Chinese gay tourist(expert) who have the rich experiences in Bangkok that is specialists ’ terminology in their domain knowledge, subsequently the ontology established on the gay-related information for Chinese gay tourist associated to terminologies of specialists and established on DMS framework. The DMS framework ontologies originated from the concept of the form of the IT infrastructure also involved with the commercial and marketing activities. It can be realised in *Fig. 4* the inference 1 and the knowledge were identify based on the concept of the DMS framework.

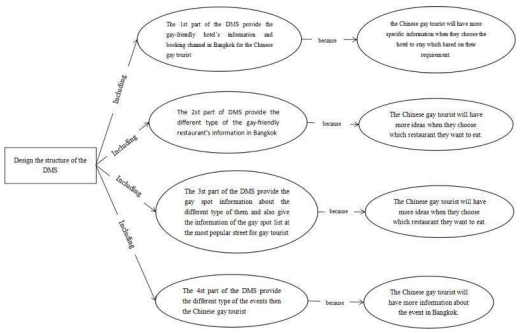

Fig.4. The example of inference 1 and domain knowledge based on the DMS framework.

This research identified and developed the first version ontology which is the specification of conceptualization of the knowledge of gay-related tourism in Bangkok for Chinese gay tourist based on the the needs of Chinese gay tourist which is follow by the DMS framework. The version 1 ontology in the *Fig. 5*, the domain knowledge and ontology is in the light gray circle. The ontologies from the version 1were minimized and then enhanced ontology into the suitable ontology for knowledge worker on gay-related tourism in Bangkok for Chinese gay tourist to learn and comprehend experts’ experience(jargon) and suitable ontologies to design the Destination Management system. Subsequently, the minimized and suitable ontology on the gay-related tourism in Bangkok for Chinese gay tourist in this step would be returned to identify and develop ontology step to modify the secondary form of DMS ontology which was sophisticated in an effectual ontology form for knowledge workers and to design DMS. The instance of ontology and domain knowledge validation and modification are shown in *Fig. 5* , this is the new domain knowledge and new ontology in the dark gray circle. The ontology version 2 will provide more specific conceptualization relationship between each subject based on each parties requirements. And it will make each party have a better understanding of the DMS. Furthermore, the ontology could be validated and modified again and again until reaching the minimized ontology version of study requirement. Then the minimized ontology version is modeled in an effective ontology version as ontological commitment to design the Destination management system.

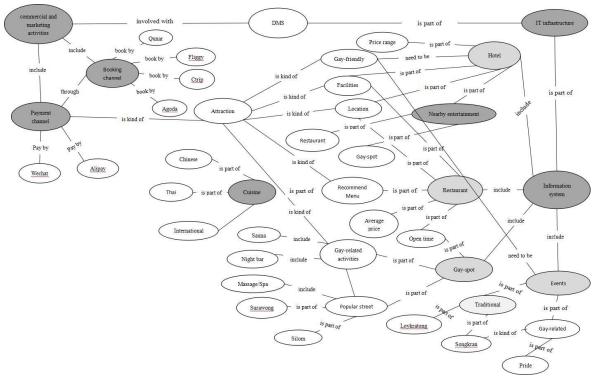

Fig.5. The example of ontology identification and development based on the DSM framework.

Ontological commitment is an agreement to use the shared vocabulary in a coherent and consistent manner within a specific context. In my research, the ontological

commitment showed in some shared vocabulary be added in the ontology version 2. it will make the experts who in the different filed like tourism part and knowledge management part have the common understanding of the subject which will put in this DMS. And it also will help to utilize the ontologies to enable knowledge an information distributing that needs understanding between the components of the ontologies fundamental the domain knowledge.one of the main concept for ontologies is that they will be able to exchange the knowledge between knowledge workers who are gonna to access the DMS.

4.5. Ontology Knowledge Validation and Verification by the triangulation method.

The triangulation method is this research is meant to use three different filed of experts to check the results of one and the same subject. And the three different filed of experts which are represented from the CoP group who have had the rich gay-related tourism in Bangkok and the expert who is specialized in Knowledge Management area, also the expert who is specialized in the professional in tourism academic. The CoP group will check the content in the DMS is appropriate or not and meet their requirement or not. And the expert in KM filed will exam the KM methodology and the tool for KM are appropriate or not. Furthermore, the expert in tourism filed will be exam the concept and the function of the DMS are appropriate or not. After getting their opinion and suggestion will do more adjustment for the DMS.

V. DISCUSSION AND CONCLUSION

Knowledge model based on Destination Management System framework for Chinese gay tourist in Bangkok by using Knowledge Engineering in this study is to develop their traveling efficiency due to the information fragmentation. Knowledge engineering is used to allow the knowledge worker and expert to decide the needs and approaches to complete the needed task and deliberate the task the knowledge level. And to extracting and capturing and experience from the specialist who is familiar in gay-related tourism in Bangkok. And the knowledge model within the CommonKADS will give an implementation-independent description of knowledge involved in a task. The ontologies based on the DMS framework will help the knowledge worker to organize, distribute and utilize the knowledge.

The future work is the Destination Management system will be on developing by using the knowledge model based on the DSM framework.

REFERENCES

[1] World Tourism Organization Second Global Report on LGBT Tourism, AM Reports Volume 3, UNWTO, Madrid, 2017, p.12-17 available at: www.e-unwto.org

[2] China Daily.Chinese Tourist Spend $170b Overseas in 2017:Report. [Online]Available<http://www.chinadaily.com.cn/a/201803/01/WS5a97dc1da3106e7dcc13ef41.html>

[3] H. Lamm,Chinese Outbound Tourism Market. World Tourism Organization Workshop on Chinese Outbound Tourism Market,2018.

[4] Kanana Katharangsiporn. LGBT Chinese flocking to buy Thai property.[Online]Available<https://www.bangkokpost.com/business/news/1529038/lgbt-chinese-flocking-to-buy-thai-property.>

[5] Collins, C. and Buhalis, D. Destination Management System Utilization in England. In: C. Collins and D. Buhalis (Eds.), Information and Communication Technology in Tourism, Vienna/NY: Springer. 2003, pp. 202-211.

[6] Lewis, R. D. modelling Tourism Impacts Using IT Based destination management System. In: K.W. Wober, A.J. Frew and M. Hitz (Eds.), Information and Communication Technologies in tourismViennaINY: Springer. 2002, pp. 97-104.

[7] Pollock, A. New Technologies as Help for Integrated Quality Management. In: European Tourism Forum, Conference Proceedings. Vienna. 1998, pp. 78-87.

[8] Liu, Y., Zheng, X., Tang, F., Chen, X., “Ontology Design with a Granular Approach”, Expert Systems with Applications, 2014, 41(10): 4867-4877.

[9] Uschold M. and Gruninger M. "Ontologies: Principles, Methods, and Applications", Knowledge Engineering Review, 1996, Vol. 11 No. 2, pp. 93-115

[10] Nicola Guarino. "Formal ontology and information systems". Formal Ontology in Information Systems: Proceedings of the First International Conference (FIOS'98), June 6–8, Trento, Italy. IOS Press. 1998, pp. 3 ff. ISBN 9051993994.

[11] Michael J. Marquardt, Building the Learning Organization a systems approach to quantum improvement and global success, McGraw-Hill, New York, 1996.

[12] Michael. H. Zack, Developing a knowledge strategy, California Management Review, Vol. 41 No. 3, 1999, pp. 125-45.

[13] Gilbert J. B. Probst, Steffen Raub, Kai Romhardt, Managing Knowledge: Building Blocks for Success, John Wiley & Sons, Chichester, 2000.

[14] kujiro Nonaka and Hirotaka Takeuchi, The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation, Oxford University Press, 1995.

Creativity Knowledge of Jewelry Design Measurement using Bloom's Taxonomy: Psychomotor Domain

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***Abstract* — A significant major research in Gem and Jewelry Industry of Thailand state that one of the weakness of this industry is designers' lacking of creativity. What is the creativities knowledge of jewelry designer and what are their activities or behavior in design process? This research aim to review creativities knowledge of Thai jewelry designer and examine its situation in minor perspective. This paper review the jewelry designer's creative behavior in design process and the measurement using Bloom's Taxonomy : Psychomotor Domain as the development of designers' physical abilities and skills measurement. The ultimate designer's learning outcome is on origination level which present originality, novelty and innovation. The samples were selected from ordinary jewelry designers and a success case. Both group were assigned to design a new jewelry collection and finished within 6 hours. All their activities and behaviour were directly observed, interpreted and measured their creativity knowledge. The research found that the Bloom's Taxonomy: Psychomotor Domain is an appropriate tool to measure creativity knowledge and creative behavior of jewelry design process. And the experimental study revealed the activities referred to the statement of designers' lack of creativity.**

Keywords—Creativity Knowledge, Creative Behavior, Jewelry Design, Jewelry Designer, The Bloom's Taxonomy : Psychomotor Domain

I. INTRODUCTION

Gems and Jewelry is a product that has made a fortune in many countries. By the end of 2022 the gem and jewelry industry world wild will reach 443,000. US $ million, [1] Gem and jewelry handicraft of Thailand had a long history and evolution. The development of the gold-silversmith production knowledge and skill has distributed in all regions of the country, this knowledge and skill has been transmitted from generation to generation and become a significant career that generates income for Thai people.

Nowadays Gems and Jewelry industry has established as the high export value product as can reach top 4th earned 438,890.7 million Baht in 2017 [2] and generated about 1.3 million jobs nationwide. [3] Thai government has declared for Thailand as The World's Jewelry Hub and governs its policy to develop this industry into a future industry in alignment with the agenda of Industry 4.0 or the disruptive industrial development strategy for the 20-year period (2560-2579). The Gem and Jewelry Industry is included in the group of Creative, Culture & High Value Services. [4] The Efforts to develop the Gem and Jewelry industry will be achieved through the cooperation of all sectors, both public and private and also the furtherance of multidimensional research to find solutions and create competitive advantage.

According to a signifiant research analyzed the situation of the Thai Gem and Jewelry industry using SWOT analysis tool. The result in weakness analysis perspective of this industry is showed the first weakness is about the shortage of raw materials - "The shortage of raw materials in the country has resulted in a high dependence on imported raw materials. And the second weakness is about the quality of design - "Thai designer mostly design by imitate the creative idea from famous international designers via reference from international leading jewelry magazines. They did not create new design by themselves". [5] The result was shown in the same direction as the office of small and medium enterprise promotion (OSMEP) which reported about the weakness of gem and jewelry industry's situation is that "there are limitations on modern design skills and unable to satisfy the new generation's need". OSMEP proposed the programme to develop human resources and skilled workers emphasized on the design process in the second strategy: Skill Development, Design and Development, Process and Product Standards. OSMEP illustrated the structure of production line in Thai gem and jewelru industry as show in Figure1 [6] Do Thai jewelry designers lack of creativity knowledge in design? How do we know that a jewelry designer has creativity? What is the creative thinking and creativity knowledge for jewelry designers? What are their activities in the design process? Those questions are the key knowledge to achieve the goal to be a leader this industry.

In the Gem and Jewelry industry, design process is major task in the production line, in both luxury and consumer markets [7]. The jewelry design process demands various activities for instance investigation, collecting the data and

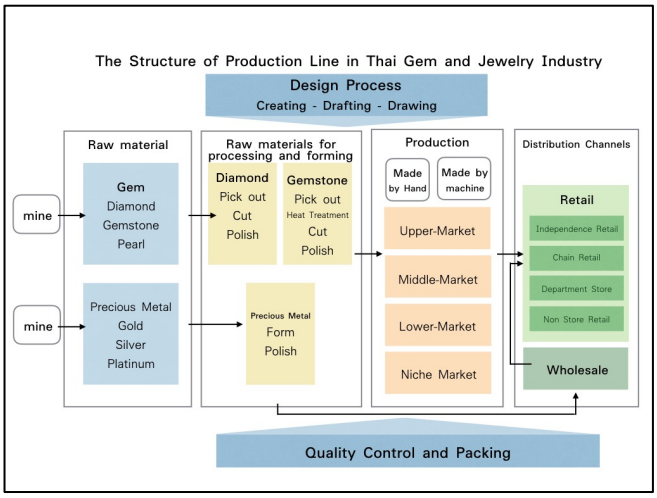

Figure1: The structure of Production Line in Thai Gem and Jewelry Industry

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information, analysis, synthesis, and need art skill such as drafting and drawing. In the design process, designers have to deal with all of these aspects to balance aesthetic and functional of artifacts. Gem and Jewelry Manufacturing is a creativity matter. In the starting of the production line, design process comes first, the outcome of the process is the set or collection as communication visualization normally drawing in paper both 2 dimensions or 3 dimensions. Then the raw materials for processing and forming will be next process. Later in production process, Nowadays in Gem and Jewelry industry two main processes of manufacturing are popular i.e. traditional method and modern method of manufacturing. The jewelry making is hundred percent a human process whereas modern method of manufacturing process is also based on machines, [8] The structure of production line is shown in Figure1. This research focus on traditional method, namely fine jewelry, which mostly made by hand.

This research aims to examine the jewelry designer's creative behavior and creativity knowledge via the tool for measuring using the Bloom's Taxonomy: Psychomotor Domain. This tool refers as the development of designers' physical abilities and skills measurement. The ultimate designer's learning outcome is on origination level which present originality, novelty and innovation. This paper is structured in five sections. First in this introduction section, next section will review creativity knowledge of jewelry designer as the main topic. In section 3 presents the experimental study using Bloom's Taxonomy: Psychomotor Domain as a measurement tool to assessment the creative behavior and creativity knowledge of jewelry designers and then the research finding will be demonstrated and discussed in section 4. Finally, conclusions and future work will be shown in section 5.

II. CREATIVITY KNOWLEDGE OF JEWELRY DESIGN

Jewelry is small decorative artifacts worn for personal adornment. Jewelry can be producted in form of brooches, rings, necklaces, earrings, pendants, bracelets, and cufflinks. Jewelry can be attached to the body or the clothes, all items are valuable durable ornaments. For many centuries precious metal, combined with gemstones, has been the standard material for jewelry making. Jewerly are the personal adornment in both gender, male and female.

Jewelry designer can be identified ranging from fine artist to craftsman. Jewelry designer is a professional who is trained in the aesthetically and functional knowledge of material selections, fabrication techniques, composition shape and form, and also understand marketing, trend and customer. "Jewelry design lies within the intersection between areas such as Product Design and Fashion Design. The jewel is an industrial product; therefore, when creating new collections, fashion trends are usually taken into consideration. On the opposite, jewelries are not ephemeral products such as clothes, shoes, handbags and others items. The jewel is a long lasting product that is known for remaining through generations." [9] The jewelry design is major bottlenecks in the jewelry production process; The clear scope of jewelry design task consists of three step as following creating, drafting and drawing. The jewelry designer should have fundamental skill of knowledge in design such as Line, Colour, Shape, Texture etc. [10]

The global new concept on jewelry design procedure is diverse, "This may be desirable for future employ ability, there is no one particular mix of skills that can guarantee good innovation performance in all circumstances, broadening the mix of skills with teams and individuals from other fields is one way to help innovation to happen" [11]. The collaboration of idea is the key framework of the Jewelry Design Knowledge. "Cross-disciplinary approaches in the creative arts have become increasingly prevalent in the last decade as artists, craftspeople and designers have sought inspiration and innovation through collaboration with scientific and technological disciplines" [12]

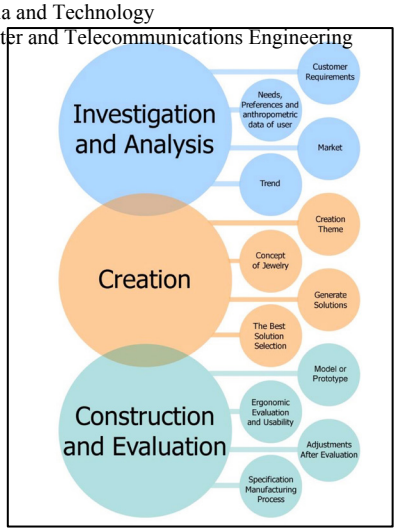

Figure2: "The Method of Jewelry Design" developed by Claudia Regina Batista

Jewelry Design is a task that involves 1) investigation and analysis, 2) creation and 3) Construction and evaluation "It is a collection of tasks established by the designer, who is taking in consideration the generation of new concepts, material selection, the piece's visual aspect and practicality, way before allowing it into the production line."[13] Nowadays emerging method in Jewelry Design Knowledge is adopted such as "The Method of Jewelry Design" proposed by Claudia Regina Batista, a professor in department of graphic expression from University of Santa Catarina, Brazil as show in Figure2. And some method in creative and thinking process such as Design Thinking developed in 2006 by IDEO, Stanford University. The main concept as "designers had to question focus on action rather than theory and on the combination of business issues as viability, and also think about technical issues as feasibility and human issues and finally see values as usability."[14] The design thinking process is analyzed as a system of overlapping spaces rather than a sequence of orderly steps: inspiration, ideation, and implementation or alternatively as empathize, define, ideate, prototype and test. [15] The effectiveness of the Design Thinking is described as "Design thinking reduces the ambiguity and risk present in innovation by involving the customers or users on a series of prototypes to find, test and improve concepts. Design thinkers dwell on users mindsets learned from real-world experiments, not merely recorded data or market research." [16]

The creativity knowledge of any design including jewelry design can be innovation. Innovation can be a new idea, a new way of looking at things, a new method or product that have value and useful. Innovation composes on the idea of output, the idea of producing or doing something differently, making something happen or implementing something novel. "Creativity is an active process necessarily involved in innovation. It is a learning habit that requires skill as well as specific understanding of the contexts in which creativity is being applied." [17] Creativity is the process of making something both novel and useful. The word "useful" doesn't have to mean practical; useful can mean getting to know oneself better or expressing something or allowing anyone access to a particular emotional experience. "Creativity requires a mixture of four components: first an intrinsically motivated person with high domain expertise and high skill in creative thinking and then works in an environment highly supported in creativity." [18] This research aim to examine the jewerly design process and jewelry designers' creative

behavior in all activities and interactive with artefact and environment related to four components as mention above and then measure their creativity knowledge via the Bloom's Taxonomy : Psychomotor Domain.

III.RESEARCH METHODOLOGY

This research utilized the psychomotor domain as the development of designers' physical abilities and skills measurement. The ultimate designer's learning outcome is on origination catalog which present originality, novelty and innovation. The research conducted experimentation in two phases, first phase with ordinary jewelry designer and second phase with success case jewelry designer. The word "jewelry design" in this research is scoped for the design only of fine jewelry, while costume or fashion jewelry is not included and the design for the product with finished made by hand not included by machine.

The first phase focused on reviewing the jewelry design process and justify the exiting problem that Thai jewelry designers are lack of creativity knowledge in jewelry design. The study operated a design process as an usual process for launching a new collection. The samples were selected from the three designers who working in case study organization, NOVA Collection jewelry studio in Chiang Mai Thailand. The procedure started from the designers were obliged to design jewelry on a given topic within six hours and measured effectiveness via The Bloom's Taxonomy: Psychomotor Domain as the assessment tool. Researcher and expert observed the designers's sequence of activities and movements in detail such as how to use any equipment and stationery, how to search for data or inspiration from any sources and how to draft and draw the idea to be a media to communication. Researcher and expert identified that psychical movement and interpretation and evaluation by score the level according to Psychomotor Domain. The second phase focused on the same procedure as the first phase, the differentiation was the sample, which was selected from social network analysis method to find a success case in jewelry design. A veteran jewelry designer was the result of the selection method. He also was obliged to design jewelry on a given topic with in six hours and measured effectiveness via The Bloom's Taxonomy: Psychomotor Domain as the assessment tool. Researcher and expert observed the veteran designer's sequence of activities and movements in detail. The result of both phase were compared and will shown in next section.

"Creative behavior has been viewed as the creative act, or a set of acts, which is made explicit through behavior. Creative behavior is not passive; it is action, which leads to a creative output or a solution to a challenge. Creative behavior is not confined solely to the domain of cognition and thought but rather it is action that yields output that is regarded original and useful."[19] "Creative behavior is also a form of exploration and adaption for the purpose of producing novel and useful outcomes. Creative behavior allows us to explore ways to rearrange features of an experience into something that is joyfully meaningful and novel."[20] The samples performed many movements actions and activities which were observed, interpreted and measured score via level of category the Bloom's Taxonomy: Psychomotor Domain.

The Psychomotor domain is one of three the Bloom's Taxonomy, a learning domains proposed in the 1950's by Benjamin Bloom (1913-1999), an educational psychologist. His vision and objective was to institute a system of categories of learning behavior to accommodate in the design and assessment of educational learning. The group identified three domains of learning composed with 1) Cognitive domain or knowledge category which show in verbal and visual intellectual 2) Affective domain or attitude category which show feelings, values and beliefs and 3) Psychomotor domain of skill category which show physical skill capabilities. Firstly his work focused on the Cognitive domain, which implicates knowledge and the development of intellectual skills. The word "domain" means category, so The Psychomotor Domain means the set of skill based which refers to the learning of skills. The set of skill namely physical skills are the ability to move, act, or manually manipulate the body to perform a physical movement. "This Taxonomy is a structure of classification which can be a list to assist in planning training to cover each development stage of the learner's or worker's growth. Measurements of learning and doing may be scale in terms of speed, strength, endurance, coordination, precision, flexibility, agility, dexterity, manipulation, grace technique."[21] The Psychomotor domain has been revised over the years by R.H. Dave (1970), Anita Harrow (1972), and E.J. Simpson (1972). Each revise has its advantages. This research applied the Simpson's revise as the tool to measure jewerly designer's creativity knowledge and creative behavior. The table below show the classification of movement, action and behavior subsumed by the simplest to more complex in higher levels.

Category	Movement, Activities, Behavior
1. Perception (awareness)	The ability to use sensory cues to guide physical activity. This ranges from sensory stimulation, through cue selection, to translation. Key Words: chooses, describes, detects, differentiates, distinguishes, identifies, isolates, relates, selects.
2. Set	The readiness to act. This is your mindset. It is the mental, physical, and emotional dispositions that make you respond in a certain way to a situation. Key Words: begins, displays, explains, moves, proceeds, reacts, shows, states, volunteers.
3.Guided Response	This is the early stage of learning a complex skill. It is the first attempts at a physical skill and involves imitation and trial and error. Key Words: copies, traces, follows, react, reproduce, responds
4. Mechanism	This is the intermediate stage in learning a complex physical skill or basic proficiency. It is the ability to convert learned responses into habitual actions so the movements can be performed with a medium level of proficiency and confidence. Key Words: assembles, calibrates, constructs, dismantles, displays, fastens, fixes, grinds, heats, manipulates, measures, mends, mixes, organizes, sketches.
5. Complex Overt Response	The ability to skillfully perform complex movements correctly. Complex movements are performed quickly, accurately, and with a minimum wasted effort. Key Words: assembles, builds, calibrates, constructs, dismantles, displays, fastens, fixes, grinds, heats, manipulates, measures, mends, mixes, organizes, sketches.
6. Adaptation	The ability to modify learned skills to meet new or special requirements. The skills are so well developed that learner can modify movement patterns to fit special requirements. Key Words: adapts, alters, changes, rearranges, reorganizes, revises, varies.
7. Origination	The ability to create new movement or activities for a specific situation or problem. Learners are able to develop an original skill from a learned skill. Key Words: arranges, builds, combines, composes, constructs, creates, designs, initiate, makes, originates.

Table1 : The Bloom's Taxonomy : Psychomotor Domain - 7 Categories

This experimental study focus on examination the fundamental performance or original movement and skill of each individual jewelry designers and later to match which action can be related to creative behavior of each jewelry designer or can show their creativity. Researcher and a expert acted as examiner, observe directly to each activities of samples then measure and score via the Bloom's Taxonomy: Psychomoter Domain's category level.

IV. RESEARCH FINDINGS

"Design is the purest exercise of human skill. To add a new instrument or process to the design treasury is to engage in the force of evolving nature. Each new design is a new discovery, conveying a specific truth about our relationship to nature and to each other". [22] This research focus on examination in design as the sequence of activities and movements in detail of jewelry designers using the Bloom's Taxonomy: Psychomotor Domain as the assessment tool measure each their activities. This part shows the research finding as shown in Table2 and analysis of this research that explains the research question.

A. Creative behavior and Creativity Knowledge

From the experimental study in two phases, we can identify some activities as creative behaviour as follow: 1) understand requirement 2) understand customer, trend and market: search information 3) abstract title : create theme 4) articulate story : create meaning 5) analysis of ideas : generate solution 6) evaluation : technical checking 7) divergence : think out of the box 8) synthesis of ideas : select best solution 9) internal visualization : draft the main idea 10) communication visualization : draft the final 11) originate of ideas : drawing the best solution

Each activities can be measured according to the Bloom's Taxonomy: Psychomotor Domain but each one can be interpreted more than one level. "Because the Psychomotor Domain is skill based and refers to the learning of skills"[23], the quality of each activities are not equal in term of skill based. Researcher and expert were aware to this constrain while observe the design process and measure each activities in difference level. The veteran designer can show the sophisticated action, which can be interpreted in higher level of Psychomotor than ordinary designers.

B. Origination level in Psychomotor Domain

This set of activities can be referred as creative behaviour and aims to produce novel and useful jewelry design as outcomes. But not every designer who performs this set of activities can be measured to reach the highest level of Psychomotor. As shown in table2, only veteran designer can perform creativity and reach the origination level in the design process while ordinary designers can reach only adaptation level. Some empirical evident shown in the activity of draft the main idea process, all ordinary designers try to elicit creativity, they used images which downloaded from the internet as the reference to create idea for drafting and drawing. This shows that they acquaint with this process and were not aware that this activity will block their creativity.

According to the weakness analysis perspective from the significant research as mention in Section 1: introduction, which state that "Thai designer mostly design by imitate the creative idea from famous international designers via reference from international leading jewelry magazines. They did not create new design by themselves" or can say that mostly Thai designers are lack of creativity. The observation result from this experimental study can support this statement.

C. Jewelry Design Process Model

The research also found and constructed a jewelry design process model in creative behavior perspective as shown in Figure 3. First, the veteran designer engaged in design process start from acquire all requirement and make sense about the market and customers. He used search engine in the internet to find the right topic to read and do research. His movements were scanning, reading and note taking. Then he sat still for awhile like incubate the ideas from all stimuli. He explored the stimuli to gain understanding and formed and abstract the title and then articulate story or

Jewelry Design process	activities, creative behavior	action	The Bloom's Taxonomy : Psychomotor Domain Category	Level of Psychomotor Domain - Category			
				Ordinary Designer1	Ordinary Designer2	Ordinary Designer3	Veteran Designer
Investigation	understand requirement	begins, proceeds react, respond	2.Set 3.Guided Response	2	2	2	3
Investigation	understand customer, trend and market : search information	react, respond assembles,constructs	3.Guided Response 4.Mechanism	3	3	3	4
Creation	abstract title : create theme	assembles,constructs organizes, sketches	4.Mechanism 5.Complex Overt Response	-	4	4	5
Creation	articulate story : create meaning	assembles,constructs organizes, sketches	4.Mechanism 5.Complex Overt Response	-	4	4	5
Creation	analysis of ideas : generate solution	assembles,constructs organizes, sketches	4.Mechanism 5.Complex Overt Response	4	5	5	5
Evaluation	evaluation : technical checking	organizes, sketches changes, revises	5.Complex Overt Response 6.Adaptation	5	5	5	6
Evaluation	divergence : think out of the box	organizes, sketches changes, revises	5.Complex Overt Response 6.Adaptation	-	-	-	6
Creation	synthesis of ideas : select best solution	changes, revises creates, originates	6.Adaptation 7.Origination	-	-	6	7
Creation	internal visualization : draft the main idea	changes, revises creates, originates	6.Adaptation 7.Origination	-	-	-	7
Creation	communication visualization : draft the final	changes, revises creates, originates	6.Adaptation 7.Origination	6	6	6	7
Creation	originate of ideas : drawing the best solution	changes, revises creates, originates	6.Adaptation 7.Origination	6	6	6	7

Table2 : The Bloom's Taxonomy : Psychomotor Domain - measurement result

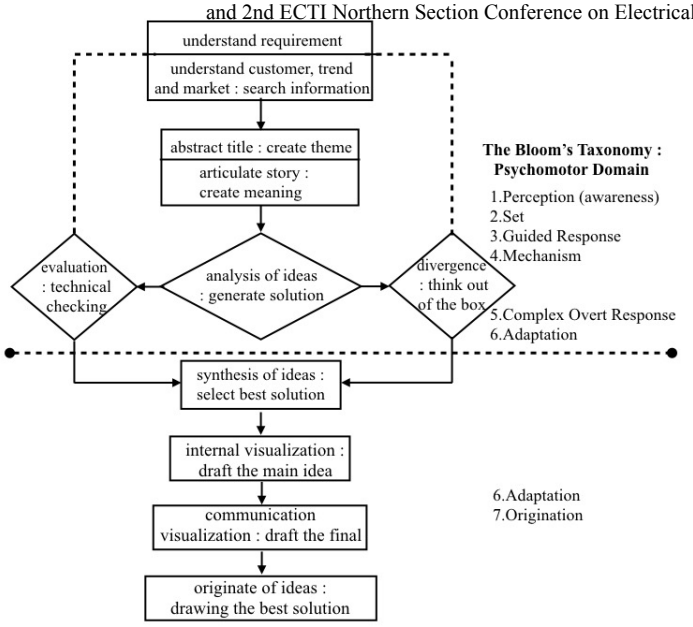

Figure3 : Jewelry Design Process Model

creating meaning for the emerging idea. In this stage the activity of veteran designer was different from the ordinary designers, He showed skill to compose all ideas by write many texts as stories and drafts the design simultaneous while all ordinary designers collected and selected many images which downloads from the internet and copy some detail as inspiration to their design. The veteran designer did not block his creativity with consuming visual stimuli. At this point the veteran designer gained creativity enough for constructing novelty. But before continue to originate this idea, he evaluated the idea and did divergence thinking or "estimate creative potential" [24] At this stage the process can be measure as level adaption and origination in the Bloom's Taxonomy: Psychomotor Domain. Then the designer synthesized the idea to select the best solution and did the final draft and finish drawing to be the final design visualization. This model is not the absolute of final process, merely a suggestion model from a veteran jewerly designer. As result finding from this research. The researcher admire the idea that each designers will find their own process to achieve the goal, create novelty and useful.

V. CONCLUSION AND FUTURE WORK

In summary, the main objective of this paper is reviewing the creativity knowledge and creative behavior of jewerly designers in their design process. This research utilized the Psychomotor Domain as the development of designers' physical abilities and skills measurement. The ultimate designer's learning outcome is on origination level which present originality, novelty and innovation. The result do not aim to show that all Thai jewerly designers are lack of creativity knowledge but show the tool for measurement and gain understanding about that activities as creative behavior. Each movement and behavior can be interpreted according to development of creativity.

The future studies can focus on the elicitation with creativity knowledge or the observation on creative behavior from the veteran jewelry designers or the experts in this domain knowledge. The study will propose how to transfer the intensive knowledge as tacit knowledge to ordinary jewelry designers who need them via learning process. The designers who engage in this learning process will gain this structuring creativity knowledge of jewelry design and will enhance the intensive knowledge and develop their own creative behavior. The learning process can assessment via the Bloom's Taxonomy: Psychomotor Domain as the measurement tool.

REFERENCES

1. TechSci Research, "Global Gems & Jewelry Market, By Type, By Region, Competition Forecast & Opportunities, 2012-2022" Website: https://www.reportlinker.com/d0120818294/Global-Jewelry-Industry.html, [Accessed: September 1, 2018].
2. Gem and Jewelry Institute of Thailand (Public Organization), "The situation of exports of Thai gems and jewelry between January and July of 2018" Pdf retrieved https://infocenter.git.or.th/GemDB_BE/upload/content/31082018.992232_ExportAnalysis_Jan-Jul%2018.pdf, [Accessed: September 1, 2018].
3. University of the Thai Chamber of Commerce, *Gem and Jewelry Census Project*, Gem and Jewelry Institute of Thailand (Public Organization), 2010
4. Ministry of Industry, *Thailand Industrial Development Strategy 4.0 20 Years (2060-2579)*, 2016
5. Chackrit Duangphastra, "Strategic Analysis of Thai Gem and Jewelry Industry Development," *Journal of Managemen*t, Vol. 3, No. 4, Bangkok University Press, 2012, pp. 16-24.
6. Office of Small and Medium Enterprises Promotion (OSMEP), S*mall and Medium Enterprises Promotion Initiative in the Gem and Jewelry Industry*, 2015
7. S. Wannarumon & E.L.J. Bohez,. "Rapid prototyping and tooling technology in jewelry CAD". *Computer-Aided Design & Applications*, 1(1-4) pp.56-57· January 2004
8. Reinhold Ludwig, *Modern Jewellery Design*, Arnoldsche Art Publishers, Stuttgart. 2008
9. K. Niedderer, Y. Imani, & M. G. Overton, "Craft as a Tool for Multidisciplinary Collaboration and Design Practice". 1st Cambridge Academic Design Management Conference.2011
10. Willhelm Lindemann, *Thinking Jewellery*, Arnoldsche Art Publishers, Stuttgart. 2012
11. Design Council,"Multi-disciplinary Design Education in the UK" (Report and recommendations from the Multi-Disciplinary Design Network) retrieved http://www.designcouncil.org.uk/sites/default/files/asset/document/multi-disciplinary- design-education.pdf 2010 [Accessed: September 1, 2018].
12. K. Niedderer, Y. Imani, & M. G. Overton, "Craft as a Tool for Multidisciplinary Collaboration and Design Practice". 1st Cambridge Academic Design Management Conference.2011
13. Claudia Regina Batista, "A contribution for Jewelry Design Teaching" *The Design Journal*, 2017 retrieved https://doi.org/10.1080/14606925.2017.1352973, [Accessed: September 1, 2018].
14. Penny Sparke, *An Introduction to design and culture 1900 to the Present*, 3th ed., Routledge Publication, 2013
15. Hasso Plattner, Christoph Meinel, Larry J Leifer. *Design thinking: understand, improve, apply,* Berlin; Heidelberg: Springer-Verlag.2011
16. Pal Prince, "What Is Design Thinking and Design Thinking Process" Pdf., *Design, UI/UX Design*, 2016 retrieved https://think360studio.com/category/uiux-design/ [Accessed: September 1, 2018].
17. P. Kampylis, E. Berki, E. "Nurturing creative thinking". *International Academy of Education*, UNESCO. pp 6. 2014
18. E. Carayannis, *The Encyclopedia of Creativity, Invention, Innovation, and Entrepreneurship*, Springer Pubication, New York, 2013
19. GJ. Puccio, JF. Cabra. *Idea generation and idea evaluation: cognitive skills and deliberate practice Handbook for organizational creativity*, New York: Elsevier, P. 187–213. 2011
20. D Uribe-Larach, JF Cabra. *The opportunities and challenges of technology driven collaborations : Technology for creativity and innovation, tools, techniques and applications*. Hershey, 2011.
21. L. W Anderson, D.R. Krathwohl, *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives* (complete edition) . Allyn & Bacon. Boston, MA (Pearson Education Group), 2000
22. Robert Grudin, *Design and Truth*, Yale University Press ,2010
23. E. J. Simpson. *The Classification of Educational Objectives in the Psychomotor Domain*. Washington, DC: Gryphon House, 1972
24. JP. Guilford, *Creativity, intelligence, and their educational implications*. San Diego: EDITS, 1968

Analysis of Critical Knowledge in a Coffee Supply Chain

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***Abstract*—Good quality coffee has high economic value in the global market. However, the quality of coffee is easy to get damage from natural factors and operation factors. Because of the complicated operation processes in a coffee supply chain, which involves cultivating, harvesting, processing, roasting, and consumption. Stakeholders should take responsibilities for the quality of products in each process. In other words, if stakeholders lack critical knowledge in a coffee supply chain, improper operations of stakeholders will damage the coffee quality. This paper aims to analyze the critical knowledge existed in a coffee supply chain. The research starts with an overview of the related stakeholders, products, processes and activities along the coffee supply chain. The interviewing from experts is used to capture knowledge and using knowledge map as a tools. The final part of this paper is presented the critical knowledge in terms of knowledge map. The results show the most critical knowledge are focus on the upstream processes from original farmers and community enterprises which is direct affected to the taste of coffee in quality.**

Keywords—coffee supply chain, stakeholder, knowledge map, critical knowledge

I. INTRODUCTION

Coffee is one of the most consumed beverages in the world and is the second largest traded commodity after petroleum[1]. Coffee has been consumed for over 1,000 years and today it is the most consumed drink in the world (more than 400 billion cups yearly) [2]. Coffee is produced in more than fifty developing countries in Latin America, Africa, and Asia and it is an important source of income for 20-25 million families worldwide[3]. Since the early 2000s, Thailand has been experiencing an increasing domestic consumption of coffee[4]. As recorded in[5] that coffee is a major income earner for Thailand. Thailand is the third largest producer in Asia (after Vietnam and Indonesia). There are two main types of coffee cultivated in Thailand; Arabica in the North and Robusta in the South. Arabica coffee has been a long history in Thailand. Arabica coffee production was promoted by the Royal Project Foundation since the 1970s mainly to replace opium production. Even though Arabica occupied 60 percent of world coffee production, but its quality is easy to get damage from natural factors. Because Arabica coffee have low resistance to pest and only can be planted at temperate zone or highland of tropical zone[6].

The quality of Arabica is not only easy to get damage from natural factors, but also human factors. As we know, the supply chain of coffee is a complicated process, which involves cultivating, harvesting, processing, roasting, and consumption. In coffee supply chain, every process links each other, it shows that the upstream problems will affect the downstream product. Stakeholders include farmer, community enterprises, roaster, wholesaler and coffee drinker in coffee supply chain. In other words, no matter in what process, if the stakeholder operates wrong action, that would damage the value of coffee.

Even though the problem about quality of Arabica coffee has been researching, these researches just focus on the natural factors such as cultivated fields, shadow place, sun insolation. The former researchers didn't put concentrate on stakeholder perspective in coffee supply chain. Therefore, this paper intends to identify the stakeholder in coffee supply chain. Then, capture and analysis critical knowledge to help stakeholders enriching knowledge operation standardization, avoiding risk, and improving coffee quality in the coffee supply chain.

This paper includes five main sections. The first section focus on the overall of coffee supply chain, the problem and the significance of the Arabica coffee in the world. The second section introduces the theoretical framework of the paper and the review of related contents. The proposed methodology of the research conducted in the paper is illustrated in the third section. The fourth section is the results of the research. The discussions and conclusion is drawn in the last section.

II. LITERATURE REVIEW

A. Coffee supply chain

The sequence of activities and processes start from cultivation end to the finished goods sold to the consumer. The coffee supply chain is consisting of many different elements that have to ensure quality. It starts from cultivation process to the roasting processes for a special taste. In general, the chain includes five processes: cultivation, harvesting, processing roasting and consumption.

Start with the cultivation, the coffee seed grows best in a humid climate, after seed sprouts, usually starts to produce flowers 3–4 years after it is planted, and it takes around 5 years for the tree to mature and produce its first crop. The second process is harvesting. In most countries, the red coffee cherries are picked by hand which is a very labor intensive and difficult process[7].This process requires a significant amount of human resources. Once coffee berries are collected they are then transported to processing mills. There are two processing methods: wet and dry process. Usually, wet process is used to process Arabica coffee. The coffee cherries are sorted by immersion in water; bad or unripe cherries float and the good ripe cherries sink. The ripe cherries are then machine cleaned by pressing the fruit in water through a screen. Lastly, the beans are dried either by

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the sun or by machines[8]. The coffee processed by the wet method is called parchment coffee. The four process roasting. Unroasted coffee is called as green coffee. Roasting presents the important step, whose main objective is to produce the desired aroma and taste[9]. This process can be divided into the following three consecutive stages: drying, roasting or pyrolysis, and cooling. [10]The last process is consumption. Through these processes, coffee beans become a cup of coffee in the hands of consumers. These five processes contain a lot of activities. These processes and activities form a complete coffee supply chain.

B. Knowledge supply chain

In an economy where the only certainty is uncertainty, one source of lasting competitive advantage is knowledge and its manipulation[11]. As this knowledge itself has an enormous supply chain and results in the rapid proliferation of information and derived knowledge, one of the challenges in manufacturing research today is how to deal efficiently with this knowledge supply chain[12]. As recorded in [13] that the research has proposed a knowledge supply chain, which is defined by the authors as "the knowledge flow and its operating process in the circle of design, implementation, and maintenance from suppliers' supplier (curriculum committee) to end-users (industry)". In implementing this knowledge supply chain, knowledge management and supply chain management are integrated for the first time to position and teaming five actors within the curriculum, namely curriculum committee, faculty, department, students and industry employers.

Knowledge supply chain can be defined as a sequence of related knowledge-based processes that together produce a product or service[14]. For example, components of a software application development project form a knowledge supply chain. The components of this supply chain include not only lower-level production processes such as research, analysis, design, coding, testing, and support but also higher-level coordination (or managerial) processes such as implementation and use of the software application to solve business problems.

C. Knowledge map

Knowledge maps typically point to people as well as to documents and databases to enable a person to find an appropriate knowledge source[15]. A knowledge map is a knowledge representation that reveals the underlying relationships of the knowledge sources, using a map metaphor for spatial display[16]. Knowledge map is a navigation aid to explicit information and tacit knowledge, showing the importance and the relationships between knowledge stores and dynamics.it illustrates or "maps" how knowledge flows throughout an organization. Often referred to as an "inventory of knowledge", these maps are organized using various interconnected nodes to make it easy to find out where to look for information. The map depicts visually the business issue or problem at hand. Pace of the group's collaborative discussions guided by questions to create knowledge sharing. A straightforward directory that points people to where they can. Capture both explicit and tacit knowledge in documents and in experts' heads certain expertise. Concept Map [17] and Mind Map [18] are drawings in which blocks represent concepts or things and connecting lines represent relationships. These maps are used to help better organize, understand, and memorize knowledge.

III. METHODOLOGY

The research method in this paper with 3 steps. To scope the overall of coffee supply chain, the researcher focuses on related stakeholders, products, processes and activities along the coffee supply chain. In this step, researcher gets explicit knowledge about scope of coffee supply chain from literature review. Secondly, in order to analyze the relationship among stakeholders, products, processes, and activities in the coffee supply chain, the researcher interviewed the managing director of social enterprise in Chiang Mai, Thailand to get more tacit knowledge. Thirdly, in order to capture and analyze the critical knowledge from stakeholders in the coffee supply chain, the researcher interviewed two experts. They are experts from Postharvest Technology Research Center, Faculty of Agriculture, Chiang Mai University and owners of a famous coffee company in Chiang Mai. The final part is the critical knowledge presented. Additionally, the research's conceptual framework is presented as in Fig. 1.

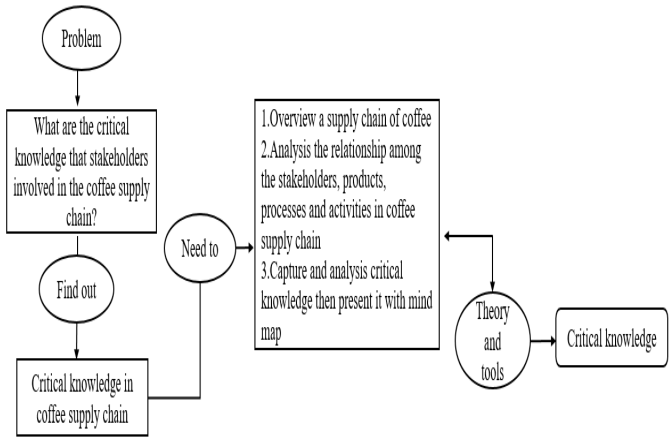

Fig.1.Conceptual Framework

This research focuses on the problem: what are the critical knowledge that stakeholders involved in the coffee supply chain? To solve this problem, the researcher focuses on finding the critical knowledge in coffee supply chain. There are 3 steps in this research. First of all, confirming the scope of supply chain of coffee. Secondly, analyzing the relationship among the stakeholders, products, processes and activities in coffee supply chain. Finally, researcher need to capture and analyze critical knowledge. Mind map is presented later. The output of this research is critical knowledge in a coffee supply chain.

A. Overview a supply chain of coffee

Based on literature review, the coffee supply chain has very complex activities. In general, the coffee supply chain includes the processes from coffee cultivation to customer drinking. There are many processes and activities involved from upstream to downstream in coffee supply chain. To scope the whole coffee supply chain, the researcher focuses on related stakeholders, products, processes and activities along the coffee supply chain. In this step, the researcher need to collect explicit knowledge form literature review.

B. *Data collection and analyze*

In this step, interviewing experts can get the data and information about the relationship among the stakeholders, products, processes and activities in coffee supply chain. The researcher interviewed the managing director of social enterprise in Chiang Mai, Thailand. The stakeholders' data of this research comes from Lanna Thai coffee hub program. The faculty of Agricultural, Chiang Mai University supports the budget from annual government statement of expenditure with the integration method for year 2017 to establish the project for increasing the potential of producing quality Lanna Coffee in the Upper Northern region 1 or Lanna Thai Coffee Hub.

C. *Present the critical knowledge with mind map*

According to the data which researcher collected from activities that each stakeholder involves in coffee supply chain, Then, the researcher have to analysis the critical knowledge and present it with mind map clearly. In order to validate these critical knowledge, the researcher interviewed two experts. They are experts from Postharvest Technology Research Center, Faculty of Agriculture, Chiang Mai University and a famous coffee company in Chiang Mai.

IV. RESULTS

As already indicated, result part presents a three parts that includes coffee supply chain overview, data collection, analysis and critical knowledge.

A. *Result of Overview a Coffee Supply Chain*

To scope the overall of coffee supply chain, the researcher focus on related stakeholders, products, processes and activities along the coffee supply chain. In other words, the coffee supply chain covers four parts. There are stakeholders, products, processes, and activities. Stakeholders are farmer, community entrepreneur, coffee roaster, wholesaler and coffee drinker in coffee supply chain. Their corresponding products are coffee seed, coffee cherries, parchment coffee, coffee bean, roasted coffee, packaging, and cup of coffee. The relative processes include take care seedling and post-harvest management, harvesting, processing, roasting, transporting, storage and consumption. The main activities of each process include coffee seeding selection, breeding, cultivate, hand pick, wet processing, dry processing, semi processing, milling, cupping test, transportation, storage.

B. *Result of Data collection and analyze*

After getting the overview of the coffee supply chain by reviewing the literature, the researcher needs to review experts to understand and acquire the relationship among stakeholders, products, processes, and activities in coffee supply chain. So, the researcher interviewed the managing director of social enterprise in Chiang Mai. According to the results of interview experts, the researcher presents the relationship among stakeholders, products, processes and activities of the coffee supply chain in table I. Figures and Tables

TABLE I. THE RELATIONSHIP IN COFFEE SUPPLY CHAIN

Stakeholder	Farmer		Community enterprise/Processor				Coffee Roaster	Wholesaler	Coffee drinker
Product	Breeder seed	Coffee cherries			Parchment coffee	Coffee bean	Roasted coffee	Packaging	Cup of coffee
Process	Take care seedling and post-harvest management	Harvesting	Collect coffee cherries	Processing	Milling		Roasting	Storage	Consumption
Activity	Coffee seeding selection	Hand pick	Transportation	Wet processing	Milling		Cupping test	Store green bean	
	Breeding			Dry processing			Store roasting bean		
	Cultivate			Semi processing					

Table I illustrates that there are totally 5 stakeholders, 7 products, 8 processes, and 12 activities from upstream to downstream in the coffee supply chain. The stakeholder of upstream is farmer, Their responsibilities are to take care seedling and post-harvest management and harvesting. Farmer chose high-quality coffee seeds for seeding and transporting harvested coffee cherries to community enterprises. Obviously, there are two products are involved this process, which are coffee seeds and coffee cherries. The second stakeholder is community enterprise. They collect coffee cherry from farmer, then process coffee cherries. The parchment coffee comes from processing, after milling, they get coffee bean. Next, community enterprise sends green bean to roast factory. Coffee roaster plays a stakeholder role in this process. The product is roasted coffee. Storage is the fourth process. wholesaler is the stakeholder in this process. Wholesaler have responsibility to store coffee beans. In this process, wholesaler's product is packaging. The last process is consumption. Coffee drinker can buy a cup of coffee from coffee shop. Therefore, coffee drinker is the stakeholder in the coffee supply chain. Whether coffee drinker can purchase a good quality coffee or not, depends on above phases.

C. *Result of critical knowledge presented*

From table I, the researcher collects the knowledge from each stakeholder's activities. Through interviewing 2 experts, we can acquire and analyze critical knowledge. They are experts from Postharvest Technology Research Center, Faculty of Agriculture, Chiang Mai University and a famous coffee company in Chiang Mai. Then, the critical knowledge can be present by mind map.

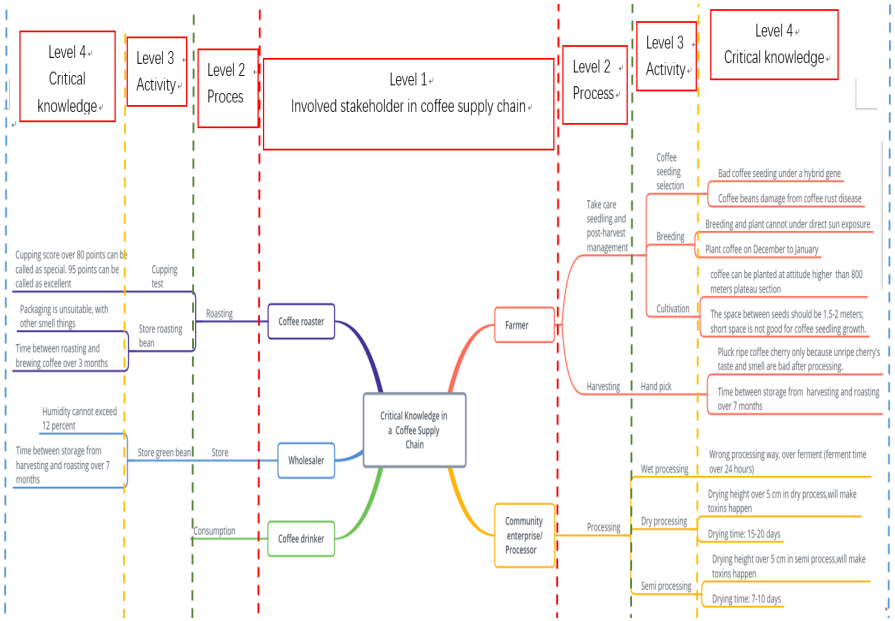

Fig.2. Critical Knowledge in a Coffee Supply Chain

Based on figure 2, this knowledge map can be presented into 4 information levels. The first level is stakeholders, they are farmer, community enterprise, roaster, wholesaler and coffee drinker. The second level is the process of stakeholder, they take care seedling and post-harvest management, harvesting, processing, roasting, storage and consumption. The third level is the high risk activities of processes, there are coffee seeding selection, cultivate, hand pick, wet processing, dry processing, semi processing and cupping test. The fourth level is the critical knowledge that high risk activities involved, it includes 18 critical knowledge.

V. DISCUSSION AND CONCLUSIONS

The discussion part mainly discusses the inspiration of critical knowledge in the coffee supply chain. Methodologically speaking, coffee is a high-value crop in the world, but coffee is easily damaged by natural and operations factors. with the development of technology, the content of critical knowledge that stakeholder involves has change. However, this research also has limitation. The research focuses on Arabica coffee in northern Thailand. There are 2 factors that make this research have strong representativeness and limitation. First, the characteristics of Arabica coffee and the natural factors make Robusta coffee lack of reference during analysis of critical knowledge process. Second, the research just focuses on the coffee supply chain of Thailand. It does not include export market. Because export will involve more stakeholders, suppliers, standards, it will be more complicated.

This research can be divided into 4 information level, they are stakeholders, processes, activities and knowledge. There are 5 relative stakeholders. The relative stakeholders are farmer, community enterprise, coffee roaster, wholesaler and coffee drinker. Moreover, there are 6 processes, 10 activates and 18 critical knowledge. It is easy to see that each stakeholder response to relative critical knowledge and information. We can conclude that the number of critical knowledge that each stakeholder involved. It can be presented as Fig. 3.

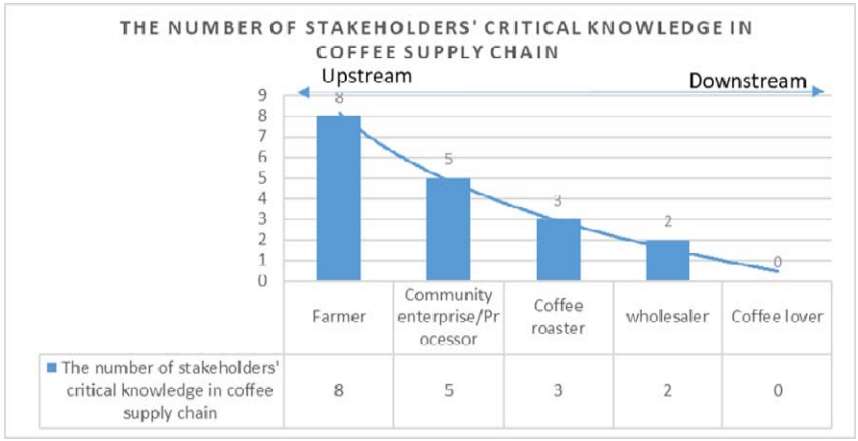

Fig.3. The number of stakeholders' critical knowledge in coffee supply chain

Based on figure 3, it shows that, farmer involves the most critical knowledge in coffee supply chain, totally 8 items. As the part of upstream in coffee supply chain, the quality of coffee has the most impact on roast of downstream. The second largest critical knowledge owner is community enterprise, totally 5 items. The third largest critical knowledge owner is roaster, totally 3 items. The last critical knowledge owner is wholesaler, totally 2 items. Coffee drinker have no relative knowledge, because coffee drinker is the last stakeholder of coffee supply chain downstream. Whether coffee drinker can drink good taste coffee or not depends on above 4 stakeholders' activities. In other words, these 4 stakeholders have responsibility to coffee drinker.

The results show the most critical knowledge are focus on the upstream processes from original farmers and community enterprises which is direct affected to the taste of coffee in quality.

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REFERENCES

[1] Solange I Mussatto, Ercília M. S. Machado, Sílvia Martins and José A Teixeira (2011) Production, Composition, and Application of Coffee and Its Industrial Residues

[2] Sobésa Café (2008). Available at: http://www.sobesa.com.br. Accessed 05 March 2010.

[3] Petit, N. (2007). Ethiopia's coffee sector: a bitter or better future. Journal of Agrarian Change, 7(2).

[4] Consortium of Mi Cafeto Company Ltd. and IC Net Limited. (2014). "Project Formulation Survey" under the Governmental Commission on the Projects for ODA Overseas Economic Cooperation in FY2013; Summary Report Myanmar, Laos, Thailand; Project Formulation Survey for the Poverty Reduction through the Implementation of the High Quality Coffee Production and Processing in the Golden Triangle Area. Retrieved from http://www.mofa.go.jp/mofaj/gaiko/oda/seisaku/kanmin/ chusho_h25/pdfs/3a24-1.pdf

[5] Angkasith, P. (2001) Coffee production status and potential of organic Arabica coffee in Thailand. In The First Asian Regional Round-table on Sustainable, Organic and Specialty Coffee Production, Processing and Marketing, 26-28 Feb. 2001. Chiang Mai, Thailand.

[6] Tuvhag, E. (2008). A value chain analysis of fairtrade coffee. Informally published manuscript, Department of Economics, Lund University.

[7] TJ Dowding, The Coffee Bean: A Value Chain and Sustainability Initiatives Analysis Melissa Murphy, University of Connecticut, Stamford CT USA

[8] Salamone, R. (2003). Life cycle assessment to coffee production: investigating environmental impacts to aid decision making for improvements at company level. Food, Agriculture & Environment, 1.

[9] Juerg Baggenstoss,Luigi Poisson,Ruth Kaegi, Rainer Perren,and Felix Escher (2008) Coffee Roasting and Aroma Formation: Application of Different Time−Temperature Conditions

[10] Sacchetti G, Di Mattia C, Pittia P, Mastrocola D. Effect of roasting degree, equivalent thermal effect and coffee type on the radical scavenging activity of coffee brews and their phenolic fraction. Journal of Food Engineering 2009;90:74–80

[11] Nonaka, I. (1991). The knowledge creating company. Harvard Business Review, November-December, 96.

[12] Niek Du Preez, Louis Louw (2014) Managing the Knowledge Supply Chain to Support Innovation

[13] Soultana Tania Kapiki, Jing Fu, Lei Mou (2014) A Systems Thinking Approach for e-Tourism Curriculum Design

[14] Hoon S. Cha, David E. Pingry and Matt E. Thatche (2008) Managing the Knowledge Supply Chain: An Organizational Learning Model of Information Technology Offshore Outsourcing

[15] T. Davenport, L. Prusak, Working Knowledge (1998) How Organizations Manage What They Know, Harvard Business School Press, Boston.

[16] Thian-Huat Ong a, Hsinchun Chen b,Wai-ki Sung b,Bin Zhu (2004) Newsmap: a knowledge map for online news

[17] J.D. Novak, D.B. Gowin, Learning How to Learn, Cambridge Univ.Press, New York, 1984.

[18] T. Buzan, B. Buzan, The Mind Map Book, Penguin Group/Dutton, New York, 1993.

A Review of Traditional Embroidery from China in Relation to Knowledge Management and Design

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***Abstract* — This paper presents research findings from a review of the literature about traditional embroidery of China in relation to knowledge management and design. Traditional embroidery is a source of Soft Power for china, some of is Chinese intangible culture, such as the four traditional embroidery. According to the SWOT analysis, the traditional embroidery community need knowledge management and design to help for developments. Therefore, rationale for selecting Shu embroidery in-depth case study. The findings are the key factors of success based on the literature from strategies of knowledge management and design for community development.**

***Keywords — traditional embroidery, knowledge management*, design, China**

I. TRADITIONAL CRAFT AND EMBROIDERY IN CHINA

A. Significance of traditional embroidery in China

In China, traditional craft has a long history and it has been regarded as a unique form of art and an oriental treasure, which affects a profound sense of Chinese value [1]. Traditional craft practices are important to the people in many ways of living .Craft is a batch-production of various products, which people use in daily live, such as quilts, pillow covers, handkerchiefs and shroud [2]. Craft practices reflect people's idea and sentiment, which are expressed through different materials, techniques and forms of crafts. Traditional craft has many qualities that are in accordance with sustainability principles [3]. i.e. the Walker's Quadruple Bottom Line of Sustainability (QBL), which comprises four components: practical meaning; social meaning; personal meaning; and economic means [4].

China is the earliest country in the world that discovered silk, since then the making and use of silk fabrics have become widespread; the people have inherited the making and use of silk fabrics for more than 5,000 years (History of China's Textile Science and Technology, 1984). Thereafter, traditional embroidery was developed in relation to ways of living of the local people and their local wisdom, which can inform Geographical Indication of the particular places [5].

> ***Geographical Indications (GIs)** are, for the purposes of this Agreement, "indications which identify a good as originating in the territory of a Member, or a region or locality in that territory, where a given quality, reputation or other characteristic of the good is essentially attributable to its geographic origin" (The world trade organization (WTO) Agreement on Trade-Related Aspects of Intellectual Property Rights ("TRIPS"), p.328).*

Traditional embroidery is the Intangible Cultural Heritage and a source of Soft Power for China [6].

> ***Intangible Cultural Heritage (ICH)** "can only be heritage when it is recognized as such by the communities, groups or individuals that create, maintain and transmit it – without their recognition, nobody else can decide for them that a given expression or practice is their heritage" (UNESCO).*

> ***Soft power** is "a concept developed by Joseph Nye of Harvard University since the 1990s [as the means to success in world politics]. It describes the ability of a country to persuade others to do what it wants without force or coercion; its three main resources include culture, political values and foreign policies"*

B. The four traditional embroideries that represent the Intangible Cultural Heritage of China

The United Nations Educational, Scientific and Cultural Organization (UNESCO) officially proposed the "Intangible Cultural Heritage" in the 32nd UNESCO General Conference in 2003 [7]. China was involved in the "Convention on the Safeguarding of Intangible Cultural Heritage" in August 2004 .This resulted in the government-led projects in the inheritance and protection of China's intangible cultural heritage, including the representative list of intangible cultural heritage and the representative inheritor of intangible cultural heritage. [8]. The State Council of the People's Republic of China announced the representative list of intangible cultural heritage in 2006, 2008, 2011 and 2014 and thereby, the cultural committees of each province selected cultural inheritors based on this list. In 2006, the State Council of the People's Republic of China announced four traditional embroideries as the first group of intangible cultural heritage of China; these embroideries include Su embroidery, Xiang embroidery, Guangdong embroidery and Shu embroidery.

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Fig. 1. A map of China depicted with the four states/provinces, which produce traditional embroideries (picture from ASDFGH, 2011)

1) Su embrodiery

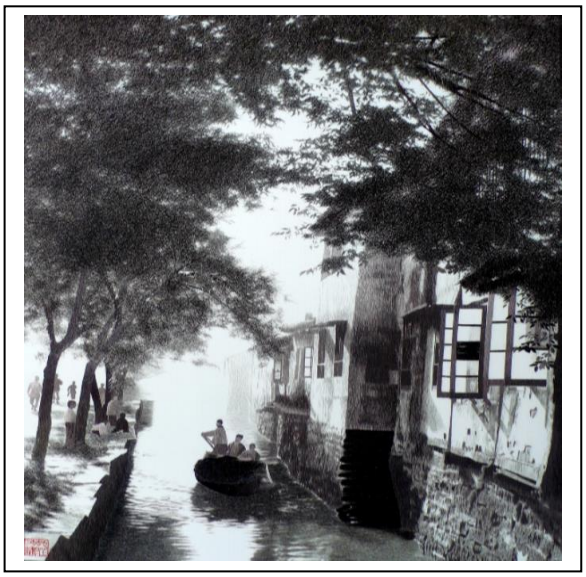

Fig. 2. Su embroidery (suzhou.gov, 2018)

TABLE I. CHARACTERISTICS OF SU EMBROIDERY (SOURCE: SUZHOU.GOV.CN, 2018)

Materials	The finest silk yarn is used as a primary material. Other fibres can be mixed in the fabrics, such as satin, cotton and chemical fibres.
Pattern making and stitch techniques	Inkjet printing is done on fabrics as a guideline for patterning. More than 40 techniques of stitches are used in Su embroidery (e.g. Qi, Zhengqiang, Pingtao).
Pictorial arts	Su Embroidery is deeply influenced by the Wu School of painting that was established in the middle of Ming Dynasty period. (Today, Wu is known as Suzhou.) The Wu School is a place , where literati depict ways of living in Suzhou through paintings, especially landscapes.
Products	Pouch, cape, quilt cover, pillowcases, partitions

2) Xiang Embroidery

Fig. 3. Xiang embroidery (picture from Liu, 2016)

Hunan province is called in a local word as "Xiang". Xiang Embroidery is a common word used to call embroidery products made in Changsha and Hunan. Xiang Embroidery is deeply influenced by the Xiangchu culture, which is a unique regional culture in the Chinese national culture [9].

TABLE II. CHARACTERISTICS OF XIANG EMBROIDERY (SOURCE: SUJING, 2016)

Materials	The thicker silk yarn is used as a primary material. Other fibres can be mixed in the fabrics, e.g. hard satin, satin, transparent nylon and transparent silk.
Pattern making and stitch techniques	The patterns are replicated. More than 100 techniques of stitches are used in Xiang embroidery (e.g. Santao, Tuozhen).
Pictorial arts	Each pattern usually illustrates animals in the local area, such as lions, tigers and squirrels.
Products	Partitions, quilt cover, pillowcases, bedsheets, cushions, tablecloths, handkerchiefs and clothes.

3) Guangdong Embroidery

Fig. 4. Guangdong embroidery (Guangdong Cultural Centre, 2018)

Guangdong Embroidery are made in Guangdong [10], which includes Guang embroidery and Chao embroidery. Guang embroidery's products are made in Guangzhou,

whereas Chao embroidery's products are made in Chaozhou. Guangzhou and Chaozhou are the city in Guangdong province.

TABLE III. CHARACTERISTICS OF GUANGDONG EMBROIDERY (SOURCE: RAN XIAO, 2016)

Materials	A variety of fibres is used in combination as primary materials, such as silk, wool, gold thread, peacock feather and horses' tails. Other fibres can be mixed in the fabrics, such as silk, satin, fibres from silken cloth and other textiles.
Pattern making and stitch techniques	The patterns are replicated. More than 45 techniques of stitches are used in Guangdong embroidery(e.g. Zhi,Kunyao,Ding).
Pictorial arts	Guangzhou Embroidery is deeply influenced by the Lingnan School of painting, which combines the traditional painting of Dongyang with the Western art. The patterns from Guangzhou embroidery usually depict natural environment in Southern China, such as lychee , mulberry trees, cotton trees, flowers and birds. Patterns from Chaozhou embroidery usually depicts Dragon and Phoenix.
Products	Costumes, partitions, quilt cover, pillowcases, bedsheets, cushions, etc.

4) Shu Embroidery

Fig. 5. Shu embroidery (www.gochengdu.cn, 2018)

Sichuan province is called in a local word as "Shu". Shu Embroidery products are made in Chengdu, which is a city in Sichuan. Shu Embroidery is deeply influenced by the Shu culture, which is a unique regional culture in the Chinese national culture [11]

TABLE IV. CHARACTERISTICS OF SHU EMBROIDERY (SOURCE: WANG, ZENG, LIU, ZHAO, 2017)

Materials	Silk is a primary material. Satin can be mixed in the fabrics.
Pattern making and stitch techniques	The patterns are replicated. More than 122 techniques of stitches are used in Shu embroidery (e.g. Luan, Jiaocha, Luoxuan).
Pictorial arts	The patterns depict panda, koi (or koi carp) and Hibiscus flowers.
Products	Partitions, quilt cover, pillowcases, bedsheets, cushions, tablecloths, etc.

C. Situation analysis of the four traditional embroideries

1) Strength

These four traditional embroideries represent Chinese's folk art and traditional cultures of the specific regions. They are the best-known among all of Chinese's embroidery products in China and gain more than 95% of the market share of embroidery products. Among the four, Su embroidery gains the highest market share over 83% for several years, whereas Shu embroidery gains the lowest market share of embroidery products, and is less than 5% [12]. Yet, these four embroideries have become widespread worldwide through the increasing numbers of exports between 2010 and 2012, from 42,000 to more than 45,000 thousand dollars respectively.

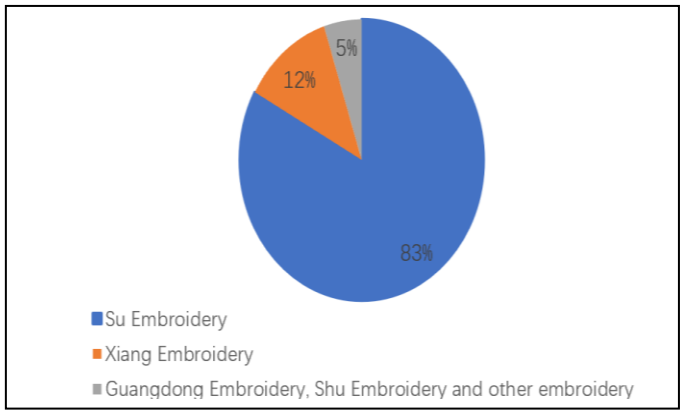

Fig. 6. Traditional embroidery market share (Tan, Fan, Liu, 2015)

2) Weakness

Craftspeople working on traditional embroideries live in rural areas and they are not well educated. They are engaged in traditional embroideries because they can gain economic benefits, such as money, food and so on, but they are not aware of the cultural value of traditional embroidery[12]. The production of traditional embroidery is time consuming and requires a number of resources, including craftspeople, materials and financial investment, but recently traditional embroidery products are not sold out (see Table V) because many customers prefer products in other styles such as modern or contemporary [13].

TABLE V. PRODUCTION AND SALES OF EMBROIDERY PRODUCTS (SOURCE: JIA, 2014, P.XXX)

year / Volume (1,000 tones)	2009	2010	2011	2012
Production	235	257	273	287
Sales	215	232	252	266
Gap	-20	-25	-21	-21

3) Opportunity

The Chinese government already set up the China's Belt and Road Initiative for win-win cooperation, common development and common prosperity between the East and the West; this initiative is aimed to build peace and friendship, enhance understanding of trust and strengthen all-round exchanges toward ASEAN (The State Council of the People's Republic of China, 2013, p.1). Recently, information about traditional embroidery were frequently searched through the use of Internet website. Baidu, the largest search engine in China, reports the statistical analysis of keywords search by which each of the keywords: embroidery; Su embroidery; Shu embroidery; Xiang embroidery; Guangdong embroidery was hit more than hundreds or thousands of times a day (Figure 7). It is likely that Chinese people are attracted to know more about their cultural capital and cultural consumption.

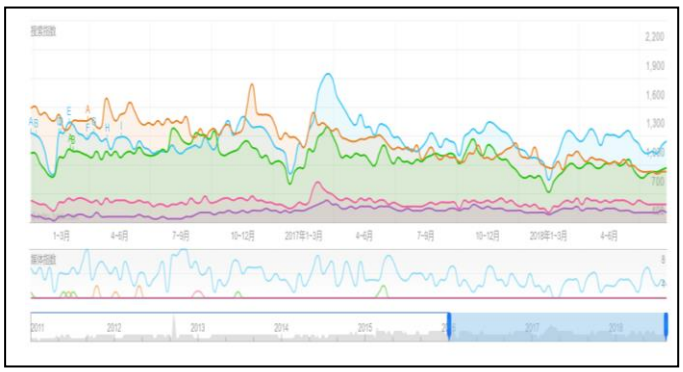

Fig. 7. Statistical analysis of the frequency of keywords search about traditional embroidery (Baidu, 2018)

4) Threat

The market share of embroidery products in China is declining and handmade embroidery products have been replaced by products, which are made from machine-based or industrial production [13].Moreover, the labour cost of Chinese craftspeople in China is much higher than of craftspeople in North Korea and Southeast Asia, i.e. Vietnam. The labor cost of Chinese craftspeople is about 37 dollars per day, whereas the labour cost of Vietnamese and North Korean craftspeople costs about 0.5 dollars per day [14].

D. Rationale for selecting Shu embroidery for in-depth case studies

Shu embroidery gains the lowest market share among the four types of traditional embroidery of China. The main researcher comes from Sichuan and intends to contribute the knowledge to enable the property of Shu embroidery and the livelihood of the people in Sichuan. Therefore, Shu embroidery is the focus of this research and in-depth case studies. The main researcher knows the local places, people and their practices in Shu embroidery and it is likely to gain access to information.

II. KNOWLEDGE MANAGEMENT

A. The importance of knowledge management

Data and information are used interchangeably, but when the data is analyzed, it becomes information; people have knowledge about something when they are aware and understand of information [15]. Knowledge can be divided into two types: tacit knowledge and explicit knowledge. Explicit knowledge is easily to communicate with others, and tacit knowledge is a kind of experience. Knowledge management is a comprehensive and conscious collection of the organization, sharing and analysis of knowledge, which are gathered from resources, documents and experiences. Knowledge management can be helpful in many ways, such as idea generation and innovation, change management and customer intelligence [15].

B. Knowledge audit

Knowledge audit is a foundation of knowledge management. Knowledge audit refers to the process of identifying the existing knowledge and the missing knowledge, as well as the systematic inspection and evaluation of organizational knowledge assets [16]. A knowledge audit comprises four components: knowledge need analysis; knowledge inventory analysis; knowledge flow analysis; and knowledge mapping [17]. According to Feng (2004, p.601), knowledge need is to learn about organizational knowledge from the opinions of knowledge owners. Knowledge inventory is to make an inventory of the tacit and explicit knowledge, including an evaluation of it. Knowledge flow is to describe the process from knowledge owners to knowledge users. Knowledge map usually delivers in forms of the final report.

C. Knowledge management & bussiness strategy for community development

The Community is a coherent entity, which its members has a common goal, for example for their cultural heritage, including ways in which they share their cultural values; their relationship can be quite competitive in practice [18]. Community development is a process, which needs to be designed to enable economic improvement of the community and thereby it involves the participation of active members. This paper presents a review of the five secondary case studies, specific to their strategies of knowledge management that enable them to overcome the particular issues. Hence, they become successful in business development.

1) Knowledge management in collaborative projects

According to Dave and Koskela [19], Pochins PLC is a large company located in the north-west region of England. Its core businesses include construction, concrete-pump hire, commercial and residential property development. It has more than 500 employees and the group of concrete pumping business is difficult to knowledge sharing between each other. Knowledge management was employed as a tool to come up with a business strategy for innovation. They employed three steps in their knowledge management system, including: requirements capture; implementation; and post-implementation review.

2) Knowledge Management in Leadership-based Strategic Community

According to Kodama [20], NTT DoCoMo is a company running a business in selling mobiles and multimedia in Japan. The company employed a knowledge management system in order to create new business models, which focus on customer-focused approaches, new products and service development. The company collaborated with Mitsubishi Electric, a large manufacture of electrical appliances from Japan. The formation and integration of both the companies involved the use of knowledge management, especially knowledge organization and knowledge sharing in diverse areas among their strategic communities.

3) Customer Knowledge Management

Starbucks Corporation is an American coffee company and coffeehouse chain, which was founded in 1971 in Seattle, Washington. It is well-known internationally. It employs Customer Knowledge Management and social media to manage and increase their customers' satisfaction, sophistication and changing preferences. Its Customer

Knowledge Management involves three parts: management of knowledge "for", "from" and "about" customers [21].

4) Design and Implementation of Knowledge Management System

Saveh Rolling & Profile Mills company produces various types of pipes and steel profiles, more than 50,000 tons per year. The company designed and implemented the knowledge management system in relation to business and market development. Developments of their knowledge management system began with brainstorming sessions, which involved 50 representatives of the staff from various departments and they attended 14 sessions of brainstorming. Next, the knowledge need was analyzed based on their existing knowledge. Finally, the knowledge map was created and updated, thereafter, the system and activities of knowledge management were implemented and monitored accordingly." [22]

5) Knowledge Management in Knowledge Sharing Networks

Small and medium-sized enterprises (SMEs) in the Northwest of the UK are able to manage their project improvements and share their generated knowledge effectively [23]. Knowledge management was used as a guideline for creating a conceptual model of knowledge sharing? It comprises four elements: manufacturing SMEs, manufacturing excellence practices, knowledge management and learning networks. KM can help transform some of the tacit knowledge about best practices and project improvements to explicit knowledge through the knowledge-based sharing system. This system can help people to record details of, monitor and control their own projects, and share their experiences and results with others.

D. Key factors of success for knowledge management

Having reviewed the five best-cases in knowledge management, the authors identifies herewith key factors of success: leadership and customer knowledge management. Knowledge management should be considered as important as other business activities. The system and activities of knowledge management should be integrated and implemented as part of business (and market) development. *Design* – It can contribute to several activities of knowledge audit, such as the specific tools, which are designed to assist the identification of knowledge needs, the visualization of knowledge inventory and knowledge mapping.

III. DESIGN

A. A variety of design for business and community development

A variety of design disciplines exist. Traditionally, design disciplines focus on designing 'products' (such as product design), whereas a more contemporary meaning of design addresses 'design for a purpose' (such as deign for sustainability) . The authors review a variety of design research in relation to craft practices, community development and enterprising as follows.

1) Design for sustainability in Thailand

The research about 'chok' weaving and textile enterprises in Northern Thailand [24] suggests for design to make a valid contribution to craft communities in many areas, including product design and development, design for marketing and sales, design in production development, design for knowledge transfer and knowledge sharing.

2) Co-design in Service Design in the Netherlands

Manschot and Koning (2011) implemented three projects in the Netherlands in order to develop successful services in …….The project implementation enabled design researchers to gain "insider knowledge". It also fostered the creativity and innovation of insiders, help to organize innovation processes more effectively and improve the service process (e.g. the ordering process) and customers' satisfaction to this service. The researcher recommends that the people (such as researchers, designers, developers, managers and other stakeholders) should be involved in a co-design process in order to relate their needs with the project goals[25].

3) Designing the craft education in China

Jiang and Nam (2018) compared two Chinses embroidery clusters (i.e. Su embroidery, Xiang embroidery) in order to develop strategies for the cultural heritage protection. The first is to maintain a solid local pool of skilled labour through training courses in embroidery. The curriculum should offer a variety of subjects, which nurture multiple specialization in fine arts, product design and marketing. So, young embroidery workers don't be skill-centered craftspeople, they can be creative and are trained to start up their own business. The second is to establish the embroidery association and build up a strong marketing capabilities and relationship with its partners.

4) Pattern design in Thailand

Sadsunka conducted a research, which involved design thinking of pattern making on handwoven loincloth. Pattern design was inspired by Thai Chess, making the products more attractive, unique and valuable to customers [27].

5) Design and branding

Huang, Cheng (2017) conducted a research about fashion brand development of a traditional aboriginal village on embroidery cross. is though product development, internal education, training with the cooperation of the designer team and the chosen community to find creative inspiration for future product design themes from within the culture [28].

B. Key factors of success for design

Having reviewed a variety of design research in relation to craft practices, community development and enterprising, the authors identifies herewith key factors of success as follows:
Product design and development; Design for marketing and sales; Branding; Pattern design; Co-design; Design for community development.

IV. CONCLUSION

This study has taken a broad look at the traditional crafts and specific to embroidery. According to the situation analysis of traditional embroidery, it shows the weakness, such as traditional embroidery products can not satisfy customers who prefer products in modern or contemporary style. It means

they need knowledge management and more knowledge to help traditional embroidery to develop. Then, the research selected Shu embroidery for in-depth case study.

From a review of best cases of their strategies of knowledge management for community development, 2 key factors of success are identified: leadership, customer knowledge management. Meanwhile, best cases mentioned that design can be contributed to organize knowledge map, that is described based on knowledge needs and knowledge inventory. It led to a review of design. After a review of design, it also mentioned design can contribute to developing knowledge hub. It shows knowledge management and design support each other. At same time, 6 key factors of success are found to help community development: (1) Product design and development; (2) Design for marketing and sales; (3) Branding; (4) Pattern design; (5)Co-design; (6)Design for community development.

The propose to develop a conceptual model of knowledge development for Shu embroidery. Meanwhile, there are some questions that be generated: (1)How Shu embroidery produce and distribute? (2) what is useful for Shu embroidery in terms of the knowledge areas form best cases; (3)What are possibilities of knowledge domains for Shu embroidery to develop? Future work might validate the knowledge domains by interviewing the expert in the Shu embroidery field and find the most important knowledge development areas to improve the current situation. The result can give the direction for future development of Shu embroidery.

REFERENCES

[1] Danyi Xiong, Research on innovation path of the business model in an enterprise — a case study of Chengdu RJ Sichuan embroidery company. Thesis (MBA), 2014, pp.1-64. In: Southwestern University of Finance and Economics.

[2] Yiyi Xu, Traditional handicrafts in Chinese history and culture. In: Jiangsu Social Sciences. 2011.

[3] Disaya Chudasri, An investigation into the potential of design for sustainability in the handicrafts of northern Thailand. Thesis (Ph.D), 2015, pp.1-292. In: Lancaster University's Library, Lancaster.

[4] Walker, S. "Design 2: Quadruple Bottom Line of Sustainability". In: Stuart Walker Design: Explorations in the theory and practice of design for sustainability. Available online:www.stuartwalker.org.uk, accessed 10 June 2018.

[5] Xiuli Shen, Promoting women's progress in Qinghai's ethnic areas with the development of folk embroidery industry. In: New Heights (Bimonthly), Vol.33 No.1 2014, p97-98

[6] Jian Sun, Hui Zhang, Cultural Soft Power of Non-materialistic Culture Heritage of Traditional Cuju. In: Journal of Shenyang Sport University, Vol. 34, No.1, Feb.2015.

[7] Yaolin Zhou, Chuanchuan Huang and Peng Ye, On the protection and inheritance of embroidery in China - based on the SMART model. In: Wuhan University Journal (Humanity Sciences), Vol.69, No.2, Mar.2016, pp. 100-112.

[8] The state council, Notice of the State Council on the Announcement first national intangible cultural heritage [EB/OL]. Available online: www.gov.cn, accessed 3 July 2018.

[9] Jing Su, A review of the history and prospect of the development of Xiang embroidery. In: Chinese Juvenile Journal, Vol. 26, Sep. 2016.

[10] Ran Xiao. (2016) The intangible cultural heritage of China - Guangdong embroidery. In: Trade Union Finance and Accounting of China, Aug. 2016.

[11] Hua Zhu, An investigation of Shu culture. In: Sichuan Silk Journal, Vol.4, 2008, p.44.

[12] Xiaofang Zhao, An analysis of the problems faced by traditional embroidery and suggestion for sustainable development. In: Shandong Textile Economy Journal, Vol.10 2016.

[13] Xuemei Wang, Research on supply-side reform of consumption industrialization development of Chinese traditional skills under the perspective of ominimedia – a case study of Sichuan embroidery. In: Innovation Journal, Vol. 4, 2017.

[14] Kangjian Wang, Nayun Li, Rong Zeng, Cairong Liu and Min Zhao. The development situation and countermeasures of Shu embroidery industry. In: Journal of Silk, Vol. 54, No.10, Oct. 2017.

[15] Carla O'dell, Cindy Hubert, The new edge in knowledge: how knowledge management is changing the way we do business. the United *States of America.2011.*

[16] Jiankang Wang, Jiuling Xiao, knowledge management aduit framework and methodology based on process, in: Journal of Technology Management in China, Vol 4, No.3, 2009, pp. 239-249.

[17] Feng jing, The First Step of Implementing Knowledge Management — Knowledge Audit, in : joural of information science, Vol. 22, No. 5, May, 2004, p.601.

[18] Marion Joppe, Sustainable community tourism development revisited. In : Tourrism Management, Vol. 17. No. 7, 1996, pp. 475-479.

[19] Bhargav Dave, Lauri Koskela, Collaborative knowledge management – A construcion case study, in: Automation in Constructioin, Vol.18, 2009, pp. 894-902.

[20] Mitsuru Kodama, Innovation and knowledge creation through leadership-based strategic community: Case study on high-tech company in Japan, in: Technovation, Vol.27, 2007, pp.115-132.

[21] Alton Y.K Chua, Snehasish Banerjee, Customer knowledge management via social media: the case of Starbucks. in: Journal of Knowledge Management, Vol,17,pp. 237-249.

[22] Yasaman Farashahian, Amin Abbasi, design and the implementation of knowledge management system. Available online: www. community of knowledge.de, accessed 18 September 2018.

[23] Agustin Perez-Araos, Kevin D. Barber and J. Eduardo Munive-Hernandez, Steve Eldrige, Designing a knowledge managemet tool to support knowledge sharing networks. In: Journal of Manufacturing Technology Management, Vol.18, pp.153-168.

[24] Disaya Chudasri, Chok Weaving and Textle Enterprises From Northern Thailand. In: Design Roots, Bloomsbury published on 08 February 2018.

[25] Marc Steen, Menno Manschot, Nicole De Koning, Benefits of Co-design in Service design projects. In: International Journal of Design, Vol.5, No.2, 2011, pp.53-60.

[26] Xin Li, Hui Jiang, Kyung-Min Nam, Adaptation in cultural industry under conservation pressure: case study of two Chinese embroidery. In: International Journal of Cultural Policy, DOI: 10.1080/10286632.2018.1486826

[27] Suwit Sdsunk, The Pattern design on Hand-Woven Loincloth, inspired by Thai Chess. In: Procedia-Social and Behavioral Sciences, Vol.197, 2015, pp.1481-1488.

[28] Huang, Ya-Ling, Cheng, Ming-Hui, The practice of Social Design-A Case Study on the Fashion Brand Development of a Traditional Aboriginal Village. In:IEEE-ICASI, 2017, pp.1339-1442.

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Optimizing PID Controller Design for Maglev Air-Gap Position Control by Bat-Inspired Algorithm

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***Abstract*—This paper proposes the proportional-integral-derivative (PID) controller design optimization for the air-gap position control of the magnetically levitated (Maglev) vehicles by using the bat-inspired algorithm (BA). Considered as the constrained optimization problem, the BA is applied to design an optimal PID controller by searching for the appropriate values of the controller gains. Results obtained by the PID controller designed by the BA will be compared with those obtained by the conventional controller from literatures. As results, the BA can provide an optimal PID controller for the Maglev air-gap position controlled system. By comparison, the PID controller yields very satisfactory responses superior to the conventional controller without steady-state error of the command-tracking and load-regulating responses.**

Keywords—PID controller, Maglev, Bat-inspired algorithm, constrained optimization

I. INTRODUCTION

In modern economies, the need for high-speed transport links has increased in magnetically levitated (Maglev) vehicles. For current technology, there are two most effective suspension and levitation methods, i.e. electro-dynamic suspension (EDS) and electromagnetic suspension (EMS). The former, EDS, requires super-conducting materials to generate the repulsive force to levitate a vehicle over a conducting track, whereas the later one, EMS, uses the attractive forces of electromagnets acting upwards to levitate the vehicle towards the tracks [1-3]. For the EMS-Maglev vehicle, it is an inherently unstable system. It needs intelligent control algorithms to maintain an air-gap between the magnet and supporting guide-way in order to avoid undesirable contact between them. Due to this, it is a critical control system. In general, the air-gap position control of the Maglev vehicles can be controlled by the PID controllers. Designing of the PID controller for the air-gap position control can be determined as the constrained optimization problem. Based on the modern optimization, designing an optimal PID controller for the Maglev air-gap position control by some well-known metaheuristic algorithms has been developed, for example, by genetic algorithm (GA) [4], particle swarm optimization (PSO) [5], bacterial foraging optimization (BFO) [5], cuckoo search (CS) [6] and firefly algorithm (FA) [6].

Among those metaheuristic optimization techniques, the bat-inspired algorithm (BA) is one of the most efficient population-based metaheuristic algorithms. The BA was firstly originated by Yang in 2010 [7]. Because the capability of echolocation of microbats is fascinating as these bats can find their prey and discriminate different types of insects even in complete darkness, the BA proposed by Yang is based on such the echolocation behavior. By literatures, the BA has been successfully applied to solve many engineering problems, for example, brushless DC motor wheel optimization, flow shop scheduling problem, topological shape optimization in microelectronic devices, clustering problem, microarray data classification, image processing and so forth [8]. In this paper, the BA is applied to control engineering application for designing an optimal PID controller for Maglev air-gap position control system based on the modern optimization framework. For the performance comparison, responses of a given Maglev air-gap position system controlled by the PID controller designed by the BA will be compared with those controlled by the conventional controller from literatures. After an introduction provided in section I, modeling of Maglev system, BA-based PID controller design problem formulation, results and discussions, and conclusions are consecutively presented in section II, III, IV, and V, respectively.

II. MODELING OF MAGLEV SYSTEM

Maglev vehicle has its inherent nonlinearity and highly unstable nature. The mathematical model of the Maglev vehicle can be linearlized by consideration of the system at an equilibrium point. The cross-section of a general Maglev vehicle is shown in Fig. 1. Its equivalent free-body-diagram is represented in Fig. 2 [2],[3], where m_1 is the chassis mass, m_2 is the passenger cabin mass, x_1 is the absolute position of the chassis, x_2 is the absolute position of the passenger cabin, b is the damping constant, k is the spring constant, F is the force (considered as the input variable) exerted by the magnet and γ (considered as the output variable) is the gap between magnet and guide-way.

By considering only the vertical movement of the chassis and passenger cabin, the force F can be derived by the magnet-force law and the current/voltage relation as stated in (1), where i is the excitation current and K_m is a constant.

$$F(i,\gamma,t) = \frac{K_m}{2}\left[\frac{i(t)}{\gamma(t)}\right]^2 \tag{1}$$

If a voltage v is applied across the electro-magnet winding, the excitation current i can be performed as expressed in (2), where R is the total resistance [3].

$$v(t) = Ri(t) + K_m \frac{d}{dt}\left[\frac{i(t)}{\gamma(t)}\right] \tag{2}$$

From Newton's law, the relationship between two bodies can be linearized as (3) and (4), where m is the total mass of the vehicle and g is the gravitational constant.

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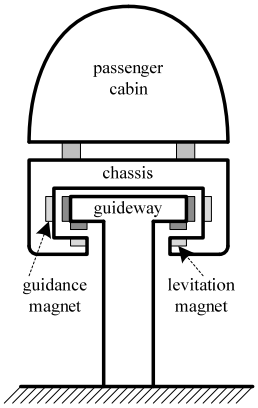

Fig. 1 Maglev vehicle system [3]

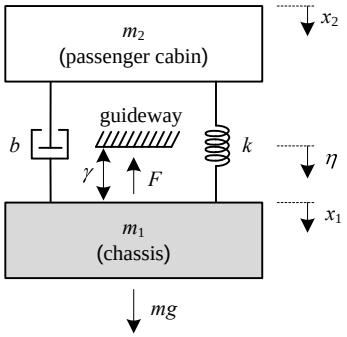

Fig. 2 Free-body-diagram of Maglev vehicle [3]

$$m_1\ddot{x}_1 + b(\dot{x}_1 - \dot{x}_2) + k(x_1 - x_2) = mg - F \tag{3}$$

$$m_2\ddot{x}_2 + b(\dot{x}_2 - \dot{x}_1) + k(x_2 - x_1) = 0 \tag{4}$$

Referring to Fig. 2, the air-gap γ is related to the absolute chassis position x_1 as stated in (5), where η is the disturbance from variations in the guide-way profile.

$$\gamma(t) = x_1(t) - \eta(t) \tag{5}$$

For a specific case, the Maglev vehicle [9],[10] can be formulated and linearlized by the transfer function model $G_p(s)$ from the excitation current i to the air-gap position γ as expressed in (6).

$$G_p(s) = \frac{\Gamma(s)}{I(s)} = \frac{s-4}{(s+2)^2} \tag{6}$$

III. BA-Based PID Design Framework

A. Bat-Inspired Algorithm

Initiated by Yang in 2010 [7], the BA's algorithm is based on three following rules.

- All bats use echolocation to sense distance, and they also know the difference between food/prey and background barriers in some way.
- Bats fly randomly with velocity $\boldsymbol{v}_i$ at position $\boldsymbol{x}_i$ with a frequency $f_{\min}$, varying wavelength λ and loudness $\boldsymbol{A}_0$ to search for prey, and they can automatically adjust the wavelength (or frequency) of their emitted pulses and adjust the rate of pulse emission $r \in [0, 1]$, depending on the proximity of their target.
- Although the loudness can vary in many ways, it was assumed that the loudness varies from a large (positive) $\boldsymbol{A}_0$ to a minimum constant value $\boldsymbol{A}_{\min}$.

The BA's algorithm can be represented by the flow diagram shown in Fig. 3. Each bat is associated with a velocity $\boldsymbol{v}_i$ and a location $\boldsymbol{x}_i$, at iteration t, in a d-dimensional search space. Among all the bats, there exists a current best solution $\boldsymbol{x}^*$. Therefore, they can be translated into the updating equations for $\boldsymbol{x}_i$ and velocities $\boldsymbol{v}_i$ as stated in (7)-(9). Once $\beta \in [0, 1]$ is a random vector drawn from a uniform distribution, each bat is randomly assigned a frequency drawn uniformly from $[f_{\min}, f_{\max}]$. During iterations, the loudness $\boldsymbol{A}_i$ and the pulse rates r_i are adjusted by (10) to balance the exploration and exploitation. For $0 < \alpha < 1$ and $\gamma > 0$, it was found that $\boldsymbol{A}_i^t \to 0$, $r_i^t \to r_i^0$, as $t \to \infty$. Yang recommended that, in the simplest case, users can use $\alpha = \gamma \in [0.9, 0.98]$ [7],[8].

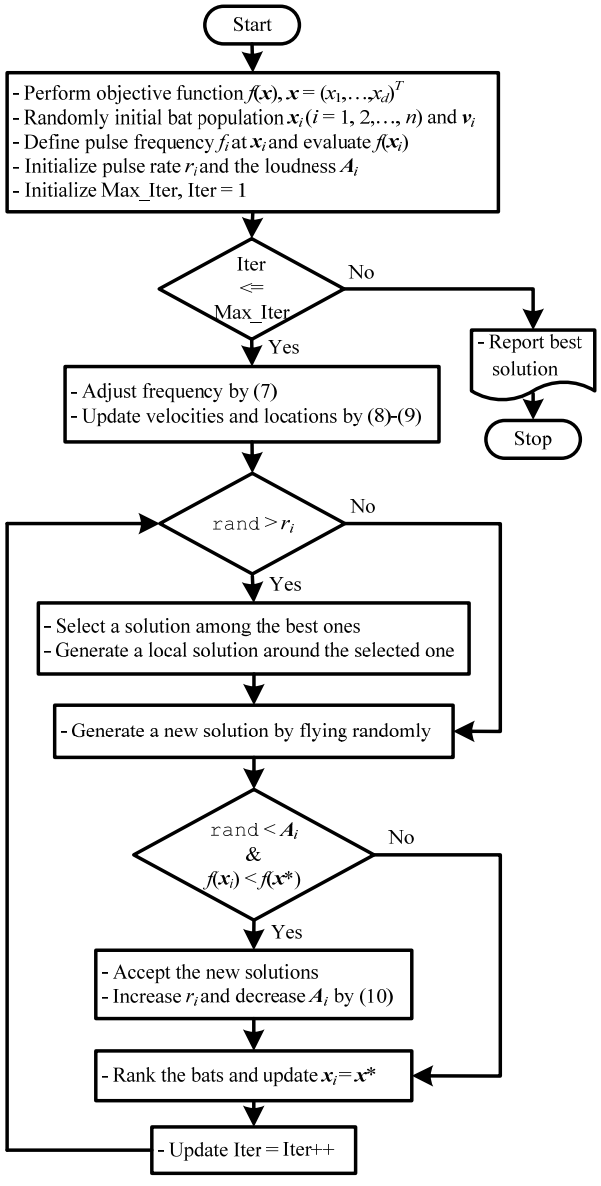

Fig. 3 Flow diagram of BA algorithm

$$f_i = f_{\min} + (f_{\max} - f_{\min})\beta \tag{7}$$

$$\boldsymbol{v}_i^t = \boldsymbol{v}_i^{t-1} + (\boldsymbol{x}_i^{t-1} - \boldsymbol{x}^*) f_i \tag{8}$$

$$\boldsymbol{x}_i^t = \boldsymbol{x}_i^{t-1} + \boldsymbol{v}_i^t \tag{9}$$

$$\boldsymbol{A}_i^{t+1} = \alpha \boldsymbol{A}_i^t, \quad r_i^{t+1} = r_i^0 (1 - e^{-\gamma t}) \tag{10}$$

B. BA-Based PID Controller Design

Based on the modern optimization framework, the application of the BA to design an optimal PID controller for the Maglev air-gap position control system can be represented by the block diagram as shown in Fig. 4. The transfer function model of the Maglev vehicle in (6) will be used as a plant model $G_p(s)$ in Fig. 4. The s-domain transfer function model $G_c(s)$ of the PID controller is stated in (11), where K_p is the proportional gain, K_i is the integral gain and K_d is the derivative gain.

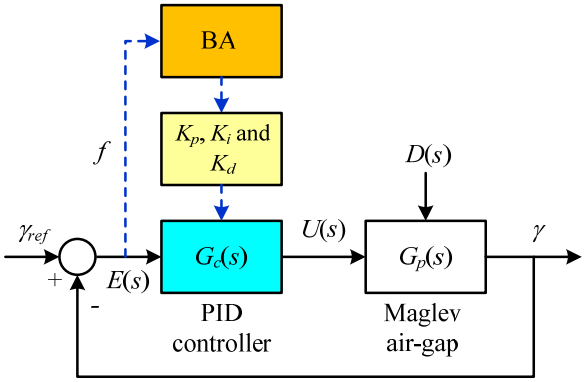

Fig. 4 BA-based PID design framework

$$G_c(s)\big|_{PID} = K_p + \frac{K_i}{s} + K_d s \tag{11}$$

In this work, the integral of squared error (ISE) between reference air-gap position γ_{ref} and actual air-gap position γ is set as the objective function $f(\cdot)$ stated in (12). As the constrained optimization, the time-domain response specification, including the rise time (t_r), the maximum percent overshoot (M_p), the settling time (t_s) and the steady-state error (e_{ss}), is defined as the constrained functions as expressed in (13). Referring to Fig. 4, $f(\cdot)$ in (12) will be minimized by the BA to search for the appropriate values of K_p, K_i and K_d of the PID controller within their corresponding boundaries (search spaces) as given from a preliminary study in (13).

$$Min \quad f(\cdot) = \int_0^t (e(t))^2 dt = \int_0^t [\gamma_{ref}(t) - \gamma(t)]^2 dt \tag{12}$$

$$\left.\begin{aligned} &Subject\ to\ t_r \le 10\ \text{sec}, \quad M_p \le 5\%, \\ &t_s \le 20\ \text{sec}, \quad e_{ss} \le 0.01\%, \\ &0 \le K_p \le 1, \ -1 \le K_i \le 1, \ 0 \le K_d \le 0.01 \end{aligned}\right\} \tag{13}$$

IV. Results and Discussions

To design an optimal PID controller for the Maglev air-gap position control system, the BA's algorithm was coded by MATLAB version 2018b (License No.# 40637337) run on Intel(R) Core(TM) i5-3470 CPU@3.60GHz, 4.0GB-RAM. Parameters of the BA are set according to Yang's recommendations [7],[8], i.e. the numbers of bats n = 20, the frequencies $f_{\min}$= 0, $f_{\max}$ = 2, the initial loudness $\boldsymbol{A}_0$ = 0.5, the initial pulse rates r_0 = 0.5 and α = γ = 0.9. The maximum iteration Max_Iter = 100 is then set as the termination criteria. 50 trials are conducted to find the best solutions (optimal PID controller).

For comparison, the conventional controller of the Maglev air-gap position control system is stated in (14) [9],[10].

$$G_c(s)\big|_{conv} = \frac{0.2241(s-1)}{(s+0.02)} \tag{14}$$

Once the BA's search process is finished, the PID controller for the Maglev air-gap position control system is optimized by the BA as expressed in (15). Fig. 5 shows the convergent rates of the objective function $f(\cdot)$ over 50 trials of the BA-based PID controller design.

$$G_c(s)\big|_{PID} = 0.2252 - \frac{0.2252}{s} + 0.0001s \tag{15}$$

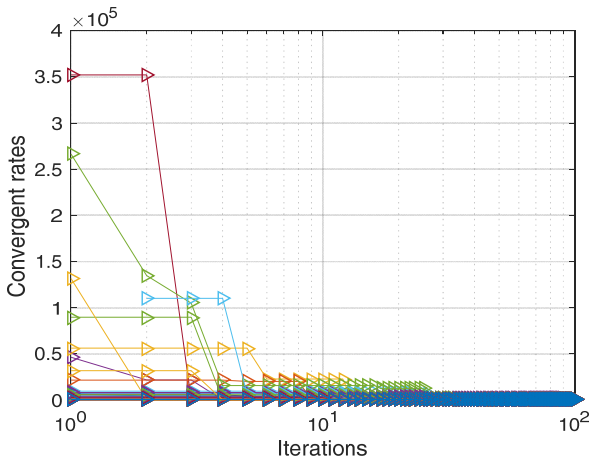

Fig. 5 Convergent rates of PID controller designed by BA over 50 trials

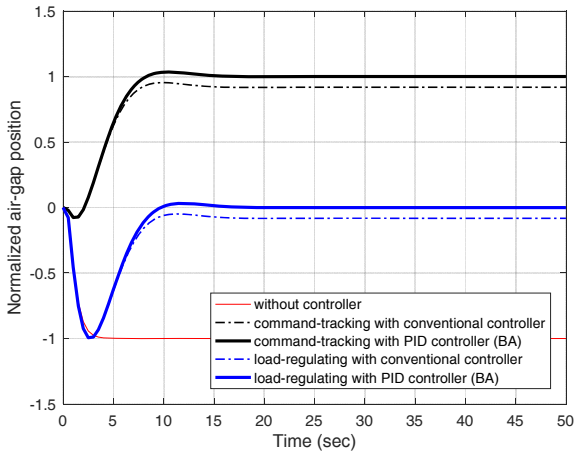

Fig. 6 Command-tracking and load-regulating responses

The command-tracking and load-regulating responses of the Maglev air-gap position controlled systems are depicted in Fig. 6, whereas all results are summarized in Table I, where t_{reg} is the regulating time. Fig. 7 and Fig. 8 show multistep command-tracking and load-regulating responses of the Maglev air-gap position controlled system.

TABLE I. RESPONSES OF MAGLEV AIR-GAP CONTROLLED SYSTEMS

Controllers	Command-tracking				Load-regulating	
	t_r (sec.)	M_p (%)	t_s (sec.)	e_{ss} (%)	t_{reg} (sec.)	e_{ss} (%)
without	2.16	0.00	3.13	100.00	-	100.00
conventional	7.82	3.89	13.41	8.20	14.10	8.19
PID	8.24	3.43	12.91	0.00	14.12	0.00

V. CONCLUSIONS

Optimizing PID controller design for the Maglev air-gap position control system by the BA has been proposed in this paper. Based on the modern optimization framework, the BA has been conducted to optimized the PID controller. By comparison, results obtained by the PID controller have been compared with those obtained by the conventional controller. Referring to Table I and Fig. 6, the Maglev air-gap position control system without controller is unstable and cannot be regulated when load disturbance occurred. The Maglev controlled system with the conventional controller can provide stable response with some steady-state errors, while that with the PID controller designed by BA can yield very satisfactory command-tracking and load-regulating responses without steady-state error. This can be observed by the multistep responses in Fig. 7 and Fig. 8. It can be concluded that the PID controller designed by the BA provides very satisfactory response for the Maglev air-gap position control system superior to the conventional controller.

REFERENCES

[1] D. S. Armstrong, "Magnet/rail systems - a critical review of the options," Proceedings of IMechE Conference on Maglev Transport - Now and for the Future, Solihull, U.K., 1984, pp. 59-66.

[2] Y. Cal, S. S. Chen and D. M. Rote, Dynamics and Controls in Maglev Systems, Argonne National Laboratory, U.S. department od Energy, 1992.

[3] V. Zakian, Control Systems Design: A New Framework, London Limited: pringer-Verlag, 2005.

[4] I. Ahmad, M. Shahzad and P. Palensky, "Optimal PID control of magnetic levitation system using genetic algorithm," Proceedings of IEEE EnergyCon 2014, Croatia, 2014, pp. 1429-1433.

[5] L. Maji, P. Roy and B. K. Roy, "Design of PID and FOPID controllers based on bacterial foraging and particle swarm optimization for magnetic levitation system," Proceedings of Indian Control Conference Indian Institute of Technology Madras, India, 2015, pp. 463-468.

[6] C. Vignesh, J. Sriram and G. H. H. Sudhan, "Design of PID controller for non-linear systems using Lévy flight based heuristic algorithms," International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, vol. 5, no. 4, 2016, pp. 2239-2247.

[7] X. S. Yang, "A new metaheuristic bat-inspired algorithm," Studies in Computational Intelligence, Springer Berlin, vol. 284, 2010, pp. 65-74.

[8] X. S. Yang, "Bat algorithm: literature review and applications," Int. J. Bio-Inspired Computation, vol. 5, no. 3, 2013, pp. 141-149.

[9] A. Charara, "Nonlinear control of a magnetic levitation system," IEEE Transactions on Control System Technology, September 1996, pp. 513-523.

[10] A. Butar and R. Sales, "Control for MagLev vehicles," IEEE Control Systems, August 1998, pp. 18-25.

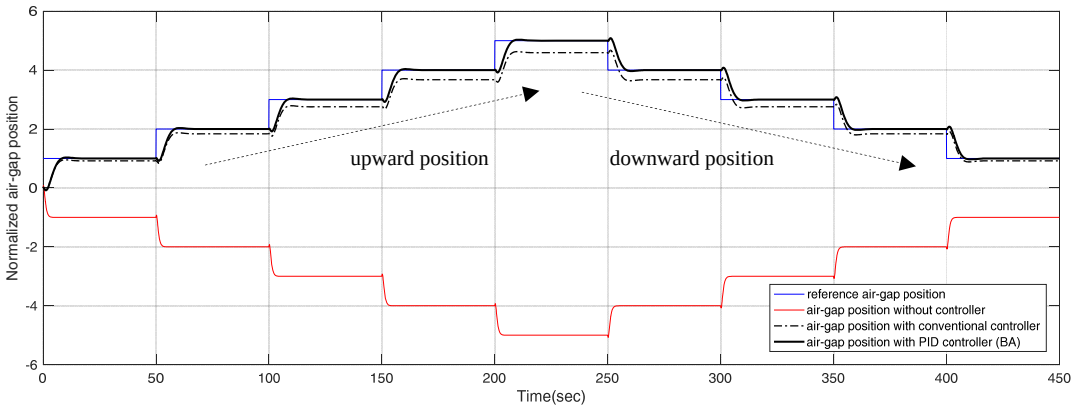

Fig. 7 Multistep command-tracking responses

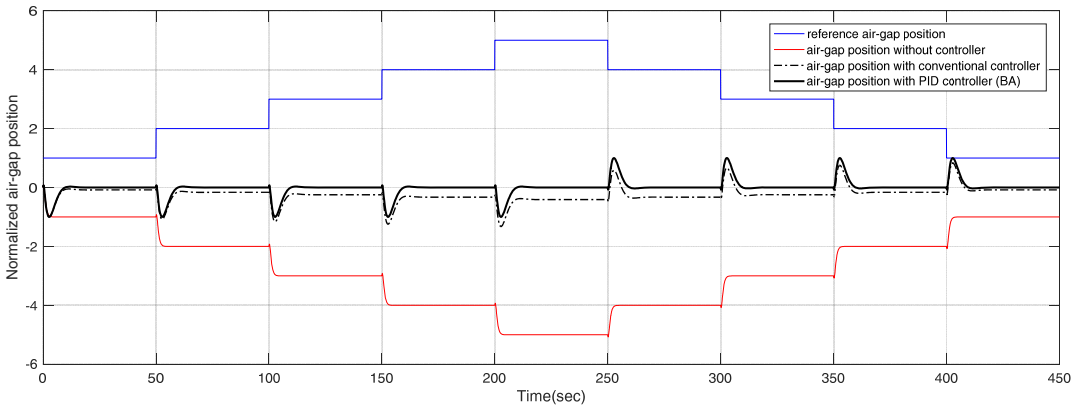

Fig. 8 Multistep load-regulating responses

Application of Spiritual Search to Optimal PIDA Controller Design for Cardiac Pacemaker

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***Abstract*—This paper presents an application of the spiritual search (SS), one of the newest and most efficient metaheuristic optimization algorithms, to optimally design the proportional-integral-derivative-accelerated (PIDA) controller for regulating the heart rate of the cardiac pacemaker in the cardiovascular system. For this biomedical engineering problem, designing of the PIDA controller can be considered as one of the constrained optimization problems. With the proposed SS-based design approach, results obtained by the PIDA controller will be compared with those obtained by the PID controller. Simulation results show that the PID and PIDA controllers for the cardiac pacemaker are optimally designed by the SS. The PIDA can provide faster and smoother response than the PID controller, significantly.**

Keywords—Spiritual search, PIDA controller ,Cardiac pacemaker, metaheuristic optimization

I. INTRODUCTION

Based on the modern optimization framework, control synthesis including model identification and controller design can be performed as the constrained optimization problems [1],[2]. Such the control synthesis problems are successfully optimized by efficient metaheuristic algorithms. Recently, the novel metaheuristic optimization algorithm named the spiritual search (SS) was firstly proposed in 2018 by Puangdownreong [3]. The SS algorithm is based on Dhamma, what the Buddha taught, focusing on the spiritual (*Citta*) concentration called *Samatha-Kammatthana* or shortly *Samadhi* [4],[5]. The SS is one of the ideal metaheuristic algorithms because its algorithm combines the single solution-based (trajectory-based) and the population-based approaches to balance the advantages of exploration (diversification) and exploitation (intensification) properties. By literature reviews, the SS provided optimal solutions of several standard benchmarking functions with the highest percentage of success rate for finding global solutions and the shortest search-time consumed once compared with the tabu search (TS) and the cuckoo search (CS) [3]. In addition, the SS was successfully applied to control synthesis problems including model identification, PID and PIDA controllers design for a DC motor speed control system [3].

One of the crucial biomedical-control engineering problems is the optimal controller design for the cardiac pacemaker. The main purpose of such the cardiac pacemaker is to regulate the heart rate of patients. Commonly, there are two main types of the cardiac pacemaker, i.e. the external pacemaker used for a short time because of the temporal damage and the internal pacemaker used for a long term due to the permanent damage preventing the heart from an abnormal triggering [6]. By literatures, the cardiac pacemaker was generally controlled by the PID controller and the fuzzy logic controller [7]. In control theory, the PIDA controller was proposed by Jung and Dorf in 1996 [8]. The PIDA possesses three arbitrary zeros and one pole at origin. This makes the PIDA more efficient than the PID for controlling higher-order plants. With metaheuristic-based design approach, designing PIDA controller by well-known metaheuristic algorithms has been proposed, for example, by genetic algorithm (GA) [9], particle swarm optimization (PSO) [10] and CS [11]. In this paper, the SS is applied to optimally design the PIDA controller for regulating the heart rate of the cardiac pacemaker in the cardiovascular system. Results obtained by the PIDA controller will be compared with those obtained by the PID controller designed by the SS for comparison. After an introduction is given in section I, the SS algorithm is briefly illustrated in section II. The SS-based PIDA controller design problem is formulated in section III. Results and discussions are discussed in section IV. Conclusions are followed in section V.

II. SPIRITUAL SEARCH ALGORITHM

Regarding to what the Buddha taught (*Dhamma*) [4],[5], *Kammatthana* is divided into two forms, i.e. *Samatha-Kammatthana* for making concentration and *Vipassana-Kammatthana* for creating wisdom of understanding the three signs of beings (*Tilakkhana*) including impermanence (*Anicca*), suffering (*Dukkha*) and non-self (*Anatta*). The basis of *Samatha-Kammatthana* is concentration of *Citta* (*Samadhi*). In Buddhist principles, *Citta* is the exposing nature for seeking the sense-objects (*Arammana*). It is one of the mental factors of the five-aggregates (*Pancakhandha*).

In early 2018, the SS was firstly proposed [3]. It is conceptualized by the spiritual concentration called *Samatha-Kammatthana*. The SS algorithm combines single solution-based (trajectory-based) and population-based approaches to balance the advantages of exploration and exploitation properties. The SS algorithm was based on three following rules.

- *Rule-1:* Once *Citta* travels to explore various sense-objects, it is regarded as the population-based metaheuristics having exploration property by using random process with unlimited distribution. In this case, Lévy distribution with an infinite variance and an infinite mean is conducted.
- *Rule-2:* When *Citta* meets concentration state with only one particular sense-object, it is regarded as the single solution-based metaheuristics having exploitation property by using random process with normal distribution denoted by $N(\mu, \sigma^2)$, where μ is the mean and $\sigma > 0$ is the standard deviation. For the

standard normal distribution, $\mu = 0$ and $\sigma = 1$ are denoted by $N(0, 1)$.

- *Rule-3:* Switching between travelling *Citta* and concentrating *Citta* can be defined by the switching probability, ρ.

Based on Rule-1, the mathematical formulation to update a new solution is expressed in (1) - (6) [3].

$$\boldsymbol{x}_i^{t+1} = \boldsymbol{x}_i^t + L(\boldsymbol{x}_j^t - \boldsymbol{x}^*) \tag{1}$$

$$L \approx \frac{\alpha\beta\Gamma(\beta)\sin(\pi\beta/2)}{\pi \mid s \mid^{1+\beta}}, \quad s \to \infty, 0 < \beta \le 2 \tag{2}$$

$$\Gamma(z) = \int_0^\infty t^{z-1} e^{-t} dt \tag{3}$$

$$s = \frac{u}{\mid v \mid^{1/\beta}} \tag{4}$$

$$u \approx N(0, \sigma_u^2), \quad v \approx N(0, \sigma_v^2) \tag{5}$$

$$\sigma_u = \left\{ \frac{\Gamma(1+\beta)\sin(\pi\beta/2)}{\Gamma[(1+\beta)/2]\beta 2^{(\beta-1)/2}} \right\}^{1/\beta}, \quad \sigma_v = 1 \tag{6}$$

- Objective function $f(\boldsymbol{x})$, $\boldsymbol{x} = (x_1,\ldots,x_d)^T$
- Generate initial n population of sens-objects $\boldsymbol{x}_i = (i = 1, 2,\ldots,n)$
- Find the initial best solution $\boldsymbol{x}^*$ among $\boldsymbol{x}_i$ via $f(\boldsymbol{x}_i)$
- Define a switching probability $\rho \in [0, 1]$
- Define a random number with uniform distribution $\gamma \in [0, 1]$

while ($t <$ MaxMom)
  if ($\gamma > \rho$) % *Population-based*
    - Set $N = n$
    for $i = 1 : N$
      - Generate L by (2) associated with (3) – (6)
      - Create new solution by (1)
    end for
  else if ($\gamma \le \rho$) % *Single solution-based*
    - Set $N = 1$
    - Generate ε by (8)
    - Create new solution by (7)
  end if
  if $f(\boldsymbol{x}) < f(\boldsymbol{x}^*)$
    - Update current best solution $\boldsymbol{x}^* = \boldsymbol{x}$
  end if
end while
- Report the best solution found

Fig. 1 Pseudo code of SS algorithm

Based on Rule-2, the mathematical formulation to update a new solution is expressed in (7) - (8) [3].

$$\boldsymbol{x}_i^{t+1} = \boldsymbol{x}_i^t + \varepsilon(\boldsymbol{x}_j^t - \boldsymbol{x}^*) \tag{7}$$

$$\varepsilon = \frac{1}{\sigma\sqrt{2\pi}} e^{-\left\{\frac{(x-\mu)^2}{2\sigma^2}\right\}}, \quad -\infty < \boldsymbol{x} < \infty \tag{8}$$

Based on Rule-3, when the switching probability ρ is fixed at particular value and γ is randomly generated in each moment (iteration), if $\gamma > \rho$, the Rule-1 is activated. Otherwise, Rule-2 is invoked. The SS algorithm can be summarized by pseudo code shown in Fig. 1.

III. SS-Based PIDA Design Approach

A. Cardiac Pacemaker System

The cardiac pacemaker is the most common medical device used for heart diagnosis. It employs an electrical impulse when it observes any ambiguity in the heart rate. The implantable pacemakers are widely used nowadays [6],[16],[17]. It was designed to detect and monitor whether the patient's heart beat is within the normal range. Fig.1 shows the basic block diagram of the implantable pacemaker. The Electrocardiogram (ECG) detector will check the heart rhythm and heart rate via electrode sensor, pre-amp and band-pass filter (BPF), and analog-to-digital (A/D) convertor, respectively. Once an abnormal heart rate is detected, electrical excitation signals will be applied to the heart using the high-voltage multiplier and pulse generator in order to maintain the patient's heart rate normal. Normally, the pacemaker requires low power consumption for long term operation by using battery management system (BMS).

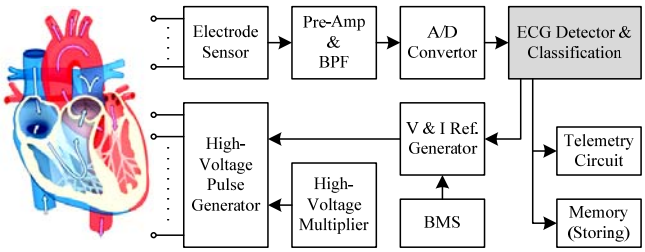

Fig. 2 Implantable pacemaker block diagram

The simplified model of the pacemaker control loop can be represented by the block diagram as shown in Fig. 3, where $R(s)$ is desired heart rate, $C(s)$ is actual heart rate, $G_p(s)$ is the pacemaker model as stated in (9) [18], $G_c(s)$ is the controller model and $G_h(s)$ is the cardiovascular system including the heart as stated in (10) [18], while $H(s) = 1$ is unity feedback gain.

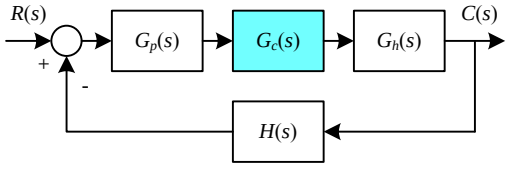

Fig. 3 Block diagram of pacemaker control loop

$$G_p(s) = \frac{8}{(s+8)} \tag{9}$$

$$G_h(s) = \frac{169}{s(s+20.8)} \tag{10}$$

B. SS-Based PIDA Controller Designs

The application of the SS to design an optimal PIDA controller for the cardiac pacemaker can be represented by the block diagram as shown in Fig. 4. The transfer function model of the PIDA controller $G_c(s)$ is stated in (11), where K_p is the proportional gain, K_i is the integral gain, K_d is the derivative gain and K_a is the accelerated gain, respectively.

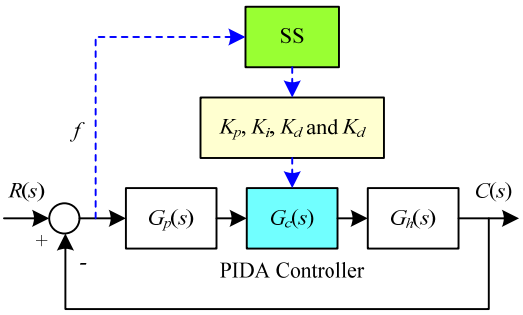

Fig. 4 SS-based PIDA controller design

$$G_c(s)\big|_{PIDA} = K_p + \frac{K_i}{s} + K_d s + K_a s^2 \tag{11}$$

The integral of squared error (ISE) between the desired heart rate $r(t)$ and the actual heart rate $c(t)$ is set as the objective function $f(\cdot)$ stated in (12). The time-domain response specification, including the rise time (t_r), the maximum percent overshoot (M_p), the settling time (t_s) and the steady-state error (e_{ss}), is together defined as the constrained functions as expressed in (13). Referring to Fig. 4, $f(\cdot)$ in (12) will be minimized by the SS to search for the appropriate values of K_p, K_i, K_d and K_a of the PIDA controller within their corresponding boundaries (search spaces) as given in (13). For comparison with the PID controller, K_a in (13) will be set as zero.

$$\begin{aligned} Min \quad f(\cdot) &= \int_0^t (e(t))^2 dt \\ &= \int_0^t [r(t) - c(t)]^2 dt \end{aligned} \tag{12}$$

$$\left.\begin{aligned} Subject\ to \quad & t_r \le 0.5 \text{ sec}, \\ & M_p \le 5\%, \\ & t_s \le 1.0 \text{ sec}, \\ & e_{ss} \le 0.01\%, \\ & 0 \le K_p \le 5.0, \\ & 0 \le K_i \le 0.1, \\ & 0 \le K_d \le 0.5, \\ & 0 \le K_a \le 0.1 \end{aligned}\right\} \tag{13}$$

IV. Results and Discussions

The SS algorithm was coded by MATLAB version 2018b (License No.# 40637337) run on Intel(R) Core(TM) i5-3470 CPU@3.60GHz, 4.0GB-RAM in order to design an optimal PID and PIDA controllers for the cardiac pacemaker. The searching parameters of the SS, i.e. number of sens-objects n = 30 and switching probability ρ = 0.25 (or 25%) are set according to recommendations of Puangdownreong [3]. In this work, 50 trails are searched to obtain the optimal PID and PIDA controllers. For all cases, the maximum moment (MaxMom) = 200 is set as the termination criteria for each search trial.

Once the search process is terminated, the PID and PIDA controller for the given cardiac pacemaker are optimized by the SS as expressed in (14) and (15), respectively. The convergent rates of the objective function $f(\cdot)$ over 50 trials of the SS-based PIDA controller design are depicted in Fig. 5

$$G_c(s)\big|_{PID} = 0.9848 + \frac{0.0014}{s} + 0.1012s \tag{14}$$

$$G_c(s)\big|_{PIDA} = 2.7412 + \frac{0.0001}{s} + 0.4855s + 0.0102s^2 \tag{15}$$

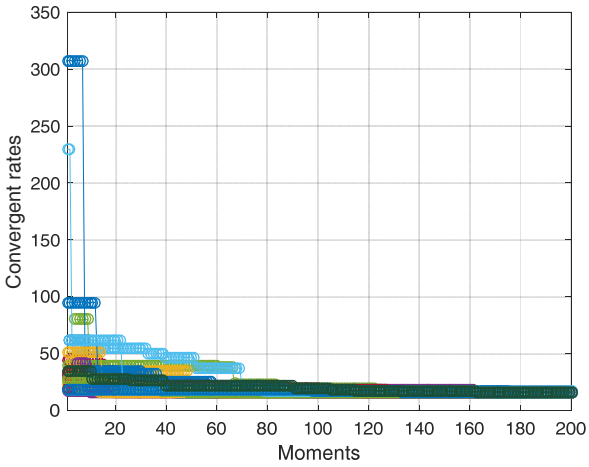

Fig. 5 Convergent rates of PIDA controller designed by SS over 50 trials

For normal adults, they have heart rate around 75 beats per minute (bpm). For old age person, they have around 65 bpm, while young active person have around 85 bpm. The step-responses of the cardiac pacemaker without (closed-loop) and with PID/PIDA controllers designed by the SS at the heart rate of 65, 75 and 85 bpm. are plotted in Fig. 6 - Fig. 8. All results are summarized in Table I. As results, it was found that the closed-loop system without controller yields higher overshoot and long settling time. The system with PID and PIDA controllers gives less overshoot. The cardiac pacemaker system with the PIDA can provide faster and smoother response than the PID controller.

TABLE I. Responses of Cariac Pacemaker Systems

Controllers	Step-responses			
	t_r (sec.)	M_p (%)	t_s (sec.)	e_{ss} (%)
without	0.3086	34.6423	1.5413	0.0000
PID	0.3072	4.6046	0.5899	0.0074
PIDA	0.1304	1.4139	0.1168	0.0000

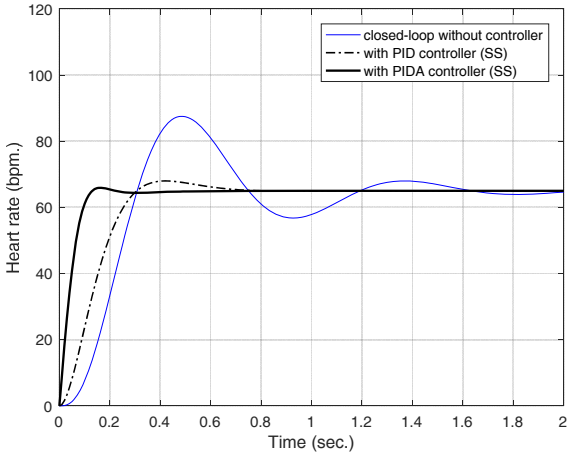

Fig. 6 Step-responses of pacemaker system at heart rate = 65 bpm

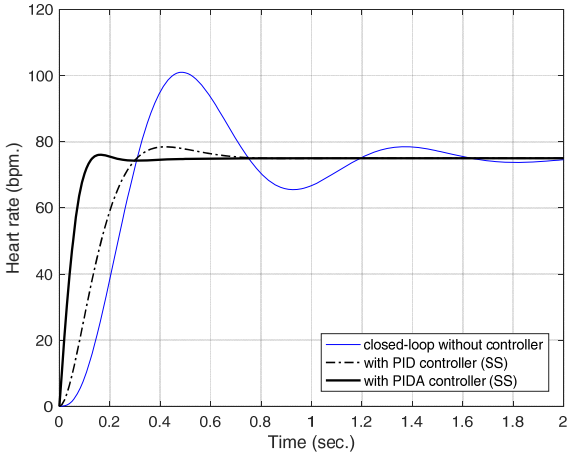

Fig. 7 Step-responses of pacemaker system at heart rate = 75 bpm

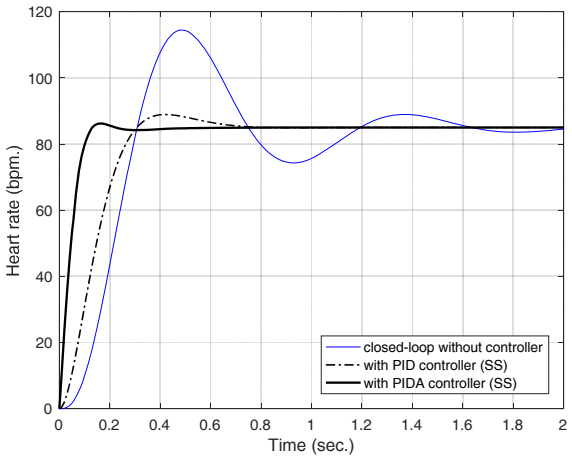

Fig. 8 Step-responses of pacemaker system at heart rate = 85 bpm

V. Conclusions

The application of the SS to design an optimal PIDA controller for regulating the heart rate of the cardiac pacemaker in the cardiovascular system has been presented in this paper. The SS, one of the newest and most powerful metaheuristic optimization algorithms, is based on what the Buddha taught focusing on the spiritual concentration. In this work, the SS has been applied to the biomedical-control engineering problem. With the proposed SS-based design approach, results obtained by the PIDA controller have been compared with those obtained by the PID controller. As simulation results, it was found that the PID and PIDA controllers for the cardiac pacemaker can be successfully optimized by the SS. By comparison, the PIDA controller could provide faster and smoother response than the PID. This can be concluded that, based on the SS-based design approach, the PIDA can regulate the heart rate of the cardiac pacemaker in the cardiovascular system at 65, 75 and 85 bpm. better than the PID controller.

References

[1] V. Zakian, Control Systems Design: A New Framework, London Limited: pringer-Verlag, 2005.

[2] H. E. P. Espinosa, Nature-Inspired Computing for Control Systems, Springer, Switzerland, 2016.

[3] D. Puangdownreong, "Spiritual search: a novel metaheuristic algorithm for control engineering optimization," International Review of Automatic Control, vol. 11, no. 2, 2018, pp. 86-97.

[4] P. Harvey, An Introduction to Buddhism: Teachings, History and Practices, Cambridge University Press, 2013.

[5] W. Rahula, What the Buddha Taught, Grove Press, New York, 1974.

[6] L.S. Dreifus, C.Fisch, J.C. Griffin, P.C. Gillette, J.W. Mason and V. Parsonnet, "Guidelines for implantation of cardiac pacemakers and antiarrythmia devices," AHA Medical/Scientific Statement, Special Report, 1991, pp.455-467.

[7] W. V. Shi and M. Zhou, "Body sensors applied in pacemakers: a survey," IEEE Sensors Journal, vol.12, no. 6, 2012, pp. 1817-1827.

[8] K. R. Govind and R. A. Sekhar, "Design of a novel PID controller for cardiac pacemaker," IEEE Advances in Green Energy (ICAGE), 2014, pp. 82-87.

[9] J. Yadav, A. Rani and G. Garg, "Intelligent heart rate controller for cardiac pacemaker," International Journal of Computer Applications, vol. 36, no. 7, 2011, pp. 22-29.

[10] T. Sugiura, N. Sugiura, T. Kazui and Y. Harada, "A fuzzy approach to the rate control in an artificial cardiac pacemaker regulated by respiratory rate and temperature," Journal of Medical Engineering and Technology, vol. 15, no. 3, 1991, pp. 107-110.

[11] A. Wojtasik, Z. Jaworski, W. Ku´zmicz, A. Wielgus, A. Wałkanis and D. Sarna, "Fuzzy logic controller for rate-adaptive heart pacemaker," Applied Soft Computing, vol. 4, no. 3, 2004, pp. 259-270.

[12] S. Jung and R. C. Dorf, "Analytic PIDA controller design technique for a third order system," Proceedings of the 35th IEEE Conference on Decision and Control, 1996, pp. 2513-2518.

[13] S. Sornmuang and S. Sujitjorn, "GA-based PIDA control design optimization with an application to AC motor speed control," International Journal of Mathematics and Computers in Simulation, vol. 3, no. 4, 2010, pp. 67-80.

[14] D. Puangdownreong and S. Suwannarongsri, "Torsional resonance suppression via PIDA controller designed by the particle swarm optimization," Proceedings of the 5th Annual International Conference Organized by Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology, 2008, pp. 673-676.

[15] A. Nawikavatan, T. Jitwang, C. Thammarat and D. Puangdownreong, "Application of cuckoo search to optimal PIDA controller design for three-tank liquid-level control system," Proceedings of the 2018 International Conference on Engineering and Natural Science, 2018, pp. 51-59.

[16] Z. Jiang, M. Pajic, S. Moarref, R. Alur and R. Mangharam, "Modeling and verification of a dual chamber implantable pacemaker," Tools and Algorithms for the Construction and Analysis of Systems, Springer, 2012, pp. 188-203.

[17] Y. Jyoti, R. Asha and G. Girisha, "Intelligent heart rate controller for cardiac pacemaker," International Journal of Computer Applications, vol. 36, no. 7, 2011, pp. 22-29.

[18] S. Biswas, A. Das and P. Guha, "Mathematical model of cardiovascular system by transfer function method," Calcutta Medical Journal, vol. 4, 2006, pp. 15-17.

Coordinated Power Controller Design of DG and EWH for Frequency Control in a Wind-Diesel Hybrid Power System by an Artificial Neural Network

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***Abstract*— This paper proposes a novel coordinated power controller design of diesel generator (DG) and electric water heater (EWH) for controlling the frequency in a wind-diesel hybrid power system. An artificial neural network (ANN) is applied for the coordinated power controller parameters prediction of DG and EWH based on the minimization of an integral absolute error (IAE) value. For the DG and EWH power controllers, it is a proportional-integral-derivative (PID) controller. The multilayer feedforward neural network is utilized for creating the system operating model. Simulation results display that the proposed coordinated PID power controllers of DG and EWH can effectively control the output power of DG and also can greatly smoothen the frequency deviation under various power change patterns from the wind farms and loads.**

***Keywords*—Artificial neural network; Wind-Diesel Hybrid Power System; Frequency Control; Electric Water Heater.**

I. INTRODUCTION

In rural areas, the diesel generators have been used widely in power systems for suppling the main powers to loads [1]. However, the power generations from the diesel generators are not friendly environmental. In addition, the fuel of diesel generator is greatly expensive. To reduce the pollution and to save the fuel use of diesel generators, wind energy sources have been utilized increasingly for connecting with the power systems due to the CO2 emissions reduction and the inexpensive cost [2]. Such power systems combined with the wind energy sources are called as the wind-diesel hybrid power system [3]. However, a severe frequency oscillation problem may happen in the system because of the variable power generations from wind farms [4].

To damp the frequency deviation, electric water heater (EWH) can be applied [5]. In [6], the EWH power controllers can pleasingly suppress the oscillation of frequency in a power system. In [7], the power controllers of the plug-in hybrid electric vehicle and the heat pump designed by a model of artificial neural network (ANN) can reduce greatly the deviation of frequency in a power system. However, improper EWH power consumption control may not be able to compensate the real power unbalance between the wind powers and loads and may cannot damp greatly the frequency deviation. In addition, the low EWH power consumption may cannot reduce the peak of frequency oscillation. Besides, the unsuitably high EWH power consumption may cannot decrease the peak of frequency change. To reduce the peak of frequency oscillation, the optimal high EWH power consumption deviation control by minimizing simultaneously the inversion of an integral absolute error (IAE) value of the EWH power consumption deviation and the IAE value of the real power unbalance deviation is proposed in this paper.

Nevertheless, in [5-7], the output power of diesel generator (DG) is not controlled during the operation. The large output power deviation of DG may occur when the severe wind power generations are subjected to the system. This may result in the wear and tear of engine and/or the deterioration of system performance because the speed-gear changer acts too fast and/or too slow [4]. To avoid the wear and tear of engine and/or the system performance deterioration, the output power of DG should be controlled as a constant or should be changed slightly [3]. As a result, the DG output power control by minimizing the IAE value of the DG output power change is highly desired.

This paper focuses on a novel coordinated DG and EWH power controllers design for controlling the frequency in the wind-diesel system. The ANN is utilized for finding the coordinated power controller parameters of DG and EWH based on the simultaneous minimizations of the inversion of the IAE value of the EWH power consumption deviation, the IAE value of the real power unbalance deviation and the IAE value of the DG output power deviation. With the power controllers of

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DG and EWH, it is a proportional-integral-derivative (PID) controller. Simulation studies show the superior frequency and DG output power control effects of the proposed coordinated PID power controllers of DG and EWH in comparison to the conventional PID power controllers of EWH designed by the conventional power controller design approach in [6] and the conventional PID power controllers of EWH designed by ANN based on the proposed power controller design method in [7].

II. THE SYSTEM

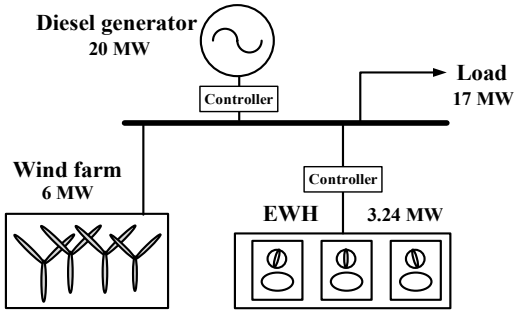

Fig. 1 The wind-diesel hybrid power system.

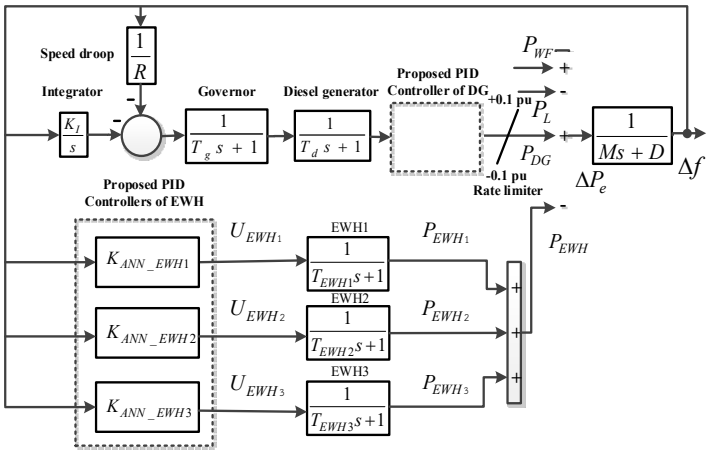

Fig. 2 The linearized model.

Fig. 1 exhibits a hybrid system [6]. The linearized model is demonstrated in Fig. 2. The proposed coordinated PID power controllers of DG and EWH are

$$K_{ANN_EWH1}(s) = K_{P1} + \frac{K_{I1}}{s} + K_{D1}s \quad (1)$$

$$K_{ANN_EWH2}(s) = K_{P2} + \frac{K_{I2}}{s} + K_{D2}s \quad (2)$$

$$K_{ANN_EWH3}(s) = K_{P3} + \frac{K_{I3}}{s} + K_{D3}s \quad (3)$$

$$K_{ANN_DG}(s) = K_{P4} + \frac{K_{I4}}{s} + K_{D4}s \quad (4)$$

where the K_{ANN_EWH1}, K_{ANN_EWH2}, and K_{ANN_EWH3} are the proposed PID controllers of EWH1, EWH2 and EWH3. The K_{ANN_DG} is the proposed PID controller of DG. For the system parameters, it is given in [6].

III. METHODOLOGY

For this section, the ANN model is used for finding the coordinated PID power controller parameters of DG and EWH. In addition, the ANN model is applied for learning the linearized hybrid power system model and also predicting the simultaneous minimum values of the inversion of the IAE value of the EWH power consumption deviation (ΔP_{EWH}), the IAE value of the real power unbalance deviation (ΔP_e) and the IAE value of the DG output power deviation (ΔP_{DG}). The ANN model architecture including the input, hidden and output layers [8, 9] is illustrated in Fig. 3.

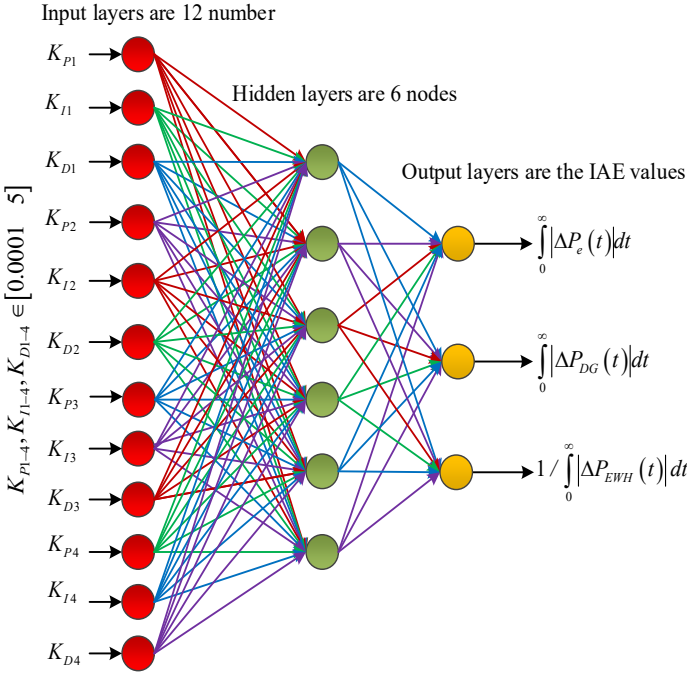

Fig. 3 The ANN model architecture.

Next, in the experiment, we randomized 1,000 samples. We took the data from the linearized hybrid power system model. The parameters of K_{P1}, K_{I1}, K_{D1}, K_{P2}, K_{I2}, K_{D2} K_{P3}, K_{I3}, K_{D3}, K_{P4}, K_{I4}, and K_{D4} are set as the input layer data. The output layer data are the inversion of the IAE of ΔP_{EWH}, the IAE of ΔP_e, and the IAE of ΔP_{DG} computed under the change patterns of the wind power and the load of case 1 as shown in Figs. 4-5.

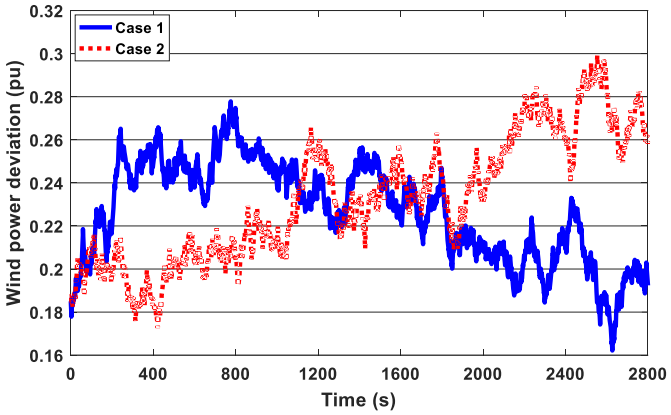

Fig. 4 Wind power deviation.

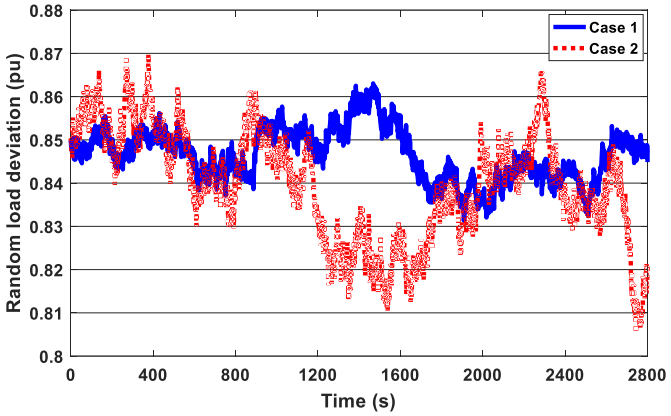

Fig. 5 Random load deviation.

IV. Experiments

In this section, we have constructed a single-hidden layer feedforward neural network [10] with a set of 6 nodes. The Levenberg-Marquardt algorithm [11-13] was utilized to train and test the dataset. We have the dataset for 1,000 samples. The 700 samples are applied for the training. The 150 samples are utilized for the validation set. The 150 samples are used for the testing.

The ANN model is able to learn the wind-diesel hybrid power system. We randomized 50,000 samples for the PID controller parameters of DG and EWH. The ANN model was used for predicting the IAE of ΔP_e, the IAE of ΔP_{DG}, and the inversion of the IAE of ΔP_{EWH}.

Fig. 6 shows the correlation coefficient (R) value. As seen in Fig. 6, the R is 0.99982. This indicates that the prediction values of ANN model is in the same direction.

Next, Fig. 7 exhibits the mean square error (MSE) value. In Fig. 7, the best validation performance is 1.6204 at epoch 14. This implies that the ANN model is appropriate for the prediction.

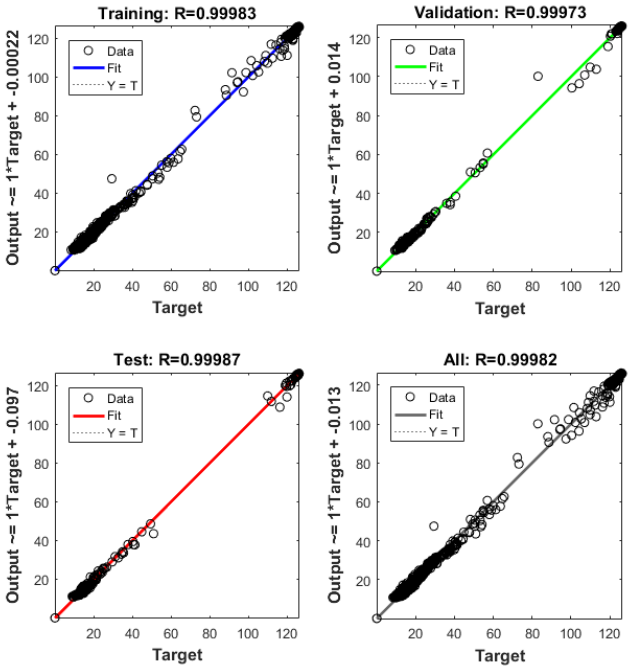

Fig. 6 The value of correlation coefficient (R).

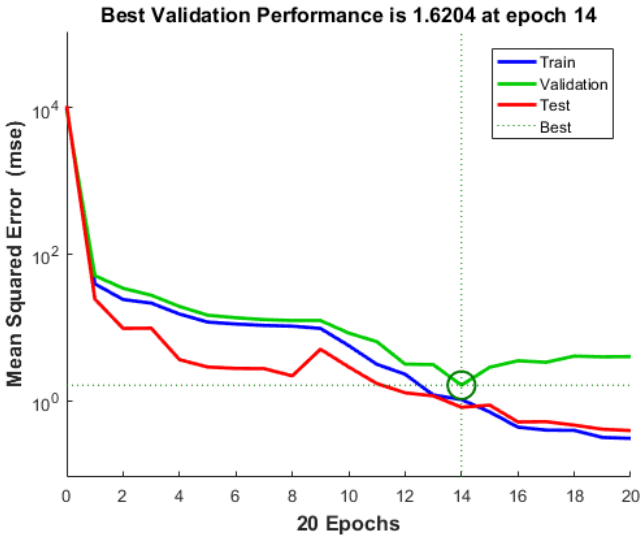

Fig. 7 The Mean square error value.

V. Simulation Results

After learning the wind-diesel hybrid power system, we randomized 50,000 samples for the PID controller parameters of DG and EWH. The ANN model was used for predicting the inversion of the IAE of ΔP_{EWH}, the IAE of ΔP_e, and the IAE of ΔP_{DG}. We found the minimum values of the inversion of the IAE of ΔP_{EWH}, the IAE of ΔP_e, and the IAE of ΔP_{DG}.

Next, the parameter values were replaced in the equations (1) to (4). Accordingly, the proposed coordinated PID power controllers of DG and EWH (proposed ANN-DG & ANN-EWH) are

$$K_{ANN_EWH1}(s) = 1.9649 + \frac{0.4267}{s} + 0.0265s \quad (5)$$

$$K_{ANN_EWH2}(s) = 1.9762 + \frac{0.5426}{s} + 0.0597s \quad (6)$$

$$K_{ANN_EWH3}(s) = 1.9412 + \frac{1.0124}{s} + 0.0976s \quad (7)$$

$$K_{ANN_DG}(s) = 0.1075 + \frac{0.0106}{s} + 0.0024s \quad (8)$$

In the comparison, the proposed ANN-DG & ANN-EWH is compared with the EWH power controllers (conventional EWH) designed by the conventional power controller design method in [6] and the conventional PID power controllers of EWH (conventional ANN-EWH) designed by the ANN based on the proposed power controller design technique in [7]. For the conventional EWH, the conventional PID power controller parameters of EWH are optimized by a particle swarm optimization (PSO) [14]. After optimizing by the PSO, the conventional EWH can be obtained as follows:

$$K_{Conventional_EWH1}(s) = 1.6296 + \frac{0.0014}{s} + 0.0002s \quad (9)$$

$$K_{Conventional_EWH2}(s) = 2.0845 + \frac{0.0009}{s} + 0.0006s \quad (10)$$

$$K_{Conventional_EWH3}(s) = 1.9721 + \frac{0.0011}{s} + 0.0004s \quad (11)$$

In case of the conventional ANN-EWH, the ANN is applied for predicting the conventional PID power controller parameters of EWH. After applying the ANN, the conventional ANN-EWH can be obtained as follows:

$$K_{Conventional_ANN_EWH1}(s) = 1.9265 + \frac{0.0059}{s} + 0.0016s \quad (12)$$

$$K_{Conventional_ANN_EWH2}(s) = 2.1621 + \frac{0.0026}{s} + 0.0021s \quad (13)$$

$$K_{Conventional_ANN_EWH3}(s) = 1.9798 + \frac{0.0096}{s} + 0.0024s \quad (14)$$

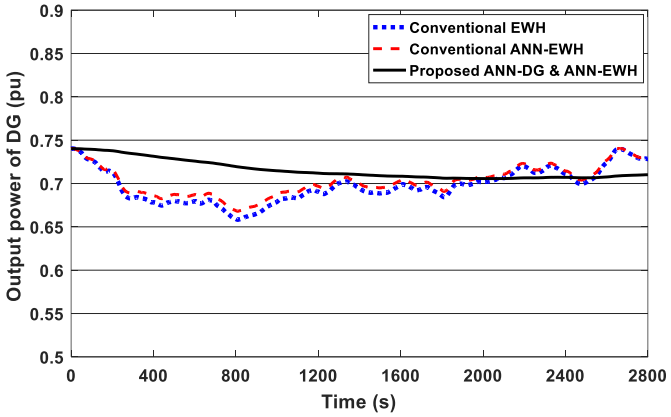

Fig. 8 DG output power under the power changes from wind farms and loads of case 1.

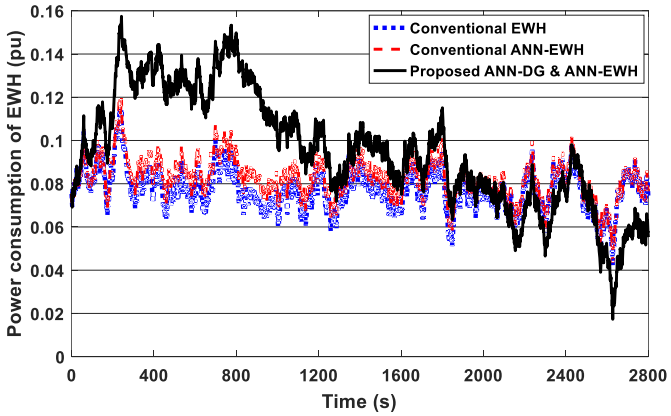

Fig. 9 EWH power consumption under the power changes from wind farms and loads of case 1.

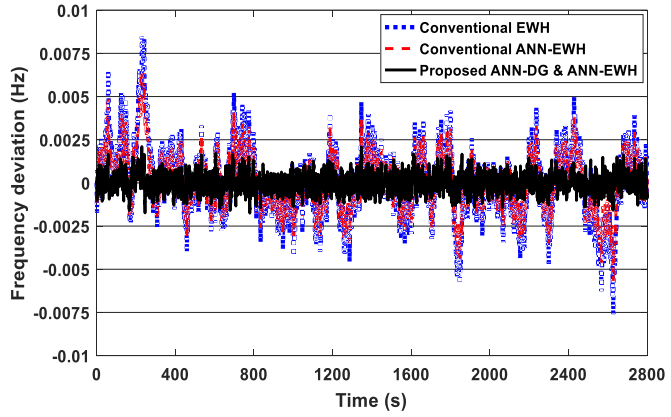

Fig. 10 Frequency deviation under the power changes from wind farms and loads of case 1.

Fig. 8 shows the output power of DG in case 1. For Fig. 8, the DG output power deviation of the proposed ANN-DG & ANN-EWH is less than those of the conventional EWH and the conventional ANN-EWH. Fig 9 shows the power consumption of EWH in case 1. The power consumption of

the proposed ANN-DG & ANN-EWH is more than those of the conventional EWH and the conventional ANN-EWH. This results in the superior frequency deviation suppression effect of the proposed ANN-DG & ANN-EWH in comparison with those of the conventional EWH and the conventional ANN-EWH as in Fig 10.

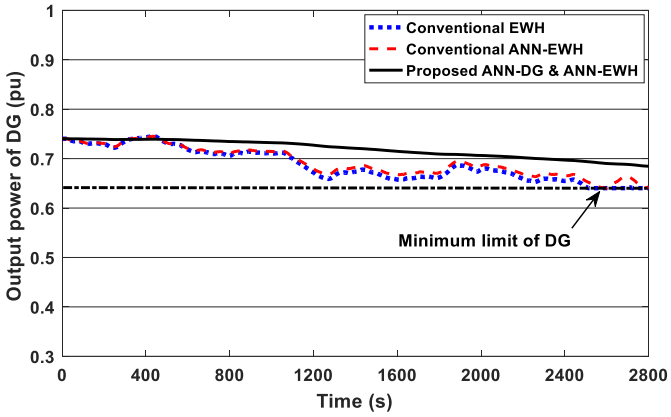

Fig. 11 DG output power under the power changes from wind farms and loads of case 2.

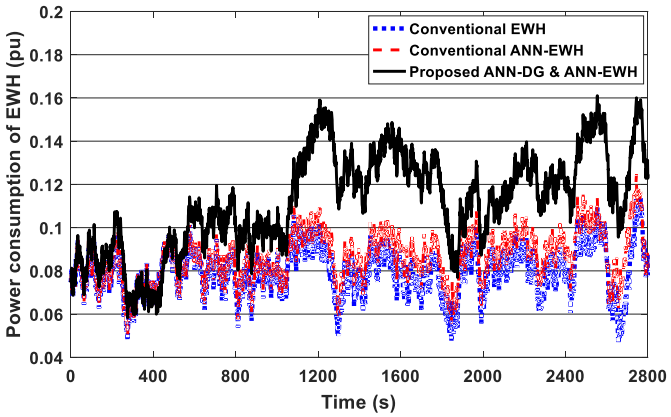

Fig. 12 EWH power consumption under the power changes from wind farms and loads of case 2.

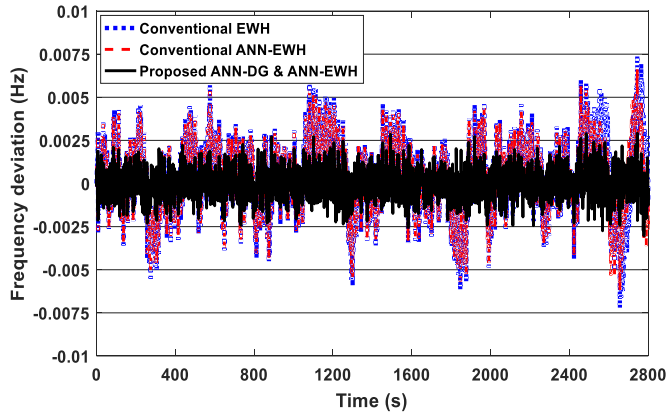

Fig. 13 Frequency deviation under the power changes from wind farms and loads of case 2.

Fig. 11 depicts the output power of DG under the wind power and load changes of case 2 as shown in Figs. 4-5. In the cases of both the conventional EWH and the conventional ANN-EWH, the output powers of DG hit the minimum limit of DG. These result in the deterioration of the DG performance. In contrast, the proposed ANN-DG & ANN-EWH can control effectively the output power of DG within its normal operating ranges. Next, Fig 12 demonstrates the power consumption of EWH in case 2. As observed in Fig. 12, the power consumptions of EWH in the cases of the conventional EWH and the conventional ANN-EWH cannot effectively manage the real power unbalance. These result in the lower frequency deviation damping effects in comparison with that of the proposed ANN-DG & ANN-EWH as noticed in Fig 13. It can be confirmed that the proposed ANN-DG & ANN-EWH not only can control efficiently the DG output power, but the proposed ANN-DG & ANN-EWH also can smoothen greatly the frequency deviation under different power change patterns from the wind farms and loads.

VI. Conclusion

The novel coordinated DG and EWH power controllers design for controlling the frequency in the hybrid system has been presented. Based on the simultaneous minimizations of the inversion of the IAE value of the EWH power consumption deviation, the IAE value of the real power unbalance deviation and the IAE value of the DG output power deviation, the output power of DG can be controlled effectively within its normal operating boundaries and also the frequency deviation can be damped greatly. Simulation results exhibit the superiority and high effectiveness of the proposed coordinated PID power controllers of DG and EWH in terms of the effective output power deviation control of DG, the optimal high power consumption control of EWH and the high frequency deviation damping effects.

References

[1] H. Yunhao, S. Yuanyuan, Z. Han, and M. Yang, "Sliding mode reactive power control of isolated wind-diesel hybrid power system based on STATCOM," *Chinese Control Conference (CCC),* 2018, pp. 8709-8714.

[2] M.Rezkallah and A. Chandra, "Control of wind-diesel isolated system with power quality improvement," *IEEE Electrical Power & Energy Conference,* 2009, pp. 1-6.

[3] S. Dhundhara and Y. P. Verma, "Performance evaluation of wind-diesel hybrid system with capacitive energy storage system," *IEEE India Conference (INDICON),* 2015, pp. 1-6.

[4] T. S. Bhatti, A. A. F. Al-Ademi, and N. K. Bansal, "Load frequency control of isolated wind diesel hybrid power systems," *Energy Conversion and Management,* vol. 38, no. 9, pp. 829-837, 1997.

[5] T. Senjyu, M. Tokudome, A. Yona, and T. Funabashi, "A frequency control approach by decentralized controllable loads in small power systems," *IEEJ Transactions on Power and Energy,* vol. 129, pp. 1074-1080, 2009.

[6] T. Senjyu, M. Tokudome, A. Yona, H. Sekine, T. Funabashi, and C-H Kim, "A frequency control approach by decentralized generators and loads in power systems," *IEEE*

International Conference on Power and Energy(PECon 08), 2008, pp. 79-84.

[7] K. Jandum and K. Tamee, "Finding optimal controller parameters of HP and PHEV for frequency control in an isolated small power system using a neural network model," *Information : an international Interdisciplinary journal,* vol. 19, no. 7, pp. 3009-3016, 2016.

[8] K. Hornik, M. Stinchcombe, and H. White, "Multilayer feedforward networks are universal approximators," *Neural networks,* vol. 2, pp. 359-366, 1989.

[9] K. Hornik, "Approximation capabilities of multilayer feedforward networks," *Neural networks,* vol. 4, pp. 251-257, 1991.

[10] P. Benardos and G.-C. Vosniakos, "Optimizing feedforward artificial neural network architecture," *Engineering Applications of Artificial Intelligence,* vol. 20, pp. 365-382, 2007.

[11] J. J. Moré, "The Levenberg-Marquardt algorithm: implementation and theory," in *Numerical analysis*, ed: Springer, 1978, pp. 105-116.

[12] M. T. Hagan and M. B. Menhaj, "Training feedforward networks with the Marquardt algorithm," *IEEE Transactions on Neural Networks,* vol. 5, pp. 989-993, 1994.

[13] Z. Wang, B. Wang, C. Liu, and W. Wang, "Improved BP neural network algorithm to wind power forecast," *The Journal of Engineering,* vol. 2017, no. 13, pp. 940-943, 2017.

[14] J. Kennedy and R. Eberhart, "Particle swarm optimization," *IEEE International Conference on Neural Networks,* 1995, pp. 1942-1948.

Smart Notification System for Detecting Fan Failure in Evaporative Cooling System of a Poultry Farm

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***Abstract*—Majority of small livestock farms such as poultry farms use evaporative cooling system to control temperature and air flow inside their houses. Hence, the operation of the evaporative cooling system is very crucial factor to the animal welfare. In Chiang Mai area, the malfunctions of evaporator system usually occurs in the cooling fans due to power outages. The current notification system is an alarm system which was installed in the farm area and has several limitations. We have developed a smart notification system to monitor fan operations in the evaporative cooling system of a local poultry farm. We applied infrared sensors which are suitable for practical usage for detecting fan malfunctions. After that, the data is sent to a computer to be processed and then notify a user in three ways: a phone call, a short message service, and a LINE application. We installed and tested our system at a poultry farm in the Mae Faek community for forty five consecutive days and during these time the system work as intended.**

***Index Terms*—Smart Notification System, Evaporative Cooling System, Infrared Sensor, Poultry Farm**

I. Introduction

Since the 2004 avian influenza epidemic in Thailand [1], the poultry farms have migrated from traditional farming system into evaporative cooling systems (EVAPs). The productivity of a poultry farm are depending on two main factors: temperature and humidity [2]. An evaporative cooling system has pad-fan system installed, which fans push outside air toward a wet pad into the poultry house to adjust the air flow for temperature and humidity controlled [3]. This EVAPs allow farmers to host around 10,000 chickens in the house. However, for rural areas in the developing countries like Thailand, the power outages occur frequently without warning especially during the summer and rainy reasons. These situations cause the malfunctioning of the EVAPs and that could means a huge loss for the farmers.

To counter these problems, the farmer has installed an alarm in the farm to notify the workers in the area if any problems occurs. Since the EVAPs system run continually, this approach is not quite practical. We focus on automatically detecting the failures of the EVAPs system by monitoring the most important component of the system which is the fan mechanisms. We have developed a smart notification system as shown in Fig. 1. The system consists of sensors and the NodeMCU to gathering the fan data, a Raspberry Pi board for processing data and making decision, and the GSM modules to handle the notifications. The system is capable of continuously monitoring the fan operations in the EVAPs system and sending notification to a user via a phone call, a short message service, and a social media LINE application.

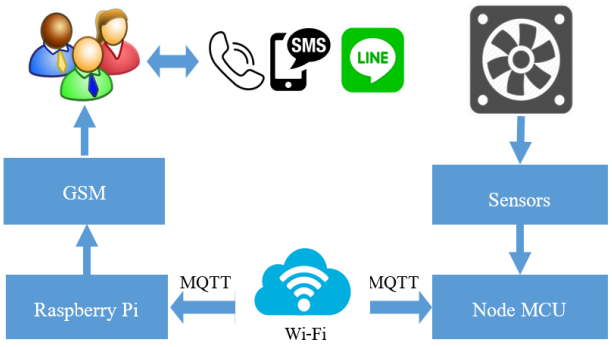

Fig. 1. An overall diagram of a smart notification for poultry farming system.

II. Related Work

For small livestock farms, farmers usually handle all the managements. This approach has several limitations such as high labor costs, inefficiency, and time consuming. With the emerge of smart technologies such as smart phones, sensors, and the internet of things, these equipments become more accessible to the farmers. In recent years, the precision farming approaches has been used for farm management to increase productivity or prevent diseases [4]. Precision farming applies sensor technologies for collecting the environmental data to process and make decision automatically. For poultry farms, various types of sensors have been used to monitor environmental data such as temperature, humidity, air velocity, rain drop, NH_3, and CO_2 [5] [6].

There are many researches that build a completed solution for poultry farm management using modern technologies which can be divided into two categories: a local and a remote field server [6]. The first approach require a computer to be set up on site to collect and process data. Bustamante et al. [7]

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built a multisensor system consists of fifty sensors to measure brolier house environment data simultaneously. Ammad-uddin et al. [8] built a wireless solution with sensors and RFID technologies to detect early sign of chicken infections and improve farm productivity.

The second approach allows farmer to manage farm remotely from a smart device. Aziz and Othman [9] proposed an framework for mobile and web application for farm management. Several reseaches [2] [10] [11] [12] [13] [14] demonstrated a farm management system, which integrated with a web server, that focused on the ease of use and low costs equipments such as Raspberry Pi, Arduino-Uno board and other similar devices.

These researches mainly focus on a farm management aspects by combining sensors and IoT technologies. However, there is no report about the technologies that would detecting the malfunction of a fan in the evaporative cooling system during the power outages. We studied the type of sensors to be used for the EVAPs in our early work [15]. We followed a common approach for poultry farms by designing a notification system with Raspberry Pi board and IoT modules.

III. Methodology

A. Overview

We selected a poultry egg production farm in the Mae Faek community, Chiang Mai for our demonstration. The farm is called Wichittra Farm which locates around 10 kilometers from Maejo University. It hosts around 10,0000 chicken in a large house with an evaporative cooling system installed as shown in Fig. 2 and Fig. 3. The EVAPs system is controlled by a programable switch box and have an alarm system put beside the box shown in Fig. 4. Hence, the current notification system would required a worker to be physically presented in the farm to hear the alarm sound.

Fig. 2. The environments inside the poultry house of Wichittra Farm.

Our proposed notification system uses smart technologies to replace a traditional alarm. However, since the evaporative cooling system is required to run continuously and could be stopped for a short period of time. Our system would have to be able to integrate with the current system without disrupting its operation. We also need our own power supply which would allow the system to work in case of power outages. Finally, the notifications are send to a user via various channels.

Fig. 3. The EVAPs system with six fans installed at Wichittra Farm.

Fig. 4. The EVAPs system switch box and an small alarm system of Wichittra Farm.

B. Architecture

Our notification system divides into four parts: fan sensor modules, data processing modules, notification modules and, power supply modules.

1) Fan sensor modules: We apply a sensor to detect the malfunctions of a fan in the EVAPs by measuring the fan frequency. From our earlier work [15], we found that an infrared sensor is very versatile and have a very high accuracy in measuring the fan movements. The infrared sensor send signal waves to the moving fan blades when the waves hit the blade, they would reflect the signal back to the infrared receiver. We use these data to calculate the fan frequency in Hz. An infrared sensor operate at voltage range is from 2.7 to 6.2 with 5mA current. The sensor has range of detecting an object from 0.8 to 4 inches and give digital output with a default response time of 2.56 mS. We installed our sensor to detect the movement of a fan. The GPIO is connected to the IoT platform called NodeMCU which run on the ESP8266 Wi-Fi SoC from Espressif Systems. The data are send to a Raspberry Pi via Wi-Fi. The implementation of this module is shown in Fig. 5 and Fig. 6.

2) Data processing modules: The NodeMCU send data to a Raspberry Pi 3 Model B board to be processed by our software. The data processing program would determine the status of a fan and then make a decision to send a notification to a user shown in Fig. 8.

3) Notification modules: To decide the types of notification to be used for the farmers. We conducted a survey on

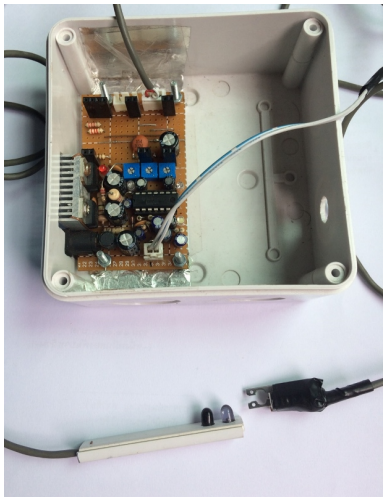

Fig. 5. The fan sensor modules consist of a NodeMCU (top) and an infrared sensor (bottom).

Fig. 6. An infrared sensor attached to the cage of the fan.

technologies usages of 33 poultry farmers in the Mae Faek community. The results showed that 94.7 percent of farmers have a smart phone and 87.2 percent of farmers use a social media called a LINE application. Therefore, we selected three ways of notification in our system: a phone call, a SMS, and a LINE application. We developed a software in Python which run on a Raspberry Pi 3 Model B board and intergraded with a GSM modules that sent notifications to a user based on the criteria of a fan status. If a fan frequency reaches below a certain threshold, the system would send the warning messages to a user as shown in Fig. 7. All components in this module are shown in Fig. 8.

4) Power supply modules: The power supply modules is one of the important parts in our system. The system have to continue working even in case of power outages at the farm. We choose the solar cell system to be our sources of power supplies. We used a couple of large solar cell panels and two batteries to ensure that the entire system would last throughout the rainy seasons as shown in Fig. 9. The components of notification modules is inside the case under the solar cell panels.

IV. Experiments and Results

We implemented our notification system at Wichittra Farm for forty five consecutive days. The infrared sensors were

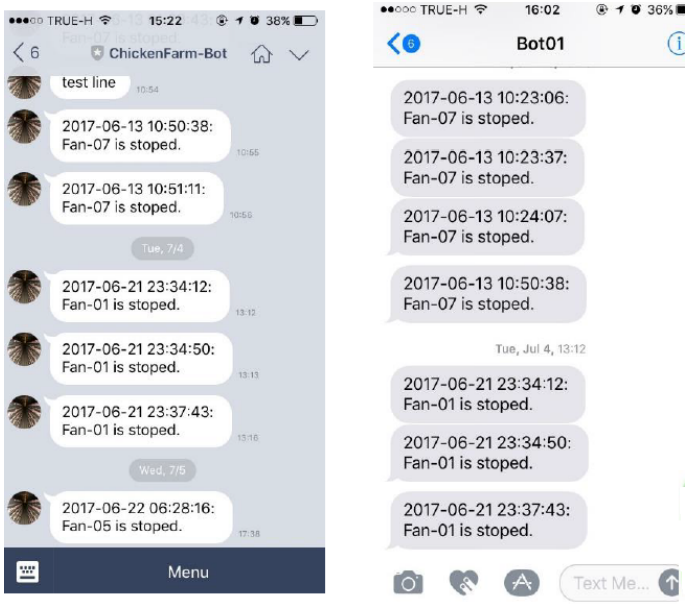

Fig. 7. Examples of notifications send to a user via LINE application (left) and SMS (right).

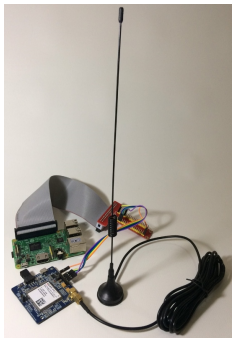

Fig. 8. A Raspberry Pi 3 Model B with a GSM modules used for processing data and send notifications to a user.

Fig. 9. A solar cell system set up on-site near a poultry farm.

attahed to six fans and the NodeMCU were located on the top of the fan outside the house. During these time, the system is able to send notifications to a user whenever the status of a fan has been changed. The solar cell system is able to provide enough power to all the devices. After the experiment period ended, most of components in the system were covered with the chicken dung and were needed to be clean as shown in Fig. 10.

Fig. 10. After 45-day trial period ended, an infrared sensor was covered in chicken dung.

V. Discussion

The smart notification system had a successfully 45 days trial in a poultry farm and was able to notify a user when there were changes in the fan status. The three types of notification channels were suitable for farmer lifestyles where the majority of them carried a smart phone. The overall system needed to be improved in terms of casing to be able to cope with the industrial hazard environments of a poultry farm. The prototype of the system could be applied to other livestock farms that are using the similar evaporative cooling system.

Acknowledgment

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References

[1] T. Tiensin, P. Chaitaweesub, T. Songserm, A. Chaisingh, W. Hoonsuwan, C. Buranathai, T. Parakamawongsa, S. Premashthira, A. Amonsin, M. Gilbert *et al.*, "Highly pathogenic avian influenza h5n1, thailand, 2004," *Emerging infectious diseases*, vol. 11, no. 11, p. 1664, 2005.

[2] M. Murad, K. M. Yahya, and G. M. Hassan, "Web based poultry farm monitoring system using wireless sensor network," in *Proceedings of the 7th International Conference on Frontiers of Information Technology*. ACM, 2009, p. 7.

[3] F. H. Fahmy, H. M. Farghally, N. M. Ahmed, and A. Nafeh, "Modeling and simulation of evaporative cooling system in controlled environment greenhouse," *Smart grid and renewable Energy*, vol. 3, no. 01, p. 67, 2012.

[4] D. Berckmans, "Automatic on-line monitoring of animals by precision livestock farming," in *Proceedings of the ISAH Conference on Animal Production in Europe: The Way Forward in a Changing World*, Saint-Malo, France, 2004, pp. 27–31.

[5] Y. Wan, S. Yu, J. Huang, J. Yang, and C. Tsai, "Automation integration for taiwan country chicken farm management using field server," in *Proceedings of the World Conference on Agricultural Information and IT (IAALD AFITA WCCA2008)*, 2008, pp. 143–150.

[6] G. Corkery, S. Ward, C. Kenny, and P. Hemmingway, "Incorporating smart sensing technologies into the poultry industry," *Journal of World's Poultry Research*, vol. 3, no. 4, pp. 106–128, 2013.

[7] E. Bustamante, E. Guijarro, F. J. García-Diego, S. Balasch, A. Hospitaler, and A. Torres, "Multisensor system for isotemporal measurements to assess indoor climatic conditions in poultry farms," *Sensors (Basel, Switzerland)*, vol. 12, pp. 5752–74, 12 2012.

[8] M. Ammad-uddin, M. Ayaz, E. Aggoune, and M. Sajjad, "Wireless sensor network: A complete solution for poultry farming," in *2014 IEEE 2nd International Symposium on Telecommunication Technologies (ISTT)*, Nov 2014, pp. 321–325.

[9] N. Aziz and F. Othman, "Design and implementation of ubiquitous chicken farm management system using ios smart phone," *Research Notes in Information Science (RNIS)*, vol. 12, pp. 150–154, 04 2013.

[10] Santoshkumar, K. Chelli, and S. Chavhan, "Development of wireless sensor node to monitor poultry farm," in *Mobile Communication and Power Engineering*. Berlin, Heidelberg: Springer Berlin Heidelberg, 2013, pp. 27–32.

[11] C. So-In, S. Poolsanguan, C. Poonriboon, K. Rujirakul, Y. Phasuk, and T. Haitook, "Smart mobile poultry farming systems in tmote sky wsns," *International Journal Of Digital Content Technology And Its Applications*, vol. 7, no. 9, p. 508, 2013.

[12] S. Jindarat and P. Wuttidittachotti, "Smart farm monitoring using raspberry pi and arduino," in *Computer, Communications, and Control Technology (I4CT), 2015 International Conference on*. IEEE, 2015, pp. 284–288.

[13] L. S. Handigolkar, M. Kavya, and P. Veena, "Iot based smart poultry farming using commodity hardware and software," *Bonfring International Journal of Software Engineering and Soft Computing*, vol. 6, no. Special Issue, pp. 171–175, 2016.

[14] R. B. Mahale and S. Sonavane, "Smart poultry farm monitoring using iot and wireless sensor networks." *International Journal of Advanced Research in Computer Science*, vol. 7, no. 3, 2016.

[15] W. Sarachai, P. Ratnapinda, and P. Khumwichai, "Sensor technologies for monitoring cooling fan operation in evaporative cooling system," in *Proceedings of MJU Annual Conference 2018*. Chiang Mai, Thailand: Maejo University, 2018, pp. 314–322.

Convolutional Neural Network Models for Hand-Woven Fabric Motif Recognition

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***Abstract*—Motifs of hand-woven fabrics are normally designed uniquely within each village or area. Thus, they represent story, culture, or history of the related areas. This research is intended to automate the motif recognition. To complete this, the authors surveyed local fabrics in Loei province, Thailand, which is called phasin. Phasins are commonly woven and worn by women. In this process, the authors collected images of phasins based on two types of phasins found in the area called mee-kun and mee-ruad. The collected images were segmented. The segmentation revealed 25 motifs, which were used for experiment. In the experiment, 10-fold cross-validation research design was employed to train and test 4,500 images in the dataset based on two convolutional neural network models: Inception-v3 and MobileNets. The results reveal that MobileNets outperforms Inception-v3 with the accuracy rate of 98.223% and 93.208% respectively.**

***Index Terms*—Fabric Pattern Recognition, Motif Recognition, Convolutional Neural Network, Deep Learning, Fabric Pattern Design, Loei Province, Inception, MobileNets**

I. INTRODUCTION

Studies of motifs or pattern designs on local hand-woven fabrics have received high attention. This is due to the fact that motifs on local fabrics commonly represent cultures, traditions, or values of people and locations where the motifs are designed and woven. Learning of fabric motifs not only helps understand their traditional backgrounds but also reserve and made them appeared to the public. In Thailand, local weaving has continued to decline due to the lack of weavers in the villages and the popularity of ready-made clothes. The existing current weavers are normally women in their old age, but with high experience in either designing motifs or weaving. Without the successors, the knowledge of these experienced weavers and local motifs are disappearing.

In order to know the name and the background of each motif, the common method is to acquire the answer from village scholars or knowledgeable weavers, who know about such motif. Instead of doing so, the pattern recognition can replace this action by reading the motif and providing related information. The machine learning methods have been employed for recognizing pattern of various fields, for example, face recognition, handwriting recognition, license plate recognition, and object recognition. In the previous literature, many studies of weaving pattern recognition have been found. Regular bands method has been used to detect the floating yarn [3]. There are also machine learning approaches, such as BayesNet, kNN, Scale-Invariant Feature Transform (SIFT), Support Vector Machine (SVM) and k-means that have been used to classify batik motif [1,5,6]. From the experiment of batik classification by Loke [5], BayesNet outperforms kNN, FarthestFirst, and k-means. Some combinations of SIFT and SVM and an improved version of SIFT have also yielded satisfactory results [1,6]. There are also applications of Convolutional Neural Network (CNN) models for recognizing motifs on hand-woven fabrics. For example, Boonsirisumpun and Puarungroj [2] introduce the approaches of applying CNN models: Inception-v1, Inception-v2, Inception-v3, and Inception-v4. The result suggests that Inception-v3 and Inception-v4 outperform others, while Inception-v4 performs slightly better than Inception-v3, but with a highly larger size. Puarungroj and Boonsirisumpun [7] also carry out the experiment on classifying fabric motifs of phasins based on Inception-v3, Inception-v4, and MobileNets. The result yields the interesting outcomes that MobileNets outperforms others and Inception-v3 achieves better performance than Inception-v4.

In this research, we explored the local hand-woven fabrics called phasins in Loei province, Thailand and carried out an experiment of motif recognition based on two CNN models: Inception-v3 and MobileNets. The performance of the two models was then calculated and compared.

II. RELATED WORK

A. Fabric Motifs in Loei Province, Thailand

Fabrics in Thailand have long been woven locally in each village, especially in the North Eastern region. Most of the motifs appeared on each piece of fabrics always bind to cultures, traditions, customs, or values of weavers' villages. The fabric products are distributed among their family, relatives, and friends for making shirts or phasins. Phasin refers to a piece of cloth, which is used for wearing by women looking like a skirt. Women who weave phasins always show their skills in weaving their unique village motifs, which are taught from generation to generation, and also designing new

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motifs. Phasins with beautiful motifs are not used in daily life, but keeping for some special occasions such as religious days in Buddhism and wedding ceremonies.

Fabric motifs found on phasins in Loei can be divided into two types: mee-kun and mee-ruad. Mee-kun refers to the pattern that one motif is appeared repeatedly in a vertical line on the fabric while another motif can be sit next to it in the same line. Different motifs are separated by some vertical straight lines. Each piece of mee-kun can contain several motifs. Mee-ruad is distinct from mee-kun that one or a group of motifs is appeared repeatedly and orderly on all over phasins. There is no straight line on mee-ruad as in mee-kun. It is common that there is only one motif on each piece of mee-ruad. Examples of mee-kun and mee-ruad phasins are shown in Fig 1.

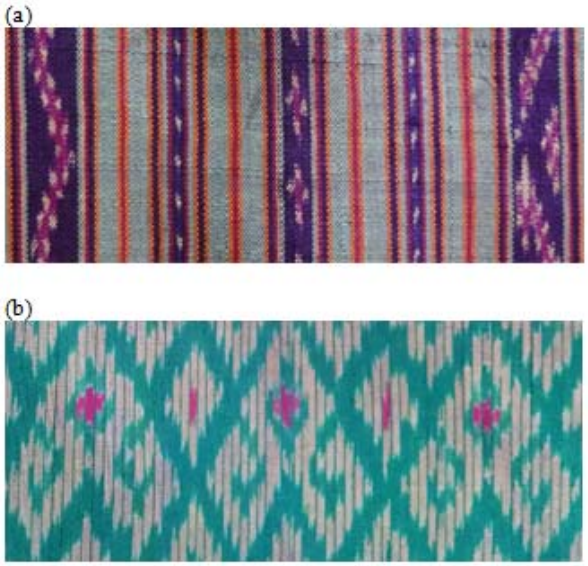

Fig. 1. Examples of (a) Mee-Kun and (b) Mee-Ruad

B. *Convolutional Neural Network (CNN)*

CNN is a deep learning method, which is suitable for image analysis. This method combines input layer, multiple hidden layers, and output layer. The hidden layers commonly contain convolutional layers, pooling layers, and fully connected layers, which try to recognize an image by analyzing its smaller parts within hidden layers. CNN is popular because of its high accuracy results. Based on CNN, Google introduce GoogLeNet or Inception, which has been developed by Szegedy et al. [8]. Inception begins with 22 layers and has been improved in the newer versions, for example, Inception-v3 has improved by using the factorization process [9] as shown in Fig 2.

Apart from Inception, other CNN models have also been developed such as MobileNets. This model is upon the attempt to overcome the size of the model to make it more suitable for mobiles. Instead of using standard convolutional filters, MobileNets replaces them with two new layers called Depthwise and Pointwise as shown in Fig. 3 [4].

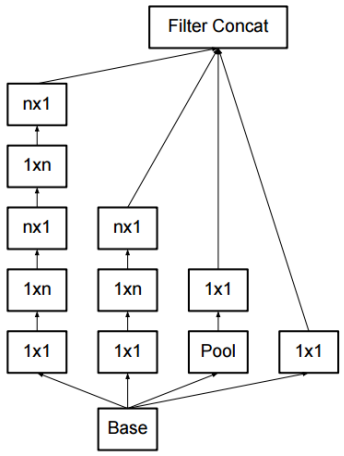

Fig. 2. The Factorization Process [9]

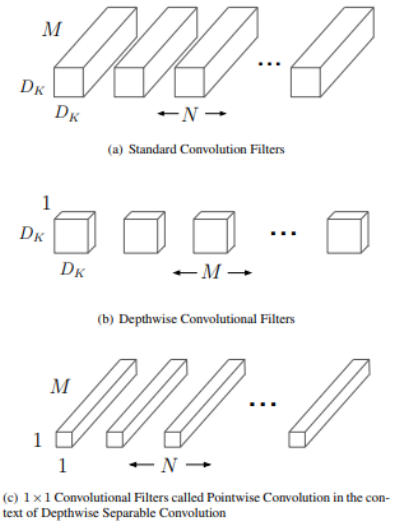

Fig. 3. The Depthwise and Pointwise Filters [4]

III. Research Methodology

The research has been conducted in 3 key steps: (1) image data collection; (2) image segmentation; (3) training and testing.

A. *Image Data Collection*

In this step, phasin images from weaving groups in Loei were collected by the authors. Images of phasins were photo taken and the details of motifs appeared on each piece of phasins were collected by interviewing with knowledgeable weavers. The collection of phasin images were based on mee-kun and mee-ruad.

B. *Image Segmentation*

In this step, motifs images were segmented. There were 25 motifs used for the experiment. From these 25 motifs, 450 images of each motif were segmented. In total, there were 4,500 images of motifs in the dataset. Examples of 25 motif images are shown in Fig 4.

Fig. 4. Examples of 25 motifs (a) Khor-Tua-Es (b) Khor-Tob-Nai (c) Tao-Noi (d) Peek-Phe-Sua (e) Khor-Pia (f) Gan Bin-Thai (g) Khor Nak Khoo (h) Khor Pak-Ar (i) Khor Ma-Nam (j) Khor Whee Yai (k) Dok Fai Meuang Loei (l) Mangmoom (m) Rung Peung (n) Whee Noi (o) Saifon (p) Phasat (q) Aue (r) Mhak Jub (s) Mhak Jub Khoo (t) Toom (u) Khapia (v) Nak Khor (w) Naknoi (x) Baipai (y) Khor

C. *Training and Testing*

The research design was based on 10-fold cross-validation method. In this design, the segmented images of motifs were organized into 10 folders where each folder contained 3,600 images (80%) for training and 900 images (20%) for testing. The training was carried out with Inception-v3 and MobileNets models. After training, the trained models based on Inception-v3 and MobileNets models were tested with the test dataset. The accuracy of testing was calculated for each folder. Then, the accuracy results of testing were compared and interpreted

IV. Data Analysis and Results

The research carried out the experiment based on 10-fold cross-validation approach. Two CNN models: inception-v3 and MobileNets were chosen for the experiment as recommended by prior research [2, 7]. In the experiment, the dataset in each folder were divided into 80% for training and 20% for testing.

TABLE I. Test Accuracy

Folder	Accuracy	
	MobileNets	**Inception-v3**
Fold0	95.783%	90.813%
Fold1	93.825%	91.265%
Fold2	98.946%	94.277%
Fold3	98.494%	93.675%
Fold4	98.946%	92.620%
Fold5	99.398%	92.018%
Fold6	99.096%	93.524%
Fold7	98.946%	94.578%
Fold8	99.398%	94.127%
Fold9	99.398%	95.181%
Average	**98.223%**	**93.208%**
SD	**1.880**	**1.466**

In Table I, the test accuracy of phasins'motif recognition is reported by each folder. The training and testing was performed with 25 motifs with totally 4,500 images in the dataset. The results show that MobileNets outperforms Inception-v3 in every folder. In average, MobileNets outperforms Inception-v3 with the accuracy rate of 98.223% and 93.208% respectively.

V. Conclusion

In this research, the experiment of fabric motif recognition was carried out. The image data were collected by the authors. Firstly, the weaver groups were surveyed and their phasins fabric products were photo taken together with their details. Traditional phasins with unique Loei' motifs were also collected. From our data collection, 25 motifs were found based on mee-kun and mee-ruad types. Secondly, the data were

classified and segmented. From this process, there were 4,500 images of motifs in the dataset. Finally, the dataset was categorized into 10 folders based on 10-fold cross-validation and trained with two CNN models namely Inception-v3 and MobileNets. The results reveal that MobileNets achieves higher performance than Inception-v3 in all folders and the average accuracy of MobileNets and Inception-v3 is 98.223% and 93.208% respectively. In future work, the research should be carried out with other CNN models or other models of machine learning approaches in order to find proper models for motifs recognition. Furthermore, the research should collect more samples of each motif in order to better train the models. Finally, the research should expand the region of data collection in order to make the trained models being able to be used widely.

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REFERENCES

[1] R. Azhar, D. Tuwohingide, D. Kamudi, Sarimuddin, N. Suciati, "Batik Image Classification using SIFT Feature Extraction, Bag of Features and Support Vector Machine," Procedia Computer Science, vol. 72, 24-30, 2015.

[2] N. Boonsirisumpun, W. Puarungroj, "Loei Fabric Weaving Pattern Recognition using Deep Neural Network," 15th International Joint Conference Computer Science and Software Engineering, IEEE, 2018.

[3] C. C.W. Chan, K.S. Li, H. Y.T. Ngan, "Weaving Pattern Recognition of Ancient Chinese Textiles by Regular Band Analysis," International Symposium on Electronic Imaging, pp. 31-36, 2017.

[4] A. G. Howard, Z. Menglong, C. Bo, K. Dmitry, W. Weijun, W. Tobias, A. Marco, A. Hartwig, "MobileNets: Efficient Convolutional Neural Networks for Mobile Vision Applications," arXiv preprint arXiv:1704.04861, 2017.

[5] K. S. Loke, "An Approach to Textile Recognition," In: Yin, P. (ed.), Pattern Recognition. InTechOpen, 439-459, 2009.

[6] I. Nurhaida, A. Noviyanto, R. Manurung, A.M. Arymurthy, "Automatic Indonesian's Batik Pattern Recognition using SIFT Approach," Procedia Computer Science, vol. 59, 567-576, 2015.

[7] W. Puarungroj, N. Boonsirisumpun, "Recognizing Hand-Woven Fabric Pattern Designs based on Deep Learning," International Conference on Computer, Communication, and Computational Sciences, Springer, 2018.

[8] C. Szegedy, W. Liu, Y. Jia, P. Sermanet, S. Reed, D. Anguelov, D. Erhan, V. Vanhoucke, A. Rabinovich, "Going deeper with convolutions," arXiv preprint arXiv:1409.4842, 2014.

[9] C. Szegedy, V. Vanhoucke, S. Ioffe, J. Shlens, Z. Wojna, "Rethinking the inception architecture for computer vision," Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition, 2818-2826, 2016.

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Face Recognition using Transferred Deep Learning for Feature Extraction

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***Abstract*—Face recognition systems are a challenging field in computer vision. An important process and key to success is the feature extraction which requires a lot of data and time for learning. Deep learning has proven to be an outstanding method for extracting relevant features of image classification when a huge amount of data is available. However, it is not an easy task for face recognition, which consists of a small number of images per person considered as classes. This paper applies the idea of transferred learning for feature extraction to a face recognition application. The feature extraction part of the trained deep learning model from a different domain is transferred for extracting face features. Then, the multilayer perceptron neural network is used for model evaluation. Experimental results on public face databases show that the proposed method is highly efficient.**

***Index Terms*—classification, convolutional neural networks, deep learning, face recognition, feature extraction, machine learning, transferred learning, supervised learning**

I. Introduction

A face recognition system can make a machine distinguish and recognize the human face. It is a branch of pattern recognition and computer vision. The system was created in the late 19th-century [1], [2]. It can be used with both pictures and videos. Machine learning can learn to detect and recognize people's identity in a supervised manner. The process of face recognition can be divided into three main stages.

1) Face detection discovers essential components of the desired face section including face shape, eyes, nose, mouth, etc. There are four techniques for face detection, i.e. Knowledge-Based, Feature invariant approaches, Template matching methods, and Appearance-based methods [3], [4].
2) Feature extraction takes out important structures and information from the first stage. It transforms the original image into an understandable computer format in an array of numerical values. There are two main methods [1] which are Holistic template-based methods and Geometric feature-based methods. The former includes Principal-Component analysis (PCA), Eigenfaces, Fisherfaces and subspace LDA. It generates a feature vector based on the structure of the acquired data. The latter includes the Pure Geometry Methods, Dynamic Architecture, Hidden Markov Model and Convolution Neural Network (CNN).
3) Face Recognition / Classification recognizes a person's identity, with the discovered features that appear on a person's face. This stage can be done using machine learning and include k-Nearest Neighbor(kNN), Support vector machine (SVM) and Multi-Layer Perceptron (MLP).

The deep neural network is a path of machine learning, which usually combines the second and third stages into a single machine learning model. There are several structures but CNN is an outstanding model for image classification. It consists of many hidden layers such as convolutional layers, pooling layers, and fully connected layers. Each layer performs different functions such as feature extractor, image reducer, and classifier. The lower-level acts on the separation of the data components and to define a higher level [5]–[8]

Deep CNN has a lot of feature extraction layers, which are the layers between input layers and the last fully connected layer. Training the model needs a huge number of the images. This is because it consists of many parameters called weights that need to be adjusted. It easily overfits a small sample size of training images. It also needs a lot of computation power and time-consuming. There is an approach that avoids training the model from scratch called Transferred Learning. Transfer learning uses a pre-trained model where weights and bias values are already learned in a knowledge domain to be applied to another specific domain [6]–[8].

This paper applies deep transfer learning as the feature extraction step of face recognition. The pre-trained CNN is used in this domain which is a many-class dataset but has small sample size per class. The MultiLayer Perceptron neural network (MLP) is used as the face recognition step. The MLP are trained and evaluated on public face databases for performance measurement.

This paper is organized as follows. First, Section I introduces the face recognition process, deep learning, transfer learning and the main contributions of this work. Second, Section II explains the structure of Convolutional Neural Networks (CNN), the transfer learning and the pre-trained CNN. Third, Section III explains the experimental setup. Forth, Section IV reports the experimental results and discussion.

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Finally, Section V concludes this paper and outlines future work.

II. RELATED WORKS

Convolutional Neural Networks have proven to be an outstanding model for image classification. One of the well-known models is Inception version 3 (InceptionV3) training for large visual recognition challenge called ImageNet. It is one of the most often used transferred learning models.

A. Convolutional Neural Networks (CNN)

Convolutional Neural Networks (CNN) are a type of deep feedforward neural network. It is a proficient recognition model which is commonly used in pattern and face recognition [5], [7]–[9]. It consists of many layers including convolutional and pooling layers. They have great performance in terms of feature extraction from images [6], [10] in the cases where there are enough images for training.

1) Input Layers: The input layers refer to the layers of loading image data which have already been pre-processed. The input image must be equal in height, width and channels as it affects the calculation in the next layers.

2) Convolutional Layers: The convolutional layer uses many of fix sized filter masks, called a kernel, and performs the convolution operation to extract important patterns. The convolution output at position (i^{th}, j^{th}), that denotes $F(i,j)$, can be computed by equation 1. It is a discrete convolution operator, $\circledast$, of the input image $\mathbf{I}$ and convolution filter $\mathbf{K}$.

$$\mathbf{F} = \mathbf{I} \circledast \mathbf{K} \tag{1}$$

where

$$F(i,j) = \sum_m \sum_n I(i-m, j-n) K(m,n)$$

$I(i,j)$ is the intensity in the image at position (i^{th}, j^{th}) and $K(m,n)$ is the kernel value in the kernel at position (m^{th}, n^{th}).

3) Activation function: The activation function is used to define the output of any given neuron. In this work, we use two activation functions, i.e., Rectified linear unit (ReLU) and Softmax.

Firstly, *the ReLU* activation function is a discrete nonlinear operator with a max output indicative function as shown in equation 2. The output is zero for negative values and positive linearly for positive values.

$$\begin{aligned} F^*(i,j) &= \text{ReLU}(F(i,j)) \\ &= \max(0, F(i,j)) \end{aligned} \tag{2}$$

Secondly, *the Softmax* activation function is a generalization of the logistic function for multiclass classification. It is applied on the output layer where the decision is made. All output values defined by Softmax are real values in the range from 0 to 1 that sum to 1 to characterize the probabilities of v different output classes as shown in equation 3.

$$P_q = \frac{\exp(y_q)}{\sum_{v=1}^{c} \exp(y_v)} \tag{3}$$

where P_q is the defined output by the activation function corresponding to the q^{th} class, y_q is the output from the neuron q^{th} in the last layer of the neuron network and v is number of nodes in the last layer corresponding to the number of classes.

Note that, the label of all samples needs to be encoded by one-hot encoder. This produces a label vector for each sample, which contains 1 at the position corresponding the sample's class and zeros elsewhere. The label vector can be compared with the model output in the equation 3. It is used by the machine learning algorithm as the target for learning.

B. Transfer learning

Transfer learning extracts existing knowledge from a specific domain using knowledge learning from one or more auxiliary domains [11]. Transfer learning is commonly used to extract knowledge exploiting a set of meticulously manufactured features [9], [12].

In this work, we use the transfer learning concept for extracting image features using trained CNN. The result of transfer learning can be retrained in the classification layers. One of the benefits of this approach is not wasting time to building a model with large data training the CNN.

C. Pre-Trained CNN

There are academic benchmarks for computer vision and pattern recognition for validating the image recognition model. ImageNet [13] is one of the well-know image databases uses Large Visual Recognition Challenge. Several popular deep convolutional neural network architectures are trained with the ImageNet database, e.g., QuocNet [14], AlexNet [15], Inception (GoogLeNet) [16] BN-Inception-v2 [17] and Inception-v3 [18].

The trained Inception-v3 is widely used and consists of 22 deep CNN layers. The number of parameters is less than that from the AlexNet model. Inception-v3 is more accurate and smaller than AlexNet. This model classifies all images into 1000 classes. In this paper we transfer the trained CNN layers from Inception-v3 for extracting face features.

III. EXPERIMENTAL DESIGN

Dataset details and the experiments designed for evaluating the idea of transferred learning are presented in this section.

A. Facial Image Datasets

This experiment selects popular image databases that has been used in face recognition research. To cover the most related to real-life problems, we selected databases with the following characteristics and conditions: quantitative and qualitative, different lighting conditions, different facial expressions and high number of classes. The image datasets which use in this work are the Extended Yale Face Database B (Cropped) [19] and the Extended Cohn-Kanade Dataset (CK+) Dataset [20]. The images are divided into two sets the training

and the test set. The training set contains known labels for the training model, the test set is used to evaluate the accuracy of models.

1) The Extended Yale Face Database B (Cropped): The Extended Yale Face Database B (Cropped) [19] consists of different lighting conditions. Images are preprocessed by being manually aligned, cropped, and then resizing only the facial shape to 168x192 pixels. Figure 1 illustrates the sample of The Extended Yale Face Database B (Cropped) in different lighting conditions.

Fig. 1. The cropped version of "The Extended Yale Face Database B"

After removal of the damaged images, there were 2404 images from 38 individuals. Subsequently, they were divided into a training set for 1910 images (80%) and the test set for 494 images (20%).

2) The Extended Cohn-Kanade Dataset (CK+): The Extended Cohn-Kanade Dataset (CK+) [20] is a facial image database that displays facial expressing various emotions. It was developed by the Cohn-Kanade (CK) database in 2000. It consists of 593 sequences from 123 subjects which validated emotional labeling from the image sequences. The labels for sequences consists of six types of human emotions: anger, disgust, fear, happiness, sadness and surprise as shown in Figure 2.

Fig. 2. The Extended Cohn-Kanade Dataset (CK+)

Although there are six emotions, some people did not include photos of all emotions. We selected top four emotions of the highest number of individuals. Then only individuals having all four emotions were selected. The four emotions were happy faces having 2043 images from 107 individuals, surprised faces having 1946 images from 115 individuals, fear faces having 1716 images from 94 individuals and disgusted faces having 1710 images from 92 individuals. There were 81 individuals having the images of all the four facial expressions.

Three facial expressions were used for training while a facial expression was withheld for testing. Therefore, the training set consisted of 4205 images showing emotions of happiness, surprise and fear. The test set consisted of 1426 images showing the emotion of disgust.

B. Methodology

We separated the experiments into two approaches: approach 1 created an MLP model for each dataset. Approach 2 extracts feature using transferred learning and then created an MLP model for each dataset.

*1) **Approach 1:** Using only multi-layer perceptron neural network (MLP):* Each dataset was divided into a training set and test set. The training set was used for model training. The test set was withheld for evaluation as shown in Figure 3.

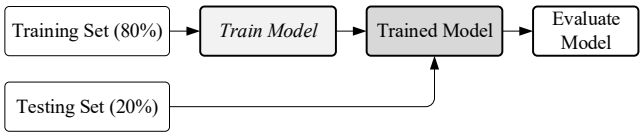

Fig. 3. The Experimental of the Multi-Layer perceptron neural networks.

*2) **Approach 2:** Using deep neural network to transfer feature extraction: CNN+MLP:* This approach used the same dataset in III-B1, but it added the feature extraction procedure using pre-trained CNN (Inception-V3). The features of the training set were extracted using the pre-trained CNN. The last layer of pre-trained CNN flats images into a feature vector. Then, all training feature vectors were used to train the classification model. Finally, the model was evaluated by using the test set which was extracted in the same way as in Figure 4.

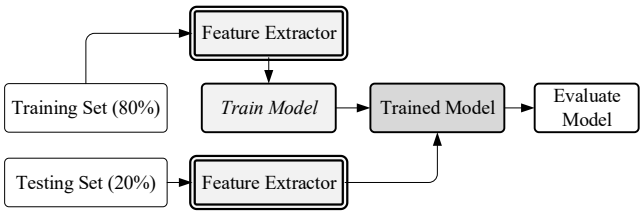

Fig. 4. The Experimental of Feature extraction of the Pre-trained CNN (Inception-V3).

3) Learning rate: The learning rate is a constant measurement in a trend of loss. If the learning rate is bigger than the best value, it means that it cannot find the minimum loss because of its overshot. However, if it is smaller than the suitable value, it will take a long time to go to the minimum. In this experiment, it demonstrates the best value of learning rate which is suitable for the classification model. The parameter uses to test the loss function which divides to five values including 0.00001, 0.0001, 0.001, 0.01, and 0.1. We can get the experimental result of loss values in figure 5.

Table I shows the loss, cross-entropy, of test dataset using different learning rate values. We found that the appropriated learning rate equal is 0.0001, since loss value of test dataset significantly decease after the few epochs of model training.

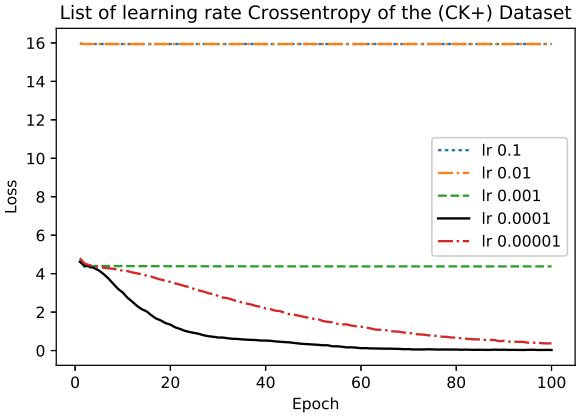

Fig. 5. The list of dropout cross-entropy of the (CK+) Dataset.

TABLE I
THE RESULT OF CROSS-ENTROPY OF DIFFERENCE LEARNING RATE VALUES.

Learning Rate	Training Loss	Testing Loss
0.1	15.9418	15.9033
0.01	15.9418	15.9033
0.001	4.2163	4.1334
0.0001	0.0313	0.0048
0.00001	0.3756	0.0552

4) Dropout: The dropout is a method to prevent the overfitting problem. Figure 6 shows the accuracy results from different dropout values. In this experiment, the learning rate was set to 0.0001. We can find that, the network does not seem to overfit to the training dataset while training. We can achieve high accuracy results using small value of dropout.

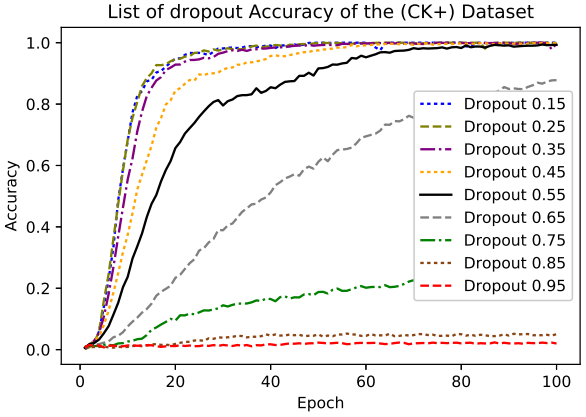

Fig. 6. The list of dropout accuracy of the (CK+) Dataset.

Table II shows accuracy results using different values of dropout. We found many appropriated dropout values having high accuracy such as 0.15, 0.25, 0.35, 0.45, 0.55 and 0.65. In contrast, the value of 0.75, 0.85, and 0.95 are in the underfitting category. Therefore, we average those appropriated values, that equal to 0.4, to represent the dropout value in the experiments.

TABLE II
THE ACCURACY RESULTS USING DIFFERENT VALUES OF DROPOUT.

Dropout	Training Accuracy	Testing Accuracy
0.15	1.0000	0.9993
0.25	0.9998	0.9986
0.35	0.9983	0.9972
0.45	0.9969	1.0000
0.55	0.9941	0.9909
0.65	0.8930	1.0000
0.75	0.2373	0.4804
0.85	0.0490	0.0968
0.95	0.0233	0.0105

The structure of multilayer perceptron (MLP) in the experiments consisted of 3 hidden layers with 1024, 512 and 256 nodes respectively. The Activation function of all nodes in the hidden layer are Rectified Linear Units (ReLU). The batch size value was set to 16, the number of samples that was propagated through the network in each step. Gradual descent algorithm with learning rate equal to 0.0001 was used as the machine learning algorithm. Also, we used the dropout technique for reducing over fitting problem in neural networks, it is set to 0.4 for each hidden layer.

All experiments were performed on a 64-bit Windows Server (10.0) OS, Intel Xeon Gold 5118 CPU @ 2.30GHz and 8 GB of RAM. This work used Inception-V3 [18], the deep convolutional neural network from Google as the pre-trained model. Implementation code in this paper is in Python with Keras [21] and TensorFlow library.

IV. RESULTS AND DISCUSSION

This section discusses the experimental results in 3 parts, i.e., Cross-Entropy, accuracy and computational time.

This paper focused on the benefits of using transferred learning on a high number of classes with a small sample size per class. There were many conditions affecting the results using different neural network models, e.g., initial weights, feature spaces and loss surfaces. Therefore, each experiment used the same environment by sharing parameters as much as possible.

A. The Cross-Entropy results

The Cross-Entropy refers to the loss function of the model. The Cross-Entropy of the test set using the model in approach 2 was far less than the one of the test set using the model in approach 1 as shown in the Table III. The loss value was slightly reduced after training over 200 and 60 epochs for Yale B and CK+ dataset as shown in Figure 7 and Figure 8 respectively.

B. Accuracy results

We found that the accuracy of the test set using the model in approach 2 was also far greater than the accuracy of the test set using the model in approach 1 on both datasets. The accuracy values of the training set for Yale B dataset using

TABLE III
THE RESULT OF CROSS-ENTROPY, ACCURACY AND COMPUTATIONAL TIMES FOR DIFFERENT DATASETS AND CLASSIFICATION METHODS.

Dataset	Model	Training Set		Testing Set		Computational Times (s)
		Cross-Entropy	Accuracy (%)	Cross-Entropy	Accuracy (%)	
Yale	MLP	15.63	3.00	15.68	2.70	15870^{c}
	CNN + MLP	0.135	95.76	0.126	96.56	957^{a}+251^{b}+3770^{c} = 4978
CK+	MLP	15.98	0.88	15.79	2.05	28709^{c}
	CNN + MLP	0.022	99.27	0.001	99.93	2305^{a}+784^{b}+2581^{c} = 5670

[a]This is the computational time of Feature Extraction of *Training Dataset*.
[b]This is the computational time of Feature Extraction of *Testing Dataset*.
[c]This is the computational time of *Model Training*.

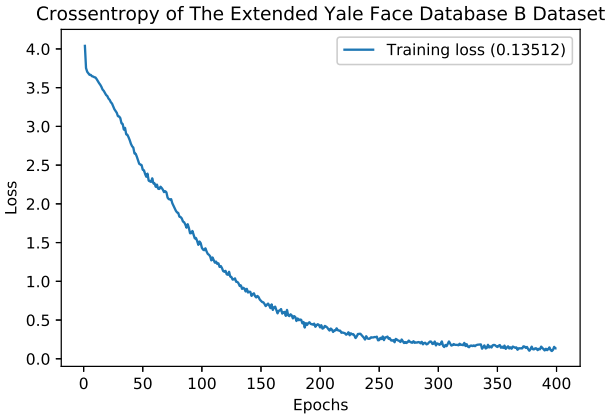

Fig. 7. The loss values on the training set of the Extended Yale Face Database B.

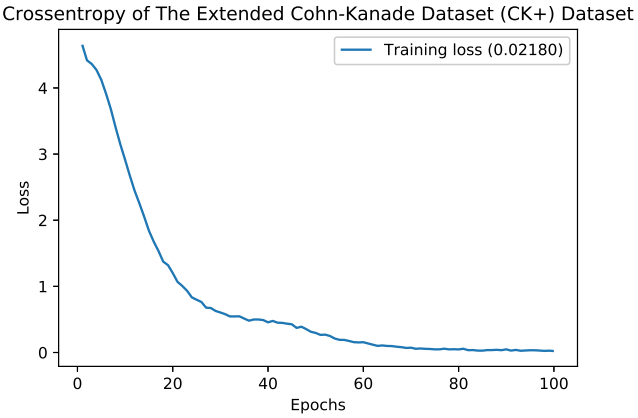

Fig. 8. The result of model loss on the training of the Extended Cohn-Kanade Dataset (CK+) .

the model in approach 2 was higher than 80% after training over 200 epochs as shown in Figure 9. This model needs only 30 epochs for the CK+ dataset as shown in Figure 10.

The accuracy for the training set matches the accuracy for the test set on both datasets. This implies that the model does not overfit the training set as it can predict the unseen data with high accuracy.

C. The computational times results

The total computation time of approach 1 has only one value, that is the model training time. The total computation time of approach 2 has three values: 1.) the computational time of feature extraction for training dataset, 2.) the computational time of feature extraction of testing dataset, and 3.) the computational time of model training. Although the models in approach 2 have many time values, the total time values are less than the one in approach 1.

V. CONCLUSIONS AND FUTURE WORK

Transferred learning using pre-trained convolution neural network as feature extractor has been applied to face recognition. Two public well-known face databases were used for evaluating the performance of the transferred learning model and traditional model. Although there are many classes, they consist of a small sample size per class in the face recognition problem. Based on the experiments, we can conclude that the results of face recognition that use transferred deep feature learning method are satisfactory. The performance of the transferred learning model is far better than the traditional model. In addition, there is no sign that an overfitting problem exists on both datasets.

In future work, we plan to fine-tune the existing pre-trained model and experiment with other pre-trained models. Furthermore, the original CK+ dataset that has non-facial parts

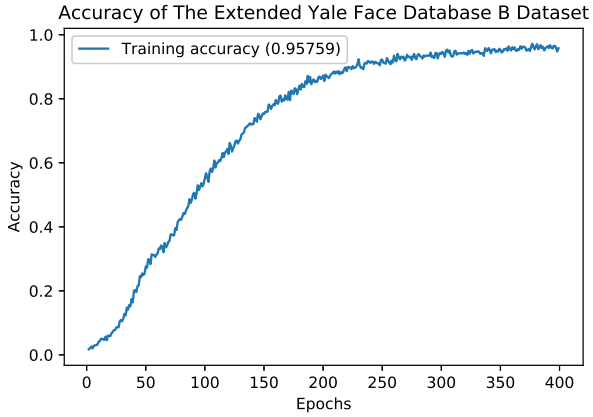

Fig. 9. The accuracy on training set of the Extended Yale Face Database B.

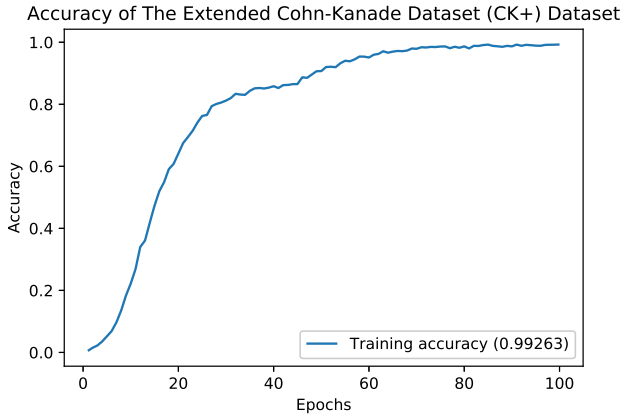

Fig. 10. The accuracy on training set of the Extended Cohn-Kanade Dataset (CK+).

and includes the ears, head or hat, part of the neck, and part of the background image. However, these elements are not required for classification and must be removed and only the portion containing eyes, nose, and mouth should be used.

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References

[1] W. Zhao, R. Chellappa, P. J. Phillips, and A. Rosenfeld, "Face recognition: A literature survey," *ACM Comput. Surv.*, vol. 35, no. 4, pp. 399–458, Dec. 2003. [Online]. Available: http://doi.acm.org/10.1145/954339.954342

[2] R. Chellappa, C. L. Wilson, and S. Sirohey, "Human and machine recognition of faces: a survey," *Proceedings of the IEEE*, vol. 83, no. 5, pp. 705–741, May 1995.

[3] M.-H. Yang, D. J. Kriegman, and N. Ahuja, "Detecting faces in images: a survey," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. 24, no. 1, pp. 34–58, Jan 2002.

[4] V. Radhamani and G. Dalin, "A supporting survey to step into a novel approach for providing automated emotion recognition service in mobile phones," in *2018 2nd International Conference on Inventive Systems and Control (ICISC)*, Jan 2018, pp. 35–39.

[5] T. Liu, S. Fang, Y. Zhao, P. Wang, and J. Zhang, "Implementation of training convolutional neural networks," *CoRR*, vol. abs/1506.01195, 2015. [Online]. Available: http://arxiv.org/abs/1506.01195

[6] M. Y. W. Teow, "Understanding convolutional neural networks using a minimal model for handwritten digit recognition," in *2017 IEEE 2nd International Conference on Automatic Control and Intelligent Systems (I2CACIS)*, Oct 2017, pp. 167–172.

[7] J. R. C. P. de Oliveira and R. A. F. Romero, "Transfer learning based model for classification of cocoa pods," in *2018 International Joint Conference on Neural Networks (IJCNN)*, July 2018, pp. 1–6.

[8] G. Gautam and S. Mukhopadhyay, "Contact lens detection using transfer learning with deep representations," in *2018 International Joint Conference on Neural Networks (IJCNN)*, July 2018, pp. 1–8.

[9] Q. Li, L. Mou, K. Jiang, Q. Liu, Y. Wang, and X. X. Zhu, "Hierarchical region based convolution neural network for multiscale object detection in remote sensing images," in *IGARSS 2018 - 2018 IEEE International Geoscience and Remote Sensing Symposium*, July 2018, pp. 4355–4358.

[10] S. D., "Understanding convolutional neural networks," *InSeminar Report, Informatik und Naturwissenschaften Lehr-und Forschungsgebiet Informatik VIII Computer Vision.*, 2014.

[11] S. J. Pan and Q. Yang, "A survey on transfer learning," *IEEE Trans. on Knowl. and Data Eng.*, vol. 22, no. 10, pp. 1345–1359, Oct. 2010. [Online]. Available: http://dx.doi.org/10.1109/TKDE.2009.191

[12] L. Shao, F. Zhu, and X. Li, "Transfer learning for visual categorization: A survey," *IEEE Transactions on Neural Networks and Learning Systems*, vol. 26, no. 5, pp. 1019–1034, May 2015.

[13] O. Russakovsky, J. Deng, H. Su, J. Krause, S. Satheesh, S. Ma, Z. Huang, A. Karpathy, A. Khosla, M. Bernstein, A. C. Berg, and L. Fei-Fei, "ImageNet Large Scale Visual Recognition Challenge," *International Journal of Computer Vision (IJCV)*, vol. 115, no. 3, pp. 211–252, 2015.

[14] Q. Le, M. Ranzato, R. Monga, M. Devin, K. Chen, G. Corrado, J. Dean, and A. Ng, "Building high-level features using large scale unsupervised learning," in *International Conference in Machine Learning*, 2012.

[15] A. Krizhevsky, I. Sutskever, and G. E. Hinton, "Imagenet classification with deep convolutional neural networks," in *Advances in Neural Information Processing Systems 25*, F. Pereira, C. J. C. Burges, L. Bottou, and K. Q. Weinberger, Eds. Curran Associates, Inc., 2012, pp. 1097–1105. [Online]. Available: http://papers.nips.cc/paper/4824-imagenet-classification-with-deep-convolutional-neural-networks.pdf

[16] C. Szegedy, W. Liu, Y. Jia, P. Sermanet, S. E. Reed, D. Anguelov, D. Erhan, V. Vanhoucke, and A. Rabinovich, "Going deeper with convolutions," *CoRR*, vol. abs/1409.4842, 2014. [Online]. Available: http://arxiv.org/abs/1409.4842

[17] S. Ioffe and C. Szegedy, "Batch normalization: Accelerating deep network training by reducing internal covariate shift," *CoRR*, vol. abs/1502.03167, 2015. [Online]. Available: http://arxiv.org/abs/1502.03167

[18] C. Szegedy, V. Vanhoucke, S. Ioffe, J. Shlens, and Z. Wojna, "Rethinking the inception architecture for computer vision," *CoRR*, vol. abs/1512.00567, 2015. [Online]. Available: http://arxiv.org/abs/1512.00567

[19] A. Georghiades, P. Belhumeur, and D. Kriegman, "From few to many: Illumination cone models for face recognition under variable lighting and pose," *IEEE Trans. Pattern Anal. Mach. Intelligence*, vol. 23, no. 6, pp. 643–660, 2001.

[20] P. Lucey, J. F. Cohn, T. Kanade, J. Saragih, Z. Ambadar, and I. Matthews, "The extended cohn-kanade dataset (ck+): A complete dataset for action unit and emotion-specified expression," in *2010 IEEE Computer Society Conference on Computer Vision and Pattern Recognition - Workshops*, June 2010, pp. 94–101.

[21] F. Chollet *et al.*, "Keras," https://keras.io, 2015.

An SDE based Stochastic Analysis of Transformer

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***Abstract*—In this research, the stochastic analysis of the transformer have been performed by using the stochastic differential equation based approach. Noise in the voltage source applied to the transformer has been considered as white noise which is a Brownian motion process or Wiener process. The analytical and numerical solutions of the stochastic differential equations of the transformer have been determined by using the Ito's formula and Euler-Maruyama scheme. The obtained results have been found to be beneficial to the analysis and designing of transformer involved circuits and systems.**

Keywords—Brownian motion process, Stochastic differential equation, Transformer, White noise, Wiener process

I. INTRODUCTION

The stochastic differential equation (SDE) has been found to be applicable in various scientific areas e.g. chemistry, physics, mathematical biology etc., and engineering fields when stochastic effects are to be considered [1]-[3]. In electrical and electronic engineering, the SDE covers various stochastic variations occurred in the systems as can be seen from many previous researches e.g. [4]-[7] etc. Many previous studies e.g. [8]-[10] etc., have focused on the effects of stochastic variations in passive circuits such as RL and RC circuits. However, there remains the transformer which can find its places in many electronic and electrical systems including those based on the up to dated low voltage/low power VLSI technology e.g. [11]-[16] etc.

Hence, the stochastic analysis of the transformer have been analyzed by using an SDE based approach in this research. Noise in the voltage source applied to the transformer has been considered as white noise which is a Brownian motion process or Wiener process. The analytical and numerical solutions of the SDEs of the transformers have been solved by means of Ito calculus and Euler-Maruyama scheme. The obtained results have been found to be beneficial to the analysis and designing of transformer involved circuits and systems including those at VLSI level.

In the subsequent section, the SDEs of transformer will be derived and their analytical solutions along with important statistical parameters such as means, second moments and variances will be determined. On the other hand, the numerical solutions of these SDEs will be evalutated in section III where stochastic responses of the transformer will be simulated. Finally, the conclusion and suggestion for further studies will be drawn in section IV.

II. THE SDES OF TRANSFORMER

Without any stochastic effect, voltage-current relationships of the transformer can be given by taking the mutual resistances which cannot be ignored in the monolithic transformer, into account for the accurate power consumption modeling [16] as follows

$$v_1(t) = L_{11}\frac{di_1}{dt} + R_{11}i_1(t) + M_{12}\frac{di_2}{dt} + R_{12}i_2(t) \quad (1)$$

$$v_2(t) = L_{22}\frac{di_2}{dt} + R_{22}i_2(t) + M_{21}\frac{di_1}{dt} + R_{21}i_1(t) \quad (2)$$

where $L_{11}(L_{22})$, $R_{11}(R_{22})$, $V_1(t)(V_2(t))$ and $I_1(t)(I_2(t))$ denote the primary(secondary) self inductance, primary(secondary) self resistance, primary(secondary) voltage and primary(secondary) current respectively. Moreover, M_{12} and M_{21} stand for mutual inductance from secondary to primary and vice versa where R_{12} and R_{21} denote the mutual resistances. Noted that R_{12} and R_{21} can be neglected for the classical off-chip transformer because its mutual impedances are purely inductive.

Since mutual coupling can be lossy in general, $I_2(t) = kn^{-1}I_1(t)$ where k and n respectively denote the coupling factor and turn ratio of the transformer. As a result, (1) and (2) become

$$v_1(t) = (L_{11} + M_{12}kn^{-1})\frac{di_1}{dt} + (R_{11} + R_{12}kn^{-1})i_1(t) \quad (3)$$

$$v_2(t) = (L_{22} + M_{21}k^{-1}n)\frac{di_2}{dt} + (R_{22} + R_{21}k^{-1}n)i_2(t) \quad (4)$$

If either $v_1(t)$ or $v_2(t)$ is known, the other terminal voltage can be determined. Therefore $i_1(t)$ and $i_2(t)$ which are the solutions of (3) and (4) can be obtained as respectively given by (5) and (6). Noted that $R_{12} = 0$, $R_{21} = 0$ and $k = 1$ must be applied if the transformer of our interested if an off-chip one. This the coupling of such off-chip transformer is lossless.

$$i_1(t) = e^{-\left(\frac{R_{11}+R_{12}kn^{-1}}{L_{11}+M_{12}kn^{-1}}\right)t}\left[i_1(0) + \int_0^t \frac{V_1(\tau)e^{\left(\frac{R_{11}+R_{12}kn^{-1}}{L_{11}-M_{12}kn^{-1}}\right)\tau}}{L_{11}+M_{12}kn^{-1}}d\tau\right] \quad (5)$$

$$i_2(t) = e^{-\left(\frac{R_{22}+R_{21}k^{-1}n}{L_{22}+M_{21}k^{-1}n}\right)t}\left[i_2(0) + \int_0^t \frac{V_2(\tau)e^{\left(\frac{R_{22}+R_{21}k^{-1}n}{L_{22}+M_{21}k^{-1}n}\right)\tau}}{L_{22}+M_{21}k^{-1}n}d\tau\right] \quad (6)$$

However, this is not the case in practice because the stochastic effect of noise in the voltage source which has been found to be significant [8]-[10] etc., must be taken into

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account. Before we proceed further, it should be mentioned here that (3) and (4) can be rearranged as follows

$$di_1(t) = -\left(\frac{R_{11} + R_{12}kn^{-1}}{L_{11} + M_{12}kn^{-1}}\right) i_1(t)dt + (L_{11} + M_{12}kn^{-1})^{-1} v_1(t)dt \quad (7)$$

$$di_2(t) = -\left(\frac{R_{22} + R_{21}k^{-1}n}{L_{22} + M_{21}k^{-1}n}\right) i_2(t)dt + (L_{22} + M_{21}k^{-1}n)^{-1} v_2(t)dt \quad (8)$$

By the stochastic effect of noise in the voltage source, $v_1(t)$ become

$$V_1(t) = v_1(t) + \alpha\zeta_s(t) \quad (9)$$

where $V_1(t)$, α and $\zeta_s(t)$ denote the stochastically varied primary voltage, noise intensity and white noise process with zero mean and unit variance respectively.

Moreover, since $v_2(t) = knv_1(t)$, $V_2(t) = knV_1(t)$ where $V_2(t)$ stands for the stochastically varied secondary voltage which can be alternatively given by

$$V_2(t) = v_2(t) + kn\alpha\zeta_s(t) \quad (10)$$

After taking these stochastic effects into account, (7) and (8) become

$$dI_1(t) = \frac{-(R_{11} + R_{12}kn^{-1})I_1(t) + v_1(t)}{L_{11} + M_{12}kn^{-1}}dt + \frac{\alpha}{L_{11} + M_{12}kn^{-1}}\zeta_s(t)dt \quad (11)$$

$$dI_2(t) = \frac{-(R_{22} + R_{21}k^{-1}n)I_2(t) + v_2(t)}{L_{11} + M_{12}k^{-1}n}dt + \frac{kn\alpha}{L_{22} + M_{21}k^{-1}n}\zeta_s(t)dt \quad (12)$$

By using (11), (12) and

$$dW_s(t) = \zeta_s(t)dt \quad (13)$$

where $W_s(t)$ is a Wiener process, the following SDEs of the transformer can be obtained

$$dI_1(t) = \frac{-(R_{11} + R_{12}kn^{-1})I_1(t) + v_1(t)}{L_{11} + M_{12}kn^{-1}}dt + + \frac{\alpha}{L_{11} + M_{12}kn^{-1}}dW_s(t) \quad (14)$$

$$dI_2(t) = \frac{-(R_{22} + R_{21}k^{-1}n)I_2(t) + v_2(t)}{L_{11} + M_{12}k^{-1}n}dt + \frac{kn\alpha}{L_{22} + M_{21}k^{-1}n}dW_s(t) \quad (15)$$

where $R_{12} = 0$, $R_{21} = 0$ and $k = 1$ for the off-chip transformer.

By using Ito's formula, the analytical solutions of (14) and (15) can be respectively found as

$$I_1(t) = e^{A_1 t}[I_1(0) + \int_0^t a_1(\tau)e^{-A_1\tau}d\tau] + b_1\int_0^t e^{-A_1\tau}dW_s(\tau)] \quad (16)$$

$$I_2(t) = e^{A_2 t}[I_2(0) + \int_0^t a_2(\tau)e^{-A_2\tau}d\tau] + b_2\int_0^t e^{-A_2\tau}dW_s(\tau)] \quad (17)$$

where $A_1 = -\frac{R_{11} + R_{12}kn^{-1}}{L_{11} + M_{12}kn^{-1}}$, $a_1(t) = \frac{v_1(t)}{L_{11} + M_{12}kn^{-1}}$, $b_1 = \frac{\alpha}{L_{11} + M_{12}kn^{-1}}$, $A_2 = -\frac{R_{22} + R_{21}k^{-1}n}{L_{22} + M_{21}k^{-1}n}$, $a_2(t) = \frac{v_2(t)}{L_{22} + M_{21}k^{-1}n}$ and $b_2 = \frac{kn\alpha}{L_{22} + M_{21}k^{-1}n}$. Moreover, $R_{12} = R_{21} = 0$ and $k = 1$ for the off-chip transformer.

Since $I_1(t)$ and $I_2(t)$ are the stochastic processes, they can be characterized by their stochastic parameters e.g. means, variances and second moments. Means of $I_1(t)$ and $I_2(t)$ can be found as

$$m_1(t) = A_1^{-1}[[A_1I_1(0) + a_1(t)]e^{A_1 t} - a_1(t)] \quad (18)$$

$$m_2(t) = A_2^{-1}[[A_2I_2(0) + a_2(t)]e^{A_2 t} - a_2(t)] \quad (19)$$

On the other hand, the variances of $I_1(t)$ and $I_2(t)$ can be given by

$$\sigma_1^2(t) = (2A_1)^{-1}[e^{2A_1 t}[2A_1I_1^2(0) + 2m_1(t)a_1(t)] - 2m_1(t)a_1(t)] - m_1^2(t) \quad (20)$$

$$\sigma_2^2(t) = (2A_2)^{-1}[e^{2A_2 t}[2A_2I_2^2(0) + 2m_2(t)a_2(t)] - 2m_2(t)a_2(t)] - m_2^2(t) \quad (21)$$

Therefore the following second moments of $I_1(t)$ and $I_2(t)$ can be obtained

$$E[I_1^2(t)] = (2A_1)^{-1}[e^{2A_1 t}[2A_1I_1^2(0) + 2m_1(t)a_1(t)] - 2m_1(t)a_1(t)] - m_1^2(t) + A_1^{-2}[[A_1I_1(0) + a_1(t)]e^{A_1 t} - a_1(t)]^2 \quad (22)$$

$$E[I_2^2(t)] = (2A_2)^{-1}[e^{2A_2 t}[2A_2I_2^2(0) + 2m_2(t)a_2(t)] - 2m_2(t)a_2(t)] - m_2^2(t) + A_2^{-2}[[A_2I_2(0) + a_2(t)]e^{A_2 t} - a_2(t)]^2 \quad (23)$$

Again, it must be kept in mind that $R_{12} = R_{21} = 0$ and $k = 1$ for the off-chip device.

III. Numerical Solutions

In order to determine the numerical solutions of (14) and (15), the often cited Euler-Maruyama scheme with strong order of convergence given by 0.5 has been used. In general, the Euler-Maruyama approximation of an arbitrary SDE given by (24) where $X(t)$, $f(t, X(t))$, $g(t, X(t))$ and $W(t)$ denote the arbitrary stochastic process, drift term, diffusion term and

Wiener process [10] respectively, can be given by (25) where t_n stands for an arbitrary n^{th} instant within time interval which $X(t)$ is a valid solution of (24) with $X(t_0)$ as the initial value.

$$dX(t) = f(t, X(t))dt + g(t, X(t))dW(t) \tag{24}$$

$$\begin{aligned} X(t_{n+1}) = X(t_n) + f(t_n, X(t_n))(t_{n+1} - t_n) \\ + g(t_n, X(t_n))[W(t_{n+1}) - W(t_n)] \end{aligned} \tag{25}$$

In this work, both step up and step down transformer which employ $n > 1$ and $n < 1$ respectively, have been considered. Firstly, the step up transformer with $n = 2$ will be treated followed by the step down device with $n = 0.5$. Since coupling can be imperfect, $k = 0.9$ have been adopted for both transformer. We also let $\alpha = 0.33$. For the step up transformer, by applying a step function as $v_1(t)$ which means $v_2(t)$ is also a step function, and assuming that $I_1(0) = I_2(0) = 0$, five sample paths of $I_1(t)$ and $I_2(t)$ simulated with MATHEMATICA by using the numerical solutions of (15) and (16), can be shown in Fig.1 and 2. On the other hand, five sample paths of $I_1(t)$ and $I_2(t)$ of the step down transformer can simulated in a similar manner as in shown Fig. 3 and 4. From these figures, it can be seen the fluctuations in $I_1(t)$ and $I_2(t)$ are of high frequencies as they are contributed by the stochastic effect of noise in the voltage source which changes very fast with respected to time.

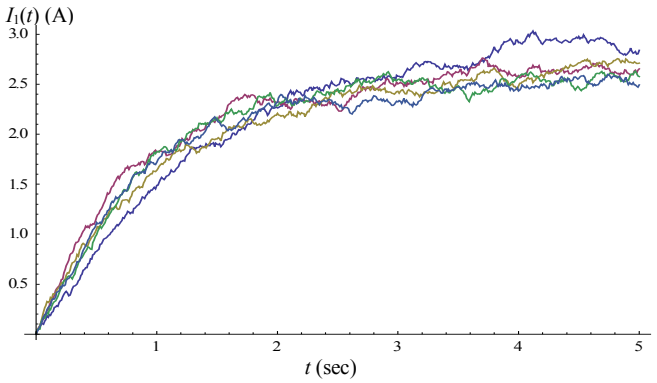

Fig. 1. Five sample paths of $I_1(t)$ of step up transformer due to step $v_1(t)$

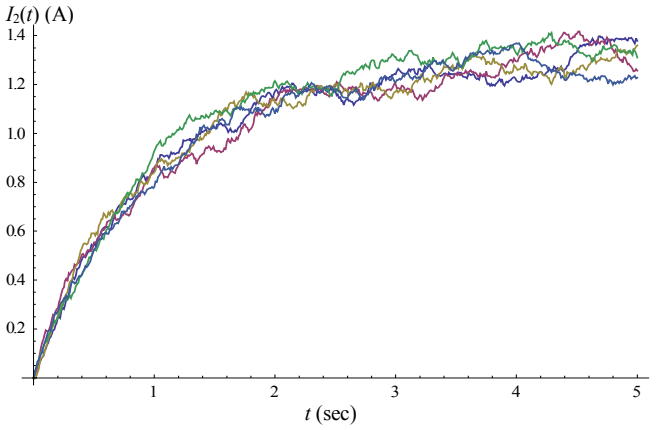

Fig. 2. Five sample paths of $I_2(t)$ of step up transformer due to step $v_1(t)$

$I_1(t)$ (A)

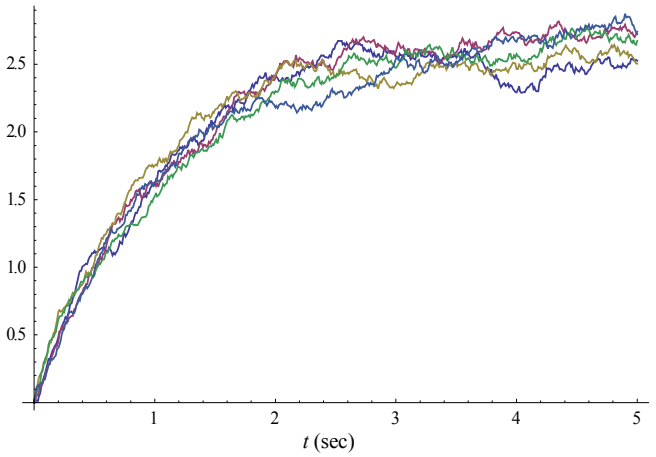

Fig. 3. Five sample paths of $I_1(t)$ of step down transformer due to step $v_1(t)$

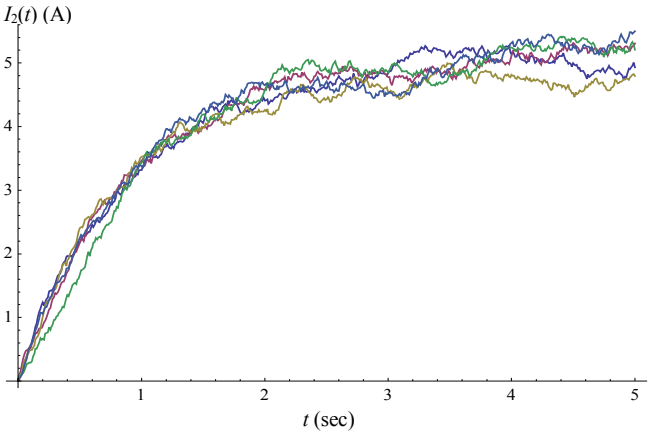

Fig. 4. Five sample paths of $I_2(t)$ of step down transformer due to step $v_1(t)$

IV. Conclusion

A stochastic analysis of the transformer have been performed by using the SDE based approach. Nose in the voltage source applied to the transformer has been considered as white noise which is a Brownian motion process or Wiener process. The SDEs of the transformer have been solved both analytically and numerically by means of Ito calculus and Euler-Maruyama scheme. The stochastic statistical parameters of the current of both windings have been analytically derived and the stochastic responses the transformer have been simulated. The results of this work have been found to be beneficial to the analysis and designing of transformer involved circuits and systems. For further study, the stochastic effects of random variations in the circuit parameters which also exist and play significant roles in the statistical/variability aware analysis and design, should be taken into account.

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References

[1] B. Øksendal, Stochastic Differential Equations, An Introduction with Applications. Newyork, NY: Springer-Verlag, 2000.

[2] S. Cyganowski, P. Kloeden and J. Ombach, From Elementary Probability to Stochastic Differential Equations with Maple. Newyork, NY: Springer-Verlag, 2000.

[3] M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.

[4] M. Carletti, "Numerical solution of stochastic differential problems in the biosciences", J. Comput. Appl. Math., vol. 185, pp. 422-40, January 2006.

[5] D. Ham and A. Hajimiri, "Complete noise analysis for CMOS switching mixers via stochastic differential equations," Proc. IEEE CICC, pp. 439-442, May 2000.

[6] C.D. Charalambous and N. Menemenlis, "A state-space approach in modeling multipath fading channels via stochastic differential equations," Proc. IEEE ICC, pp. 2251-2255, June 2001

[7] K. Wang, M. L. Crow, "Numerical Simulation of Stochastic Differential Algebraic Equations for Power System Transient Stability with Random Loads," Proc. IEEE PES GM, pp. 1-8, July 2011.

[8] A. Zjajo, Q. Tang, M. Berkelaar, J. P. de Gyvez, A. Di Bucchianico and N. van der Meijs, "Stochastic analysis of deep-submicrometer CMOS process for reliable circuits designs," IEEE Trans. Circuits Syst. I, Reg. Papers, vol. 58, pp. 164-175, January 2011.

[9] E. Kol´aˇrov´a, "Modelling RL electrical circuits by stochastic differential equations," Proc. EUROCON, pp. 1236-1238, November 2005.

[10] T.K. Rawat and H. Parthasarathy, "Modeling of an RC circuit using a stochastic differential equation", Int. J. SC.Tech, vol. 13, pp. 40-7, April-June, 2008.

[11] F. Rahman and N. Parisa, "A stochastic perspective of RL electrical circuit using different noise terms," COMPEL, vol. 30, pp. 812-822, March 2011

[12] J.J. Zhou and D.J. Allstot, "Monolithic transformers and their application in a differential CMOS RF low-noise amplifier," IEEE J. Solid-State Circuits, vol. 33, pp. 2020–2027, Decomber 1998.

[13] J.R. Long, "Monolithic transformers for Silicon RF IC design," IEEE J. Solid-State Circuits, vol. 35, pp. 1368-1382, September 2000.

[14] K.T. Ng, B. Rejaei, and J.N. Burghartz, "Substrate effects in monolithic RF transformers on Silicon," IEEE Trans. Mic. Theo. Tech., vol. 50, pp. 377-383, January 2002

[15] A. Tang, F. Yuan and E. Law, "CMOS active transformers and their applications in voltage-controlled quadrature oscillators," Analog Integr. Circuits Signal Process., January 2009.

[16] A. Tang, G. Zhu and F. Yuan, "Current-mode phase-locked loop with constant-Q active inductor CCO and active transformer loop filter," Analog Integr. Circuits Signal Process., pp. 365-375, February 2013.

[17] Y. Mayevskiy et.al., "A new compact model for monolithic transformers in Silicon-based RFICs," IEEE Microw.Wirel. Compon. Lett., vol. 15, pp. 2203-2210, June 2005.

A Universal-Mode Chaotic Oscillator

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***Abstract*— This paper presents a universal-mode chaotic oscillator. In the proposed circuit, the second-order autonomous, the third-order autonomous, and the second-order non-autonomous chaotic systems are designed and implemented. The proposed circuits are verified by Pspice simulation and are validated by experiments.**

Keywords—Chaotic oscillator, Chaos application, Analog Sgnal Synthesis .

I. INTRODUCTION

Chaos is a periodic long term behavior in a deterministic system that exhibits sensitive dependence on initial condition. Applications of chaos in engineering have been drawn attention from several communities [1-3]. The core of the ideal of systems is a chaotic generator. Chua's circuit exhibited complex dynamical behavior is the simple circuit for chaotic sources [4]. Due to random-liked nature property, chaotic path planning is exploited for chaotic signal generating by Chua's circuit shown in [5]. Reduction of harmonic amplitude of switching converter is also employed Chua's circuit to replace the modulation source [6]. In [7], a continuous-time chaotic oscillator is introduced to generation random number. The intensive study on how to construct several chaotic circuits as a gallery of autonomous and non-autonomous circuits designed is mathematically carried out in [8]. Recently [9], for analog music synthesizer applications, the complex-signal sources which provide many patterns are adopted to create the harmonic structure of musical instrument. In this paper, we propose a universal-mode chaotic circuit modified from mixed-mode chaotic circuits in [10], to serve the need of synthesizer requirement.

II .THE PROPOSED UNIVERSAL-MODE CHAOTIC OSCILLATOR

The universal-mode chaotic proposed circuit shown in Fig. 1 consists of a two-integrator loop, a lossy inverting integrator , an inverting amplifier and a nonlinear function circuit using four current mode operation amplifiers (AD844) and one operational amplifier (TL071).

The two-integrator loop circuit [11] using CFOA1 and CFOA2 are shown in dash line. The lossy integrator is implemented by CFOA3 used for extension of the second-order of the integrator loop to the third-order linear system. The inverting amplifier CFOA4 is designed for a mixed-mode operation by adding signals from the nonlinear device and the driving signal generator

The nonlinear circuits is implemented by OA1 used for activating the Heaviside function. The sign, the hysteresis functions are implemented by setting the switches S3-S4 to select the feedback resistor and the output voltage of the OA. The operational functions of the switches are shown in Table 1.

Table 1. Parameter configuration of the switches for activation of the selected function

Function	S3	S4
Heaviside	off	off
Signum	off	on
Hysteresis	on	on

In addition, two integrators are employed for assigning the complex conjugate poles moving between the LHP and the RHP. When the switch S2 is closed, the two-integrator loop exhibits stable condition. The matrix equation of double loop integrator is given by

$$\begin{bmatrix} Vc_1' \\ Vc_2' \end{bmatrix} = \begin{bmatrix} 0 & \frac{1}{R_1C_1} \\ \frac{-1}{R_2C_2} & \frac{1}{R_2C_2} - \frac{1}{R_3C_2} \end{bmatrix} \begin{bmatrix} Vc_1 \\ Vc_2 \end{bmatrix} \quad (1)$$

And when switch S2 is opened, the two-integrator loop exhibits unstable condition. The corresponding state equation can be written as

$$\begin{bmatrix} Vc_1' \\ Vc_2' \end{bmatrix} = \begin{bmatrix} 0 & \frac{1}{R_1C_1} \\ \frac{-1}{R_2C_2} & \frac{1}{R_2C_2} - \left(\frac{1}{R_3C_2} + \frac{1}{R_4C_2} \right) \end{bmatrix} \begin{bmatrix} Vc_1 \\ Vc_2 \end{bmatrix} \quad (2)$$

To operate in each chaotic mode, the state equations of the proposed circuit can be shown as follows.

1 The second-order autonomous chaotic circuit

Consider the autonomous chaotic circuit, whose dynamical behaviors have been explained in detail in [12]. This circuit is an unstable second-order linear system with feedback and a hysteresis function, described by

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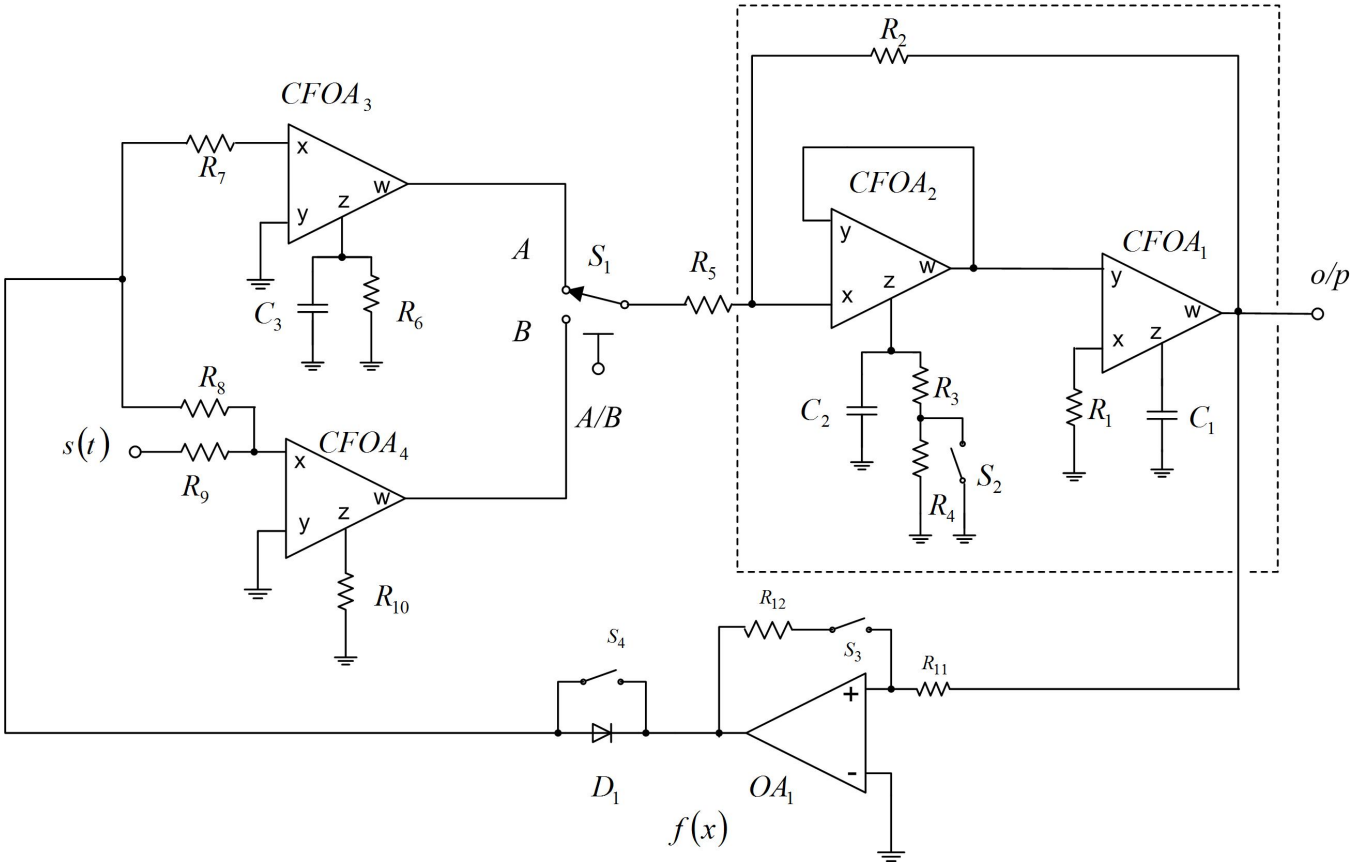

Fig.1 Universal-mode chaotic oscillator

,

$$\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -1 & \alpha \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} 0 \\ hys(x) \end{bmatrix} \tag{3}$$

where x and y are state variables and $hys(x)$ is a hysteresis function,

$$hys(x) = \begin{cases} +1, & -1 < x < \infty \\ -1, & -\infty < x < 1 \end{cases}$$

The model consists of an unstable second-order linear system with a hysteresis feedback. In order to guarantee chaotic oscillations of the system (3), one should require $\alpha < 1$.

The mixed-mode chaotic circuit operates as the second-order autonomous switching system, which is unstable by turning off switch S2, and switch S1 connecting to position B respectively

Hysteresis is provided by the nonlinear elements via turning on switch S3. The circuit equation of this mode is

$$\begin{bmatrix} Vc_1' \\ Vc_2' \end{bmatrix} = \begin{bmatrix} 0 & \frac{1}{R_1 C_1} \\ \frac{-1}{R_2 C_2} & \frac{1}{R_2 C_2} - \left(\frac{1}{R_3 C_2} + \frac{1}{R_4 C_2} \right) \end{bmatrix} \begin{bmatrix} Vc_1 \\ Vc_2 \end{bmatrix} + \begin{bmatrix} f(t) \end{bmatrix} \tag{4}$$

2 The third-order autonomous chaotic circuit

To simplify construction of the third-order autonomous chaotic system, this can be done by creating a wide range of chaotic signals from a single scroll to complex scrolls by switching and adding an external driving function. The proposed model [10] is specified by

$$\begin{bmatrix} x' \\ y' \\ z' \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ -1 & \alpha & 1 \\ 0 & 0 & -1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ f(x) \end{bmatrix} \tag{5}$$

The system equation (5) consists of the third-order linear system and a nonlinear element. Since the system is unstable on the $x - y$ plane, the trajectory scrolls are away from the equilibrium point. To fold the trajectories, the Heaviside function $H(x)$ is applied to obtain a single scroll,

$$H(x) = \begin{cases} 1 & x \geq 0 \\ 0 & x < 0 \end{cases}$$

while the signum function $sgn(x)$ is enforced to generate double scrolls.

$$\text{sgn}(x) = \begin{cases} 1 & x \geq 0 \\ -1 & x < 0 \end{cases}$$

In this mode, states x and y in the two-integrator loop act as the unstable quadrature core oscillator. The state-*z* is at the inverting integrator CFOA3. To activate this mode, switch S2 must be turned off, and switch S1 is set to position A. The circuit equation of this mode is

$$\begin{bmatrix} Vc_1' \\ Vc_2' \\ Vc_3' \end{bmatrix} = \begin{bmatrix} 0 & \frac{1}{R_1C_1} & 0 \\ \frac{-1}{R_2C_2} & \frac{1}{R_2C_3}+\frac{1}{R_5C_2}-\left(\frac{1}{R_3C_2}+\frac{1}{R_4C_2}\right) & \frac{1}{R_5C_2} \\ 0 & 0 & \frac{-1}{R_6C_3} \end{bmatrix} \begin{bmatrix} Vc_1 \\ Vc_2 \\ Vc_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ f(t) \end{bmatrix} \quad (6)$$

3 The second-order non-autonomous chaotic circuit

To generate a chaotic attractor from a non-autonomous system, the system consists of the second-order linear circuit and a nonlinear element in the feedback loop driving by pulse excitation [13], the state equation is given by

$$\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -1 & \alpha \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} 0 \\ f(x)+s(t) \end{bmatrix} \quad (7)$$

where α is the damping coefficient, and *f(x)* is signum function respectively. To generate chaotic signals from the system (7), the damped-stable second-order system is now activated by turning on switches S2 external periodic signals is connected to system by connecting switch S1 to position B. The circuit equation of this mode is

$$\begin{bmatrix} Vc_1' \\ Vc_2' \end{bmatrix} = \begin{bmatrix} 0 & \frac{1}{R_1C_1} \\ \frac{-1}{R_2C_2} & \frac{1}{R_2C_2}-\frac{1}{R_3C_2} \end{bmatrix} \begin{bmatrix} Vc_1 \\ Vc_2 \end{bmatrix} + \begin{bmatrix} 0 \\ f(t)+s(t) \end{bmatrix} \quad (8)$$

III. SIMULATION AD EXPERIMENT RESULTS

For Pspice simulation and the experiments on the real circuit, all current feed-back amplifiers are AD844, the operational amplifier is TL071 with supply ±12V and the diode is 1N4148. The circuit elements are $R_1 = R_2 = R_6 = R_7 = R_8 = R_9 = R_{10} = R_{11}$ =10KΩ, R_3 =9.8KΩ, R_4 =680Ω, R_5 =100KΩ, R_{12} =300KΩ, and $C_1 = C_2 = C_3$ =1*n*F. When the proposed circuit operates in the second-order autonomous mode, the wave forms of V_{C1} and V_{C2} are shown in Fig.2.1. For circuit experiment, the phase portrait on the x-y plane of V_{C1} and V_{C2} are shown in Fig.2.2.

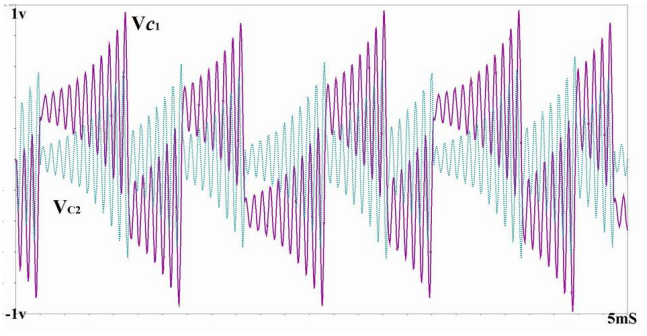

Fig 2.1 Simulation results of the second-order autonomous mode

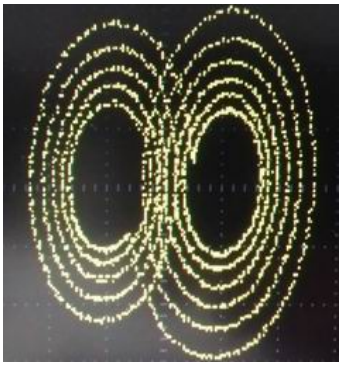

Fig 2.2 Experiment results of the second-order autonomous mode

Figure 3.1 shows the Pspice simulation waveforms of V_{C1} and V_{C2} operating in the third-order autonomous chaotic circuit with the signum function and phase portraits on the x-y plane of V_{C1} and V_{C2} as shown in Fig.3.2.

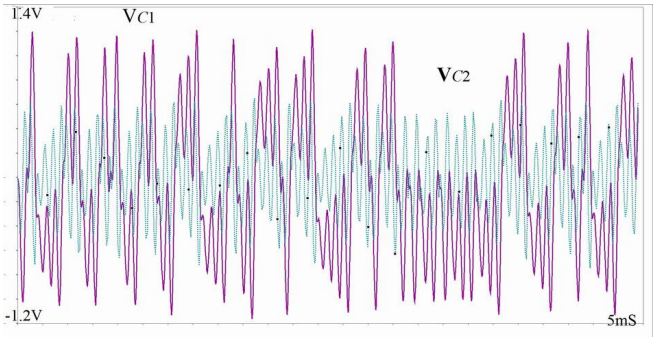

Fig 3.1 Simulation results of the third-order autonomous mode.

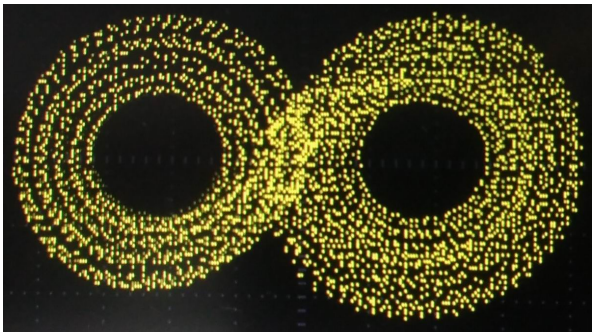

Fig 3.2 Experiment results of the third-order autonomous mode

For the second-order non-autonomous driving by 16KHz square wave with magnitude ±5V, the Pspice simulation

wave-forms of V_{C1} and V_{C2} and phase portraits on the x-y plane of V_{C1} and V_{C2} are shown in Figs. 4.1 and 4.2, respectively.

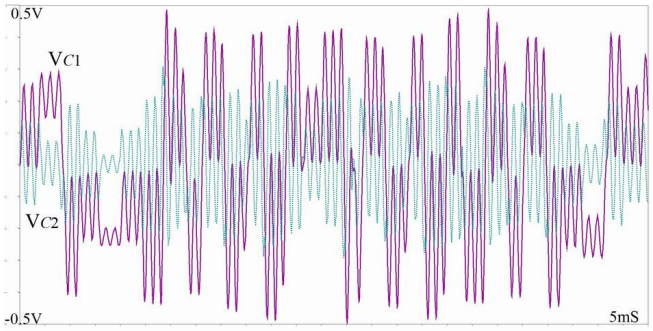

Fig 4.1 Simulation results of the second-order non-autonomous mode with pulse excitation.

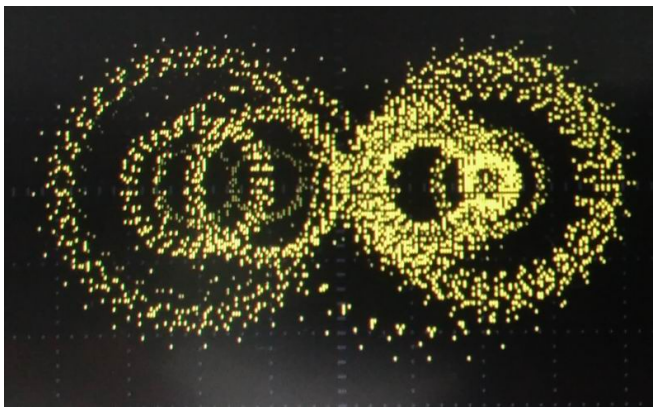

Fig 4.2 Experiment results of the third-order autonomous mode with pulse excitation

Conclusion

In this paper, a universal-mode chaotic circuit is designed and is verified by Pspice simulation. The experimental results confirm that various complex dynamical wave-forms of the proposed circuit can be applied for analog signal synthesizers.

REFERENCES

[1] G. Chen and T. Ueta Ed., Chaos in Circuits and Systems, Singapore:World Scientific, 2002.

[2] P. Stavroulakis, Ed., Chaos Applications in Telecommunications. CRC Press, Taylor & Francis Group, 2006.

[3] W. Perruquetti, J. P. Barbot, Chaos in Automatic Control, FL, Boca Raton:CRC Press, 2005.

[4] R. Kili, A practical guide for studying Chua's circuits,Singapore:World Scientific, vol. 71, 2010.

[5] P. Sooraksa and K. Klomkarn, "No-CPU Chaotic Robots: from classroom to commerce," IEEE Circuits and Systems Magazine, pp. 46-53, 2010.

[6] K. K. Tse ,R. W.-M. Ng, H. S.-H. Chung and S. Y. R. Hui, "An evaluation of the spectral characteristics of switching converters with chaotic carrier-frequency modulation," IEEE Trans. Ind. Electron. vol. 50 no. pp. 171-182 Feb. 2003.

[7] S. Ergün, Ü. Güler and K. Asada, "A High Speed IC Truly Random Number Generator Based on Chaotic Sampling of Regular Waveform," IEICE Trans. on Fundamentals of Electronics Communications and Computer Sciences, vol. E94-A, no. 1, pp. 180-190, Jan. 2011.

[8] A. Buscarino, L. Fortuna, M. Frasca and G. Sciuto, A Concise Guide to Chaotic Electronic Circuits, Springer, Berlin DE, 2014.

[9] S. Mcguire and N.Van Der Res , The musical art of synthesis, Focal press, 2016.

[10] K. Klomkarn and P.Sooraksa "Simple Self-Instructional Modules Based on Chaotic oscillators: Few Blocks Generating Many Patterns," International Journal of Bifurcation and Chaos vol. 21, no 5, pp.1469-1491 · May 2011.

[11] A. M. Soliman, "Current feedback operational amplifier based oscillators," Analog Integr. Circuits Signal Process., vol. 23, no. 1, pp. 45-55, Apr. 2000.

[12] U. F. Moreno, P. L. D. Peres and I. S. Bonatti, "Analysis of piecewise-linear oscillators with hysteresis," IEEE Trans. Circuits Syst. I Fundam. Theory Appl., vol. 50, no. 8, pp. 1120-1124, 2003.

[13] S. Zouz and A. S. Elwakil, "On the realization of circuit-independent non-autonomous pulse-excited chaotic oscillator circuits," IEEE Trans. Circuits Syst. II Exp. Briefs, vol. 51, no. 10, pp. 552-556, Oct. 2004.

Different Sampling Rates on Neural NILM Energy Disaggregation

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***Abstract*—Energy disaggregation is a process to estimate an appliance power usage by providing only a household power reading. One of the techniques used in the energy disaggregation is to use neural network. However, when using neural network in the energy disaggregation, it can be time consuming for an online or real-time applications. In this paper, it is to investigate if lowering the sampling rate would reduce time for disaggregating an aggregated reading while still provide an acceptable result. The experiment in this paper using RNN with LSTM as a disaggregation algorithm on a public dataset of UKDALE. The results show that lowering the sampling rate can significantly reduce both training time duration and disaggregating time duration, but it reduces the performance of the algorithm by a little.**

Keywords—sample period, nilm, non-intrusive load monitoring, energy disaggregation

I. INTRODUCTION

In the last decade, lots of smart appliances and new electric devices are introduced. In addition, modern smart building can be monitored its environment using difference kinds of sensors. The data retrieve from the environment can be used to analyze or maintain the buildings. Here, power consumption data can be used to analyze by extracting power consumption for an appliance in a building which is called as energy disaggregation.

Energy disaggregation is a process of extracting an individual appliance power consumption from a group of appliances or from a household power meter which is known as Non-Intrusive Appliance Load Monitoring (NALM or NILM). It allows us to monitor the power consumption of an individual appliance by only providing a household meter reading. This reduces the need of using an individual meter for monitoring each appliance, but just having only one meter typically taken the data from the mains.

The very first energy disaggregation algorithm was started in the mid-1980s by George Hart [1]. It was based on a pattern recognition and event-based method. Hart [2] proposed the energy disaggregation technique using the transition between steady-states of appliance to extract power usages data. It makes use of the combinatorial optimization technique by finding the sum of power consumption and comparing with the meter reading. The limitation of this work is that it works well on an appliance with a finite number of states. In other words, the algorithm cannot monitor an appliance which has a variable and continuous power consumption like computers or air conditioner.

Lately, machine learning has been applied in NILM. It is used to train a model for an individual appliance using existing datasets. Then the model is used to predict or disaggregate the particular appliance power usage from the unknown aggregated power meter reading. Using this approach, the model can be reuse again. There are some Artificial Neural Networks published like [3-8] for NILM tasks.

Researchers in NILM area have published several datasets. Lots of existing datasets provide with low frequency sampling, typically with a sampling rate from 1 Hz (or every 1 seconds) to several seconds. However, when working with NILM algorithm, the sampling data is often needed to be filled as some data for a different timing are missing. It has to be done with a forward fill or a backward fill. In either way, lots of duplicate data is added. Therefore, it is interesting to see if reduce this duplicated data will affect the performance of the algorithm.

In addition to the duplicated data concern, a time complexity in neural network is also a concern for an online or real-time application. In this paper, it is to study if lowering the frequency of the sampling rate when using neural NILM algorithm would reduce the computational time while still perform an acceptable disaggregation results. In section II, related works will be discussed. In section 3, the experiment details will be described. The section 4 shows the results from the experiment and the last section concludes the paper.

II. RELATED WORKS

A. NILMTK

One of the evaluation tools used in the experiment is NILMTK [9] (Non-Intrusive Load Monitoring Toolkit). NILMTK is a toolkit written in python used to evaluate the NILM algorithm. NILM researchers can use NILMTK to evaluate and compare several NILM algorithm. NILMTK is written in python and it is considered as one of the most popular tool in NILM research.

B. UK Domestic Appliance-Level Electricity (UK-DALE) dataset

UKDALE is one of the very first UK base dataset published for energy disaggregation research. It contains both mains (aggregated power reading) and individual appliance power reading data for 5 houses. UKDALE dataset has several releases dated in which data are collected from 2012 to 2017. The power reading is collected at every 6 seconds (1/6 Hz), and some houses also provided with a 16kHz voltage and current reading.

C. Recurrent Neural Networks Disaggregation Algorithm

One of the very first neural network algorithm applied for disaggregating energy is the use of Recurrent Neural Networks (RNN) along with Long Short-Term Memory (LSTM) architecture [4]. This algorithm is not suitable for a real-time disaggregation as it is using bidirectional layers. However, with a small batch of data, it can be done to serve as

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an online solution. In the experiment, the implementation of the RNN with LSTM disaggregation algorithm published from [8] will be used.

III. Experiment Setup

A. Hardware and Software

In the experiment, the RNN network is implemented in Python taken from Neural Disaggregator [8]. The environment used are Windows 10 x64, Anaconda, python 3.6, NILMTK v0.2 [9] and tensorflow-gpu v1.12.0.

The networks are trained on a PC with Intel Core i5 2500 and a GPU of Nvidia GTX 950 2GB. On this GPU, it takes up to 10 minutes to train the model for each epoch on our specific training set.

Table I shows the parameters used in the experiment. The parameters includes the number of epochs, sampling rate, dataset used for training and testing (disaggregation), and the appliance used in the experiment.

TABLE I. Parameters Details

Parameters	Details
Algorithm	RNN [3,4]
Epochs	30 epochs
Sampling Rate	6, 12, 18, 24, 30, 60 seconds
Dataset	UKDALE (Jan 2015 release)
Training Set	House 1
Testing Set	House 1
Training Period	13/04/2013-01/01/2014
Testing Period	01/01/2014-30/03/2014
Appliance	Fridge

B. Sampling Rate

Typically, UKDALE dataset provides with a sampling rate of 6 seconds. Here, in the experiment, the sampling rate is lower by using an average value between two points. For example, if the sampling rate of 12 seconds is used, each tuple will be taken as the average of the current tuple and the next coming tuple. This goes the same as a higher sampling rate. This means the number of tuple will be less when the sampling rate is lower.

C. Appliances

The appliance used in this study is a fridge, as it has the highest ratio between ground truth data and the main reading (or aggregated meter reading). This is because the activation count for the fridge ground truth data is 19,033 times (using `Electric.get_activations()` method in NILMTK), while the second and the third most activation count appliance are the microwave (at 3,713 times) and the kettle (at 3,379 times)

In order to get activation count, some arguments need to be passed to `Electric.get_activations()` method for each selected appliance. The arguments used to find the activation count are shown in Table II as followed.

TABLE II. Argumentes for Finding Activation Counts

Appliance	Max Power (watts)	On Power threshold (watts)	Min. On Duration (seconds)	Min. Off Duration (seconds)
Fridge	300	50	60	12
Microwave	3000	200	12	30
Kettle	3100	2000	12	0

IV. Experiment Results

The experiment results are shown in this section. The performance metrics used in this study are time complexities for training and disaggregating, and also the disaggregation results of the chosen appliance.

A. Training Time Duration

Training time duration is calculated from the average time consumption from all of the training time duration for each epoch (from 30 epochs). The results are shown in Table III.

TABLE III. Time Spent for Training with Different Sample Rate

Sampling Rate (seconds)	Average Training Time Duration (seconds)
6	636.78
12	336.41
18	232.85
24	177.74
30	148.16
36	128.91
42	113.98
48	102.77
54	94.06
60	88.21

The results for training time duration show that a higher sampling rate takes a longer time to train a model. The results can be expected as the higher sampling rate means higher data feeded into the network. Therefore, a longer time to train the model. However, the training time duration is reducing less when the sampling rate is getting lower. Figure 1 shows the graph of the average training time duration for each sampling rate.

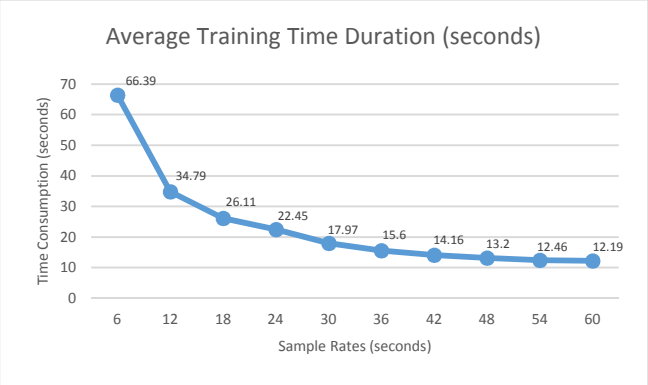

Figure 1. Average Training Time Duration for Each Sampling Rate

B. Disaggregating Time Duration

Disaggregating time duration is the time spent for disaggregating the power usage of the appliance from the main. When preparing data to disaggregate, the sampling rate of the main reading also changes to the same as the trained model. The results of the disaggregating time duration are shown in the Table IV.

TABLE IV. TIME SPENT FOR DISAGGREGATING WITH DIFFERENT SAMPLE RATE

Sampling Rate (seconds)	Average Disaggregating Time Duration (seconds)
6	66.39
12	34.79
18	26.11
24	22.45
30	17.97
36	15.60
42	14.16
48	13.20
54	12.46
60	12.19

From the results, it can be seen that when the sampling rate is lower than 30 seconds, the time spent in disaggregating do not reduce much. It is around 1 or 2 seconds different for each step of sampling rate reduced. Figure 2 shows the graph between the disaggregating time duration and the sampling rate.

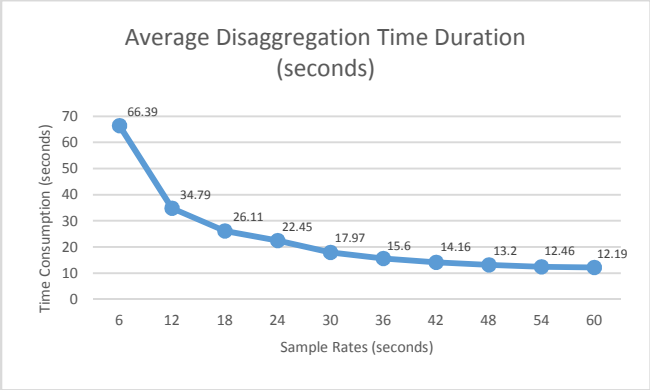

Figure 2. Average Disaggregating Time Duration for Each Sampling Rate

It is obvious that using the lower sampling rate can reduce a training and disaggregation time. The question is that would reducing the sampling rate affect the performance of the disaggregation? Here, the results from the disaggregation will be discussed in the next section.

C. Performance Metrics

In NILM, the on-off state prediction of an appliance is used to evaluate the algorithm. When the power reading is higher than a threshold, the state of appliance is considered as on. On the other hand, when the appliance is off, the power reading is below the threshold. Then this on-off state will be used to calculate the performance metric like precision, recall, accuracy, F1 score and Mean Absolute Error (MAE).

In order to find the performance metrics, preliminary variables like True Positive, True Negative, False Positive and False Negative need to be calculated first. Here, in NILM

- True Positive (TP) is the number of correctly detection when an appliance is on.
- True Negative (TN) is the number of correctly detection when an appliance is off.
- False Positive (FP) is the number of wrongly detection that an appliance is off.
- False Negative (FN) is the number of incorrect detection that an appliance is on.

Then these variables will be used to calculate the performance metrics later on. The details of these metrics are as follow,

Precision metric indicates how well the algorithm can predict when an appliance is correctly on.

$$Precision = \frac{TP}{TP + FP}$$

Recall metric shows how algorithm mistakenly guessing that an appliance is off.

$$Recall = \frac{TP}{TP + FN}$$

Accuracy is the metric indicating if an algorithm can predict both on and off state of the appliance.

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$

The accuracy metric can be bias in an appliance which is off most of the time. This is because when an appliance is off most of the time and an algorithm predicts the appliance is always off, the accuracy can be really high. However, in this experiment, a fridge is selected. It is turned on pretty often when compare with other types of appliance. Therefore, an accuracy is still also taken into the performance metrics here.

The performance metrics are calculated by comparing the disaggregated power data and the ground truth provided by the dataset. The results are taken from the best epoch out of 30 epochs trained. Table V shows the results of the performance metrics.

TABLE V. THE RESULTS OF PERFORMANCE METRIC

Sampling Rate (s)	Precision	Recall	Accuracy	F1 Score	MAE (watts)
6	0.67	0.88	0.70	0.75	38.41
12	0.61	0.99	0.71	0.74	33.41
18	0.66	0.99	0.71	0.74	39.31
24	0.64	0.98	0.71	0.74	35.56
30	0.61	0.98	0.71	0.73	35.47
36	0.63	0.99	0.71	0.73	37.62
42	0.62	0.97	0.71	0.73	36.62
48	0.64	0.99	0.71	0.73	42.27
54	0.66	0.99	0.71	0.73	42.88
60	0.63	0.98	0.71	0.73	40.62

From these metrics, it can be seen that the disaggregated results when using a lower sampling rate only reduces the performance of the disaggregation. However, the MAE value can be getting worse when the sampling rate is over 42 seconds.

V. DISCUSSIONS AND FUTURE WORKS

This paper shows that reducing a sampling rate significantly reduces a time consumption for training and disaggregating process. Since disaggregation time can be reduced to a few seconds, using a lower sampling rate can be a solution to an online neural network disaggregation. It can provide similar results while the computational time is much faster. On the other hand, when lowering the sampling rate, the results of the performance in terms of different metrics does not reduce much. However, it is still unknown if the sampling rate is far lower (more than 10 times slower) than the original sampling rate would affect the performance.

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REFERENCES

[1] G. W. Hart. Prototype nonintrusive appliance load monitor. Technical report, MIT Energy Laboratory and Electric Power Research Institute, Sept. 1985.

[2] G. W. Hart. Nonintrusive appliance load monitoring. Proceedings of the IEEE, 80(12):1870–1891, Dec. 1992. doi:10.1109/5.192069.

[3] Francesca Paradiso, Federica Paganelli, Antonio Luchetta, Dino Giuli and Pino Castrogiovanni. 2013. ANN-based appliance recognition from low-frequency energy monitoring data. 2013 IEEE 14th International Symposium on "A World of Wireless, Mobile and Multimedia Networks" (WoWMoM).

[4] Jack Kelly and William Knottenbelt. 2015. Neural NILM. Proceedings of the 2nd ACM International Conference on Embedded Systems for EnergyEfficient Built Environments - BuildSys '15.

[5] Henning Lange. and Mario Berges. 2016. The Neural Energy Decoder: Energy Disaggregation by Combining Binary Subcomponents. Proceedings of the 3rd International Workshop on Non-Intrusive Load Monitoring.

[6] Lukas Mauch and Bin Yang. 2015. A new approach for supervised power disaggregation by using a deep recurrent LSTM network. 2015 IEEE Global Conference on Signal and Information Processing (GlobalSIP).

[7] Chaoyun Zhang, Mingjun Zhong, Zongzuo Wang, Nigel Goddard and Charles Sutton. 2017. Sequence-to-point learning with neural networks for nonintrusive load monitoring. ArXiv e-prints. https://arxiv.org/abs/1612.09106.

[8] Odysseas Krystalakos, Christoforos Nalmpantis, and Dimitris Vrakas. 2018. Sliding Window Approach for Online Energy Disaggregation Using Artificial Neural Networks. In Proceedings of the 10th Hellenic Conference on Artificial Intelligence (SETN '18). ACM, New York, NY, USA, Article 7, 6 pages. DOI: https://doi.org/10.1145/3200947.3201011

[9] Nipun Batra, Jack Kelly, Oliver Parson, Haimonti Dutta, William Knottenbelt, Alex Rogers, Amarjeet Singh, Mani Srivastava. NILMTK: An Open Source Toolkit for Non-intrusive Load Monitoring. In: 5th International Conference on Future Energy Systems (ACM e-Energy), Cambridge, UK. 2014.

Combination of GLCM and KNN Classification for Chicken Embryo Development Recognition

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***Abstract*— This paper presents techniques for chicken embryo development recognition based on textural analysis using Gray Level Co-occurrence Matrix (GLCM) and image classification using k-nearest neighbors algorithm (KNN). Data employed in the experiments were collected during the eighteen days of incubation, which was divided into four stages, namely Stage 1: days 1-3, Stage 2: days 4-6, Stage 3: days 7-9, and Stage 4: days 10-18. Results of the experiments reveal that the recognition accuracy rates for Stage 1, Stage 2, Stage 3 and Stage 4 are 73.33%, 60%, 66.67% and 93.33%, respectively.**

Keywords*— Chicken Embryo, Recognition, GLCM Features, KNN Classification

I. Introduction

Today computer system is capable of fast data processing or analysis; thus, it is very helpful for data analysis, decision-making, search for information, and image data recognition or digital image processing. We can use different techniques and methods to recognize image data in order to solve problems or develop a system to make decisions for human beings. There are many feature extraction methods and in this article, the tool used for texture analysis [1] is Grey Level Co-Occurrence Matrix (GLCM) [2-4], a technique that enables extraction of texture feature value of an image. Results of GLCM method can be used as training data input into image classification algorithm. It is a technique employed to define a particular spatial relationship based on the KNN algorithm [5-6]. The purpose of this research was to develop the procedure for recognizing chicken embryo development using Gray Level Co-occurrence Matrix (GLCM) texture analysis and KNN algorithm image classification. The results of this research can be used to improve the efficiency of chicken reproduction process of farmer groups or poultry industry in Thailand since now there is no tool used to detect embryo development in the incubation process. A test is conducted to detect chicken embryo after 1-9 days of incubation from a total of 18 days of incubation to remove eggs not containing viable embryos from egg incubators in order to reduce the problem of generation of hydrogen sulfide, which is caused by eggs without sperm that makes it impossible for embryo development. Details of the procedure and technique of digital image processing system to solve such problem are described in Section II.

II. Proposed Method

The method proposed in this paper is to detect main feature of an image employed to identify the time of conception and chicken embryo development from image dataset. Generally, main feature is texture feature that can be used to classify the image data, which will be distributed in the form of tones within an image. Therefore, change in tones within the image is important for image data classification, which can be defined from the grayscale matrix by using GLCM functions to calculate and compare the occurrence of gray levels in an image or pattern of gray levels between pixels in the image in order to utilize the texture feature in the processes of image data classification and recognition. KNN algorithm is used for image data classification. The distance between datasets is computed to measure similarity of image datasets. Algorithm of the image data classification and recognition processes is shown in Figure 1.

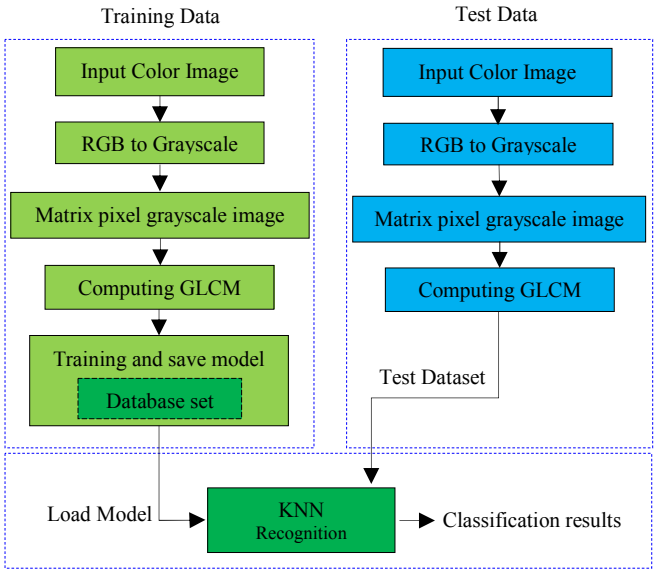

Fig. 1. Block diagram of proposed system

A. Data set

The image data used for image data analysis were collected from the results of chicken embryo development in each stage throughout 18 days of incubation. The method used to collect image data for image data analysis was egg candling in a dark room to collect image data of chicken embryos. The results of incubation can be summarized as follows: conception occurred on day 4 of incubation where mottle was surrounded by light structure of blood vessel. The mottle or blood vessel could be seen more clearly during days 10-18 from a total of 18 days of incubation. Figure 2 shows collection of data used for image texture analysis based on the method proposed in the image processing system to automatically recognize and identify the time of conception and chicken embryo development.

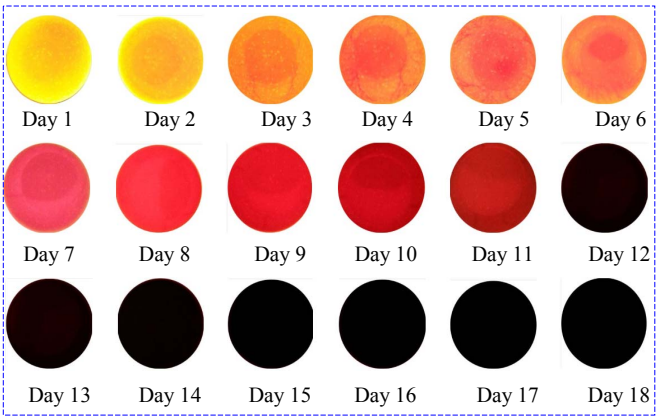

Fig. 2. The results of chicken embryo development within 18 days

B. Feature Extraction for Chicken embryo Analysis

Data pre-processing for feature extractions is a process to convert data into a pattern that can be used to create machine learning model. For example, conversion from image data to numerical data using GLCM technique is a statistical method used in texture analysis based on pixel spatial relationship where features of image texture can be defined by calculating co-occurrence matrices, which can be explained in accordance with steps in Figure 1. The process starts with converting RGB to grayscale and, then, main features of the image can be calculated as follows:

1) Contrast

Contrast is the difference between maximum and minimum gray levels of neighboring pixels [1],[3].

$$Contrast = \sum_i \sum_y (i-y)^2 P(i, y) \quad (1)$$

where i and y are horizontal and vertical coordinates of GLCM and $P(i, y)$ is probability value of pixel on row i and column y of each image. It is the mean of values obtained from GLCM.

2) Correlation

Equation for finding linear relation between gray levels of the adjacent pixels [1],[3-4].

$$Correla = \sum_i \sum_y \frac{(i-\mu i)(y-\mu y)P(i,y)}{\sigma i \ \sigma y} \quad (2)$$

where σi and σy are the standard deviations of probability matrix GLCM along horizontal and vertical directions, which can be calculated from equations (3) and (4).

$$\sigma i = \sqrt{\sum_i \sum_y (i-\mu i)^2 P(i,y)} \quad (3)$$

$$\sigma y = \sqrt{\sum_i \sum_y (y-\mu y)^2 P(i,y)} \quad (4)$$

where μi and μy are relations between horizontal and vertical directions and can be calculated from equations (5) and (6).

$$\mu i = \sum_i \sum_y iP(i,y) \quad (5)$$

$$\mu y = \sum_i \sum_y yP(i,y) \quad (6)$$

Resulting value will be between -1 and 1 where 1 is the maximum relation value and -1 means there is no relation.

3) Energy

Consistency of image size or energy consumption for measurement of image similarity [1],[7] can be obtained with equation (7).

$$Energy = \sum_i \sum_y P(i,y)^2 \quad (7)$$

4) Homogeneity

Homogeneity of image textures [7] can be obtained with equation (8).

$$Homoge = \sum_i \sum_y \frac{P(i,y)}{1+|i-y|} \quad (8)$$

5) Entropy

Entropy reflects the non-uniformity of image textures [8] and can be obtained with equation (9).

$$Entropy = -\sum_i \sum_y P(i,y) \log_2 P(i,y) \quad (9)$$

C. K-Nearest Neighbour Algorithm

K-Nearest Neighbour Algorithm is an approach used for image data classification based on similar recognition data by calculating and comparing the sums of datasets undergoing the learning process. Similar datasets and nearest datasets are classified by determining the member values (k). Euclidean distance [1],[9-10] between training datasets and test datasets can be obtained with equation 10

$$D(i, y) = \sqrt{\sum_{k=1}^{n} (i_k - y_k)^2} \quad (10)$$

Where $D(i, y)$ is Euclidean distance between vector i and vector y, provided that member values are n, k and n is the number of vectors i and y.

In determining the accuracy of proposed algorithms, the following calculation principle and efficiency measurement standard is applied:

$$\%\,Acc = \frac{T_{classify}}{T_{image}} \times 100 \qquad (11)$$

where *%Acc* is accuracy of image data classification.

$T_{classify}$ is the number of images correctly classified.

T_{image} is the total number of images used in the experiments.

III. Results and Discussions

A. Data Pre-processing

Experiments were conducted using data on chicken embryos as shown in Figure 2. Data were divided into two datasets in each stage. The ratio of training dataset to test dataset was 50:50. Datasets used in the experiments of Stages 1-3 (15 images in training dataset for each stage: 15 images in test dataset for each stage) and Stage 4 (45 images in training dataset for each stage: 45 images in test dataset for each stage). There were a total of 180 images used in the experiments and data pre-processing process for the data recognition using feature extraction technique to analyze image texture with contrast, correlation, energy, homogeneity and entropy. Results of the feature extractions are shown in Table I.

TABLE I. GLCM Feature Extraction Values

Features detection results	Days	Images	Contrast	Correlation	Energy	Homogeneity	Entropy
Normal Egg	1		0.0251	0.9735	0.3980	0.9885	5.5891
	2		0.0339	0.9705	0.3382	0.9865	5.8239
	3		0.0537	0.9573	0.3352	0.9737	5.1087
Chicken Embryo	4		0.0296	0.9794	0.5912	0.9881	4.9113
	5		0.0403	0.9859	0.4149	0.9841	5.0906
	6		0.0662	0.9843	0.3278	0.9740	4.9503
	7		0.0524	0.9903	0.6096	0.9878	4.6890
	8		0.1094	0.9845	0.3019	0.9609	4.5848
	9		0.0922	0.9818	0.3973	0.9676	4.7467
	10		0.0617	0.9859	0.3232	0.9766	4.9896
	11		0.0749	0.9880	0.5121	0.9807	4.6736
	12		0.1280	0.9916	0.3388	0.9687	4.6925
	13		0.1397	0.9901	0.4471	0.9602	4.2348
	14		0.1453	0.9887	0.4688	0.9597	4.0149
	15		0.0912	0.9944	0.6546	0.9946	3.1676
	16		0.0805	0.9951	0.6504	0.9949	3.7772
	17		0.0793	0.9864	0.6592	0.9861	3.7610
	18		0.0759	0.9954	0.6447	0.9941	3.7669

Comparison of the texture analysis results of training data set and testing data set is shown in Figure 3.

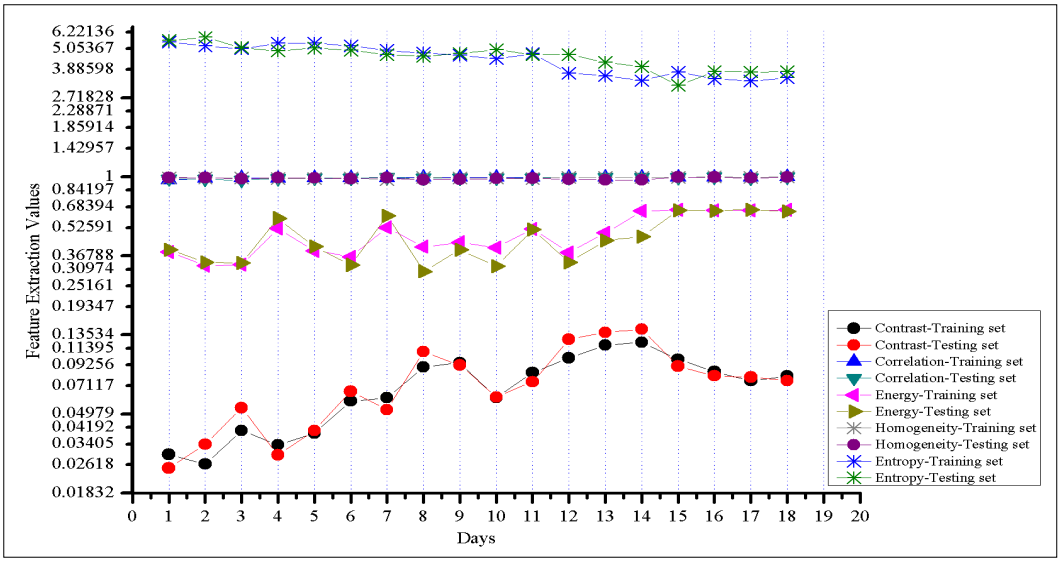

Fig. 3. Comparison of the results of training data set and testing data set

According to Table I. GLCM Feature Extraction Values of image dataset in each stage, it was found that contrast was the visible difference of gray levels of an area whereas correlation coefficients were not different. In terms of energy, it was to measure main features of the image and avoid change in the main features to help in image adjustment. For homogeneity and entropy, they were high and low values of textural changes that reflected non-uniformity or randomness. From Figure 3, results of a comparison of datasets used in the recognition accuracy tests and not undergoing recognition process reveal that changes in the values of image textures were in the same direction.

B. Results of KNN Classification

Results of the accuracy tests based on feature extractions using GLCM (contrast, correlation, energy, homogeneity, and entropy) to recognize chicken embryo development in each stage of a total of 18 days of incubation with KNN algorithm where the k value determined at used in this experiment was 2,4,6,8,10 and 12, found that the most appropriate k value was at 10 are shown in Table II. below.

TABLE II. THE ACCURACY TEST RESULTS

Image Features Detection	Range of Data Set (Days : D)	Total Data set	Training Set	Test Set	Accuracy (%)
Normal Egg	Stage1 : D1 - D3	30	15	15	73.33%
Chicken Embryo	Stage2 : D4 - D6	30	15	15	60%
	Stage3 : D7 - D9	30	15	15	66.67%
	Stage4 : D10 - D18	90	45	45	93.33%

According to Table II, it can be concluded that accuracy rate of chicken embryo development recognition in Stage 4 (Day 10 to Day 18) was the highest at 93.33%, followed by that of Stage 1 (Day 1 to Day 3) at 73.33% and Stage 3 (Day 7 to Day 9) at 66.67%, respectively. Accuracy rate was the lowest in Stage 2 (Day 4 to Day 6) at 60%. Due to the fact that it was the period during which changes in texture layout of the images were quite similar and the pattern of each image datum was different, the analysis efficiency was at the moderate level.

IV. CONCLUSION

In this paper, the recognition of conception and chicken embryo development in each stage of a total of 18 days of incubation is presented. Texture extractions using GLCM technique and machine learning (KNN algorithm) data classification were employed for patterns feature recognition of chicken embryos. With regard to test procedure, there were two image datasets in each stage. The ratio of training dataset to testing dataset was determined at 50:50. There were a total of 180 images used in the experiments. Results of the accuracy tests show that Stage 4 had the highest rate of accuracy at 93.33% whereas the accuracy rates of recognition for Stages 1, 2 and 3 were quite close to each other. It was found that the accuracy rate was not less than 60%.

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REFERENCES

[1] O. Rena Indriani, E. Jaya Kusuma, C. Atika Sari, E. Hari Rachmawanto and D. Rosal Ignatius Moses Setiadi, "Tomatoes classification using K-NN based on GLCM and HSV color space," International Conference on Innovative and Creative Information Technology (ICITech), Salatiga, Indonesia, 2017, pp.1-6.

[2] A. Parvez and A.C. Phadke, "Ef cient Implementation of GLCM based Texture Feature Computation using CUDA Platform," International Conference on Trends in Electronics and Informatics (ICEI), Tirunelveli, India, 2017, pp. 296-300.

[3] R. Asery, R. Kumar Sunkaria, L. Dev Sharma and A. Kumar, "Fog Detection using GLCM based Features and SVM," Conference on Advances in Signal Processing (CASP), Pune, India, 2016, pp. 73-76.

[4] S. Aygün and E. Olcay Güneş, "A benchmarking: Feature extraction and classification of agricultural textures using LBP, GLCM, RBO, Neural Networks, k-NN, and random forest," 6th International Conference on Agro-Geoinformatics, Fairfax, USA, 2017, pp. 1-4.

[5] T. Makkar, Y. Kumar, A. Kr Dubey, Á. Rocha and A. Goyal, "Analogizing Time Complexity of KNN and CNN in Recognizing Handwritten Digits," IEEE Fourth International Conference on Image Information Processing (ICIIP), Shimla, India, 2017, pp. 182-187.

[6] M. Dahmani and M. Guerti, "Glottal signal parameters as features set for neurological voice disorders diagnosis using K-Nearest Neighbors (KNN)," 2nd International Conference on Natural Language and Speech Processing (ICNLSP), Algiers, Algeria, 2018, pp.1-5.

[7] M. Bella Al Rasyid, Yunidar, F. Arnia, and K. Munadi, "Histogram Statistics and GLCM Features of Breast Thermograms for Early Cancer Detection," International ECTI Northern Section Conference on Electrical, Electronics, Computer and Telecommunications Engineering (ECTI-NCON), Chiang Rai, Thailand, 2018, pp.120-124.

[8] A. Reema Mathew, P. Babu Anto and N.K. Thara, "Brain Tumor Segmentation And Classification using DWT,Gabour Wavelet And GLCM," International Conference on Intelligent Computing, Instrumentation and Control Technologies (ICICICT), Kannur, India, 2017, pp.1744-1750.

[9] P. Raktrakulthum and C. Netramai, "Vehicle Classification in Congested Traffic Based on 3D Point Cloud Using SVM and KNN," 9th International Conference on Information Technology and Electrical Engineering (ICITEE), Phuket, Thailand, 2017, pp.1-6.

[10] A. Al-Zoubi, K. Tatas and C. Kyriacou, "Design Space Exploration of The KNN Imputation on FPGA," 7th International Conference on Modern Circuits and Systems Technologies (MOCAST), Thessaloniki, Greece, 2018, pp.1-4.

Automatic Scale Selection and Multifocal Imaging for Object Detection using Depth-of-Field Extension

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Abstract—Working on only one image plane turns out partially intrinsic image features, especially the images obtained in different ranges of focus. Multifocal imaging often causes difficulty in image segmentation due to its sparse features. To handle this by simplicity feature extraction, extended depth-of-field is a comprehensive method that consolidates those multifocal images into a distinguishable composite. Automatic scale selection is also investigated to provide the optimum depth-of-field using a scale space algorithm. Multichannel images without preprocessing are applied separately to obtain depth-of-field features using surface-based representation. The desired object is detected by maximizing the high corresponding coefficient values over scale space parameters in each plane. Finally, we obtain a binary map of the results by using adaptive thresholding over scales, generating a threshold aspect based on the maximum coefficient provided by the previous steps. Our approaches are applied to discriminate applications in object detection. Experimental results on the test datasets are reported to demonstrate the performance without comparison with current object detection methods.

Keywords - Multifocal imaging; extended depth-of-field; depth-based feature extraction; depth-based segmentation; scale space algorithm

I. Introduction

One of the most crucial tasks in digital image processing to find proposal objects inside images is object detection. In the object detection process, the desired object which is obscured by the presence of other objects is challenging in this area. This is due to the objects are unclearly manifest in the image and shown trivial features. Besides that, the objects which contacting each other also cause the detection process difficulties. Hidden objects will be unable to locate and detect precisely. The intensity level on each object makes the other contacting or background objects having almost the same features as the targeted objects. To handle all these issues, a proper object detection technique must be considered.

There exists a number of related works investigating these tasks. Somewhat conventional methods are acceptable in obviously detecting where they are deployed by using distinguishable features. Image color, shape, and texture are usually considered to be the detection facets for simple object detection techniques as well as its reference subjects. Multifocal imaging is one of the challenging features to improve object detection results when the targeted objects appear particularly in different image spaces. This can overcome the detection results by enhancing the input images when we combine noticeable features over image spaces.

Hussin et.al. [1] first proposed the detection technique based on color image processing and shape analysis to detect and count mangos on the mango tree. The complex background was filtered out of the targeted objects by considering the conditions of intensity level in each color space of RGB images. Circular Hough Transform was then applied to obtain the object boundaries. It brings out the prominent features on the combination of RGB colour to achieve precise detection performance. However, fixed parameters of the lighting conditions for each pixel color value were still required to compare to a common RGB colour of the green mango.

In this paper, we introduce alternative approaches for object detection by using multifocal imaging as a preprocessing step. Automatic scale selection is also applied to select the best-fit focal to provide good quality of input images. The depth-of-focus extension is then provided human-like vision to distinguish complex objects. By doing this to obtain the experimental setting, twenty-eight retinal fundus images are acquired for the proposed approaches testing system. Peripapillary atrophy (PPA), a crescent shape region adjacent to the optic disk (OD) in a retinal fundus image, is defined as the targeted object in this study. Generally, PPA is appeared brighter than surrounding while it is present in lower intensity level compared to the OD, see Fig. 1. Many techniques have been proposed for PPA detection based on multifocal imaging.

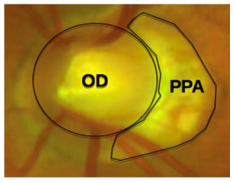

Figure 1. Illustration of the presence of peripapillary atrophy.

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II. Related Works on PPA Detection

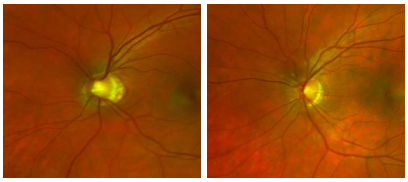
Quantitative PPA detection methods have been proposed regarding feature selection as follows in [2] and [3]. Lee et al. [2] employed texture and grey level analysis to identify PPA through regions of interest (ROI) contained OD. Smoothen image was obtained by eliminating vessels and suppressing noise. Entropy values were calculated to find roughness of the focal ROI texture map. The focal ROI was partitioned into four sectors to determine a particular feature, which is superior, inferior, temporal, and nasal quadrants. According to the clinical observation, PPA normally occurs in the temporal side. Mean intensity and standard deviation values of each side were the verification of the final PPA result. The method did not provide exact PPA contour while rough PPA region was identified.

Related work proposed by Lu et al. [4] applied the Chan-Vese model to investigate elliptic constraint evolution for PPA detection. The manually cropped image having OD and PPA was considered to eliminate irrelevant interference. Varying color spaces; red, blue, hue, and Lab color spaces, were involved to obtain the optimum segmented results. The OD is segmented using a direct least square fitting algorithm of an ellipse (DLSFE) under the fitting constraint of an ellipse radius. PPA detection based on clinical OD partitions (temporal, superior, nasal, and inferior) was performed after excluding the OD region. Detecting the presence of remaining bright pixels in the temporal section was indicated approximate PPA. The modified Chan-Vese model and a multiseed region growing were then employed to segment PPA boundary. The PPA detection rate was achieved by 89.47% while the success rate of PPA segmentation was reported slightly high by 73.57%. This is because of the fundus images represented in low contrast and unsharpened OD edge related to OD segmentation accuracy by 81.31%. The OD region estimation with and without PPA has achieved an accuracy of 81.31% and 95.32%, respectively.

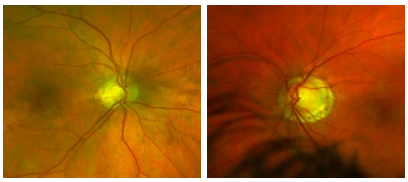
Thus, the preprocessing step is necessary to be considerate. There were still some remaining limitations about pre-defined preprocessed images. Distractions such as noise, blood vessels, and a poorly defined boundary would be managed to improve the success rate of the segmentation. The proposed methods were verified effectiveness by replacing and combining with particular conventional methods. These methods required well-defined prior knowledge to attempt varying size and orientation of PPA.

III. Preprocessing and Experimental Setting

This section provides the experimental setting for object detection on multifocal image preprocessing. In the process of image acquisition, 14 patients of Ultra Wide Field of view (UWF) of Scanning Laser Ophthalmoscopy (SLO), UWF of Fundus Auto Fluorescence (FAF), and Optical Coherence Tomography (OCT) are provided both eyes by Prof. Pearson Thomas from University of Edinburgh. As stated in the proposed task for the study, the 936x822 pixels of 28 cropped retina fundus images with the presence of PPA have been obtained. PPA visually categorized into four characteristics by contrast and its shape which are PPA with high contrast and poor contrast, and PPA with crescent shape and ring shape (see Fig. 2).



a. high contrast b. crescent shape



c. low contrast d. donut shape

Figure 2. Characteristics of PPA.

To get more precise PPA boundary, the OD annotation VAMPIRE tools were utilized to obtain optic disk (OD) boundary (see Fig. 3). These tools have been developed by the VAMPIRE research group from the School of Computing, the University of Dundee.

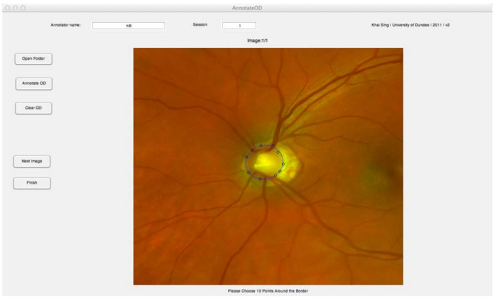
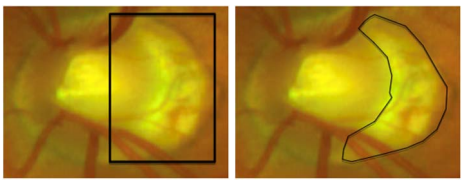


Figure 3. VAMPIRE tools to get OD annotation.

We then prepare the PPA annotation by getting clinician consultant, which there might be two possible annotations as shown in Fig. 4. The first PPA annotation (Fig. 4(a)) is defined as the region of interest of PPA while the second PPA annotation (Fig. 4(b)) is defined by expert drawing the exact boundary. In this study, we proposed the latter PPA annotation. The object detection results also have an influence on how accurate the algorithm can obtain the PPA for further clinical treatment.



a. the 1st annotation b. the 2nd annotation

Figure 4. Two possible PPA annotations.

Since the OD boundary has been allocated, the region of interest (ROI) where contains both OD and PPA was predefined by dilating one-time radius of the OD. The region is so-called predefined PPA ROI as shown in Fig. 5. The predefined PPA ROI was bounded in a rectangle shape.

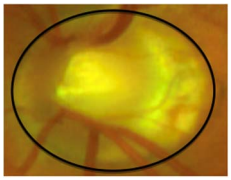


Figure 5. Predefined PPA region of interest.

IV. Object Detection based Depth-of-Field Extension

The proposed approach on object detection is described in this section. Multifocal imaging was first determined to obtain the multi-focused images by combining the intrinsic features over multichannel of color models. Image profiles was also taken into account to find radial lines crossing the intensity variation where the PPA contour has been traced. Finally, iteration processes were employed on each selected image plane instead of taking on only one object field.

A. Multifocal Imaging

This task represents the configuration of multifocal imaging in the preprocessing stage. As stated by a number of the related works, the detection of PPA was first investigated. We then provided the process to define the region of interest with the inclusion of OD and PPA so-called predefined PPA ROI. The cropped RGB images were considered into different image planes from RGB and HSI color models. Fig. 6 shows the procedure of multifocal imaging to select the eligible color spaces which are green channel from RGB color model, luminance and hue channels from HSI color model.

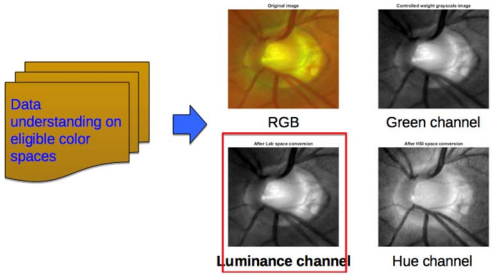


Figure 6. Selected color spaces for multifocal imaging.

Band-pass filtering were applied to enhance and filter out unwanted objects. Three selected color spaces were then integrated to show multifocal images where the intrinsic features were revealed to distinguish the presence of PPA. The result of multifocal imaging and its corresponding histograms compared to the original image is shown below in Fig. 7 and Fig. 8, respectively. When we consider to the histograms, unwanted objects were eliminated from the original image while the desired objects were enhanced noticeably.

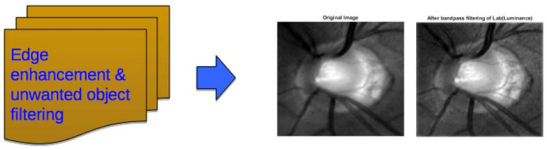


Figure 7. Multifocal imaging using Band-pass filtering.

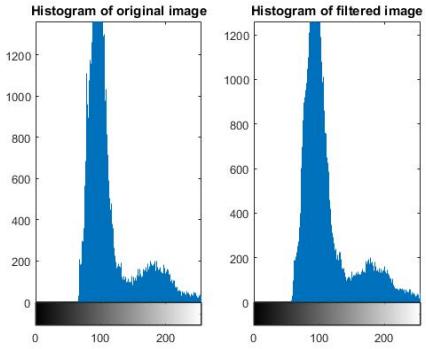


Figure 8. Comparison of histogram between the original image and the multifocal image.

B. Automatic Scale Selection

This process provides the automatic scale selection by checking of intensity variation using image profile of line segments across the predefined PPA ROI. The lines were drawn in four directions: horizontal, vertical, and 2 diagonal lines to return image profiles. Fig. 9 shows the line segments crossing the synthetic PPA in both crescent and ring shapes.

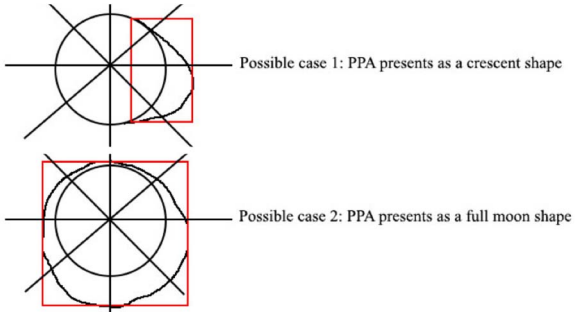


Figure 9. The line segments crossing the synthetic PPA.

The image (intensity) profiles of the corresponding line segments have showed the change of intensity level where the OD and PPA contour were differentiate.

C. Object detection using extended depth-of-field

To define the in-focus criterion of images, the images having higher frequency components than wider spread function (blurred images) are the in-focus subjective components. The wavelet transform was implemented to return the high saliency detection with spatial localization. We can verify the multifocal images from section IV-A in this stage. By doing this, the complex Daubechies wavelets [5]

was performed by filtering of finite-length complex low and high pass filters in each color space of the images. The complex-valued coefficients were then obtained and transformed by adding robustness for rule selection and consistency checking algorithm. The coefficients having largest absolute value in the subbands correspond to the variation of brightness sharpening and the most salient features. There are two approaches for the consistency checks to select the optimum coefficient which are spatial and subband consistency [6]. The spatial consistency considered by choosing from the same slice on the majority of neighboring pixels within a 3 x 3 sliding window. While the subband consistency provide by choosing the corresponding pixels in different subbands from the same slice. Finally, the composite image was obtained by the combined complex coefficient inversion.

V. Experimental Results

This task has represented the implementation and preliminary evaluation of the PPA detection. As stated by a number of the related works, the presence of PPA was first investigated. The region of interest was indicated consequently with the inclusion of OD and PPA. Multifocal imaging and depth-of-field extension were then provided the enhanced input images. Thirty-six radial line segments are collected their corresponding profiles, intensity and gradient profiles, through the predefined PPA ROI (see Fig. 10).

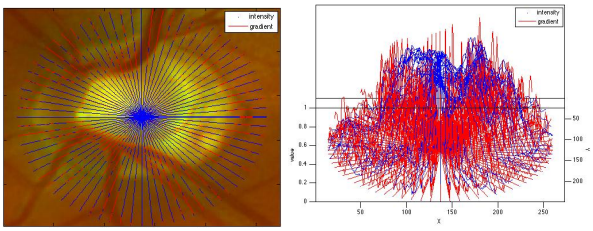


Figure 10. The intensity and gradient profiles along the line segments.

To detect the PPA, the local extrema analysis was performed. The local minimum among top three highest peaks will be considered as the contour variation between the OD and PPA. The higher frequency of the intensity profiles was shown the presence of the PPA since the OD has normally bigger size than the PPA or been showing in lower frequency. Fig. 11 shows how the local extrema analysis was performed.

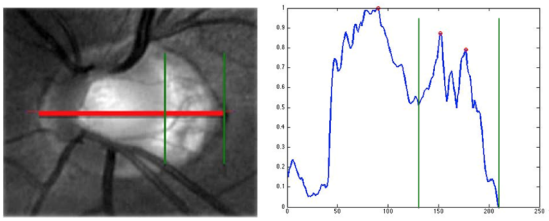


Figure 11. The local extrema analysis.

The proposed approaches perform very well in the good quality images having high contrast and distinguishable components. The performance matric for the PPA detection rate is shown below as in (1)

$$dtr = Ps/Po. \quad (1)$$

Noted that Ps is the number of images detecting correct PPA and Po is the number of the overall original images. The accuracy of the PPA detection showed 78.57% of the detection rate.

VI. Discussion

After we have considered the experiment results, to ensure that the selected features are appropriate compared to other related works in object detection. Trying to get prior clinical information from experts to classify category of images such as healthy or unhealthy, image with or without PPA could be examined to clarify on the PPA detection algorithm. For example, the shape feature of crescent or ring shape is also required to be performed. In addition, the comparison of performance estimation might be done in variety color spaces i.e. RGB, Lab, or HSI color spaces. The visualization on 3-Dimensions can also carry out high corresponding profile features (see Fig. 12).

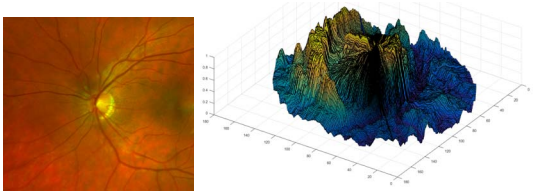
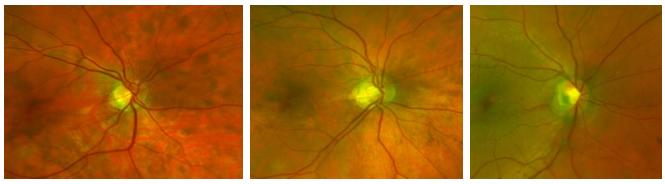


Figure 12. The 3-D visualization of the PPA annotation.

Furthermore, the considered image cases where poor quality of image have been concentrated to get higher accuracy. The images having poor quality can be displayed in Fig. 13(a-c) that would be boundary confusion, poor contrast, and leakage superimposition, respectively.



a. b. c.

Figure 13. The considered cases in poor quality image

VII. Conclusion

We presented an alternative method of applying the multifocal imaging and automatic scale selection for object detection based on the extended depth-of-field. The retinal fundus images were then chosen for the study to detect peripapillary atrophy or PPA where it appears very similar

nearby optic disk (OD). Our proposed approach enables the good quality image in high performance detection. However, there are still rooms for improvement where the feature selection should be taken into account.

Acknowledgment

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References

[1] R. Hussin, M. R. Juhari, N. W. Kang, R. C. Ismail, and A. Kamarudin, "Digital Image Processing Techniques for Object Detection From Complex Background Image," Procedia Eng., vol. 41, pp. 340–344, Jan. 2012.

[2] B. Lee et al., "Fusion of pixel and texture features to detect pathological myopia," in 2010 5th IEEE Conference on Industrial Electronics and Applications, 2010, pp. 2039–2042.

[3] C. Muramatsu, Y. Hatanaka, A. Sawada, T. Yamamoto, and H. Fujita, "Computerized detection of peripapillary chorioretinal atrophy by texture analysis," Conf. Proc. Annu. Int. Conf. IEEE Eng. Med. Biol. Soc. IEEE Eng. Med. Biol. Soc. Annu. Conf., vol. 2011, pp. 5947–5950, 2011.

[4] C.-K. Lu, T. B. Tang, A. Laude, B. Dhillon, and A. F. Murray, "Parapapillary atrophy and optic disc region assessment (PANDORA): retinal imaging tool for assessment of the optic disc and parapapillary atrophy," J. Biomed. Opt., vol. 17, no. 10, p. 106010, Oct. 2012.

[5] J.-M. Lina and M. Mayrand, "Complex Daubechies Wavelets," Appl. Comput. Harmon. Anal., vol. 2, no. 3, pp. 219–229, Jul. 1995.

[6] B. Forster, D. Van De Ville, J. Berent, D. Sage and M. Unser, "Extended depth-of-focus for multi-channel microscopy images: a complex wavelet approach, " Proc. 2nd IEEE International Symposium on Biomedical Imaging: Nano to Macro (IEEE Cat No. 04EX821), Arlington, VA, USA, 2004, pp. 660-663, doi: 10.1109/ISBI.2004.1398624.

An Implementation of Automatic Inductive-Loop Vehicle Sensor Using Low-Cost Microcontroller

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***Abstract*— This paper presents a vehicle sensor circuit. This circuit is based on inductive-loop as a resonant circuit. The signal from this circuit is capture on a low-cost microcontroller with a low-speed build on ADC. This automatic calibration algorithm is based on k-mean clustering. The experimental results showed 100% accuracy detecting the subcompact car.**

Keywords—Vehicle Sensor, Inductive-Loop, Resonant Circuit, Digital Signal Processing, Magnetic Signature

I. INTRODUCTION

Vehicle sensor is a device used to detect the presence of a vehicle, such as a car and truck. This device is a crucial component for modern traffic management and parking lot management. There are many technologies have been used in this application such as radar, infrared, video image processing and inductive loop detector.

Today, the most widely used vehicle detection technology is inductive loop detector. This technology is operating based on 3 components, oscillator, inductive loop, and the signal comparator.

The oscillator is an electronic circuit that produces a periodic signal, a square wave ranging from 10 kHz to 200 kHz is widely used in this application

The inductive loop is an inductor created by a coil of insulated conducting wire that produced the electrical inductance ranging from 100µH to 700µH. This component also called detector loop since it acts as a vehicle detecting probe. The electrical inductance value will be change if the metal is present over the coil, this effect is also equivalence to changing the resistance in AC circuit and its resonant frequency. The capacitor is connected to this loop wire to tune the resonant frequency. The LC resonant circuit or Tank circuit is commonly used.

The signal analyzer is a circuit that used to compare the signal from the oscillator with the predefined on to determine that the vehicle is present on a detector loop or not. The comparing parameter can be frequency or magnitude deepened on the circuit implementation.

There are 4 types of the circuit implementation that widely used, LC-Generator, Resonant Circuit, AC-Bridge and Impedance-to-Voltage Converter[1] as shown in Fig.1.

LC-Generator implementation used inductive loop to control oscillation frequency. The vehicle presents over the loop is result in the changing frequency output of the oscillator circuit. The changing frequency is detected by the signal comparator circuit to identify the presence of a vehicle. The frequency counter circuit is commonly used in this circuit [2, 3].

Resonant circuit implementation does not change the oscillator frequency, but it changes the output amplitude by passing the waveform through the inductive-loop. This loop is allowing the waveform that matches its resonant frequency to pass while blocking others. The present of a vehicle over the loop results in changing its resonant frequency, this will affect the amplitude of the output signal. This changing is detected using the voltage comparator circuit. Operational Amplifier (Op-Amp) is commonly used in this circuit.

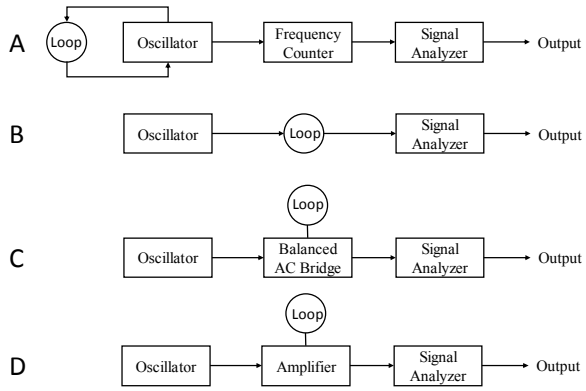

Fig. 1. The 4 types of Inductive loop vehicle sensor implementation, LC-Generator (A), Resonant Circuit (B), AC-Bridge (C) and Impedance-to-Voltage Converter (D)

AC-Bridge implementation is based on inductive-loop as a pre-balanced AC-bridge working in the quasi-balanced state. This state is produced zero voltage at the output, however, the presence of vehicle cause the bridge to unbalanced, finally output voltage is produced[4-7].

Impedance-to-Voltage Converter implementation is based on amplifier circuit. The oscillator output is feed to Op-Amp input using inductive-loop as a feedback impedance to control amplifier gain. The presence of a vehicle is causing the gain to change. The voltage comparator circuit is often used to detect the changing of signal gain[1].

These implementations required a complex installation process. The loop wire must be carefully winding to match the designed resonant frequency. The circuit requires fine-tuning to operate correctly. The signal comparator circuit must be calibrated in every installation to prevent the false detection that can cause by the installation environment, such as steel mesh buried in the concrete pavement.

The automatic tuning inductive-loop vehicle sensor is proposed based on a bridge-balance implementation. However, this implementation required additional circuit and the sensitivity of this sensor can be effect by the lead-in cable [4].

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The Inductive-loop vehicle sensor is widely used in many application, such as vehicle counting, vehicle type classification, speed measurement, and undisciplined traffic detection. These applications required the additional microcomputer or microcontroller to process the sensor output. However, a separated inductive-loop sensor circuit that does not utilize the microcontroller that already presents is used.

In this research, the inductive-loop vehicle sensor implementation based on a microcontroller is proposed. The circuit is simple, the signal processing algorithm does not require intensive computational power and can be implemented on a low-cost microcontroller.

II. METHOD

The challenge of design the microcontroller for inductive loop applied to vehicle detection is the high bandwidth of the signal requirement. The operation of the oscillator is ranging from 10kHz to 100kHz, in order to correctly sampling this signal is required the sampling rate must be double the signal bandwidth[8]. This required a dedicated Digital Signal Processor or High Bandwidth Analog to digital converter, which is not capable of a low-cost microcontroller. Decrease the oscillation frequency is possible, but the inductive-loop must be designed to match the resonant frequency. The recommend inductance value by NEMA is 100µH to 700µH, the out of range value is result in decreasing the detection sensitivity[9].

The inductive-loop vehicle sensor circuit can be simplified as a signal modulation and demodulation circuit. There are two signals, oscillator signal (f_c) and information signal generated by a vehicle passing over inductive-loop (f_i). The output of the circuit is the modulation of both signal (f_o), then the output signal is demodulating base on frequency, phase or amplitude depending on the implementation to recover the information signal (f_i).

A. The Circuit

The proposed model is based on a resonant circuit implementation. This model is equivalent to an amplitude modulation and demodulation as shown in Fig. 2. The f_c signal is generated using 555 timer IC, this circuit is designed to oscillate at the 100kHz. However, the frequency can be fine-tuning using VR1 to match the resonant frequency of the inductive-loop. The output from the oscillator is grounded by the Tank circuit created by inductive-loop (L1) and C4. This circuit is equivalent connecting f_c to ground via a high-resistant resistor, the amplitude of f_c is not changing. However, the presence of a vehicle over inductive-loop is causing the decreased of the inductance value [2, 3], this results in changing the resonant frequency of the Tank circuit. This effect lowers the resistance of the Tank circuit and creates a short circuit of signal f_c to ground, the amplitude of the f_c will be decreased. The current from the oscillator is limited by **R3** to prevent a long short circuit caused by the vehicle parking over the inductive-loop. The output from Tank circuit is rectified by D1, since the current in the loop is low due to the high value of **R3** , then a Schottky diode is used. The output of this circuit is f_o. However, the frequency of f_o is equal to 2 times of f_c. Then this output current signal is converted to voltage by R4 and sampling to digital data by a microcontroller.

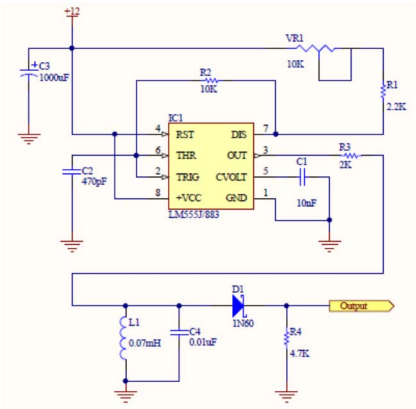

Fig. 2. The proposed oscillator and detector circuit

B. The Sampling Algorithm

The output signal from the inductive loop circuit is impossible to sampling without distortion due to the high bandwidth requirement of analog-to-digital converter module: ADC. The bandwidth of this signal is 200kHz, thus the 400kHz ADC is required. However, the operation principle of this proposed circuit is similar to an Amplitude Modulation, thus the full digitally reconstruction of f_o is not necessary. Since the bandwidth of the information (f_i) created by a vehicle passing over the inductive-loop is very low, this information is possible to recover using a low-speed ADC.

The output from circuit (f_o) is sampling by a low-speed ADC and, then the information (f_i) is extracted, as in:

$$f_i'(t) = Max(f_o'[t, \dots, t+j]) \quad (1)$$

$$f_s(t) = f_i' * G \quad (2)$$

The low-speed sampling of signal f_o is collected for j samples as f_o'. The information is recovered by extract the maximum value of each f_o'. This process will capture the signal envelope caused by the vehicle similar to AM demodulation circuit. The spike can occur in the moment vehicle enter and leave the detector loop, but it is removed using low-pass filter by convolution the signal with the low-pass filter kernel $\boldsymbol{G}$

The signal f_s is now representing the magnetic signature, which is unique for each vehicle [1, 10], in addition, this signal is also containing noise caused by the ambient environment.

This signal is then analyzed by comparing its amplitude with the threshold value θ to determine the vehicle is present or not, where 5 is mean detected and 0 for not detected, as in:

$$f(t) = \begin{cases} 5\,; f_s(t) \le \theta \\ 0\,; others \end{cases} \quad (3)$$

C. Automatic Calibration Algorithm

The signal magnitude difference between the presence of a vehicle and not present varies in every installation. This is because by the different inductance value of loop-wire, stray capacitance, steel mesh buried in the concrete, and the oscillation frequency error. The threshold value θ must be changed in every installation for the sensor to be working correctly. The threshold value is automatically determining in the installation process using the automatic calibration algorithm.

The first step of this algorithm is preparing a training dataset by collecting sample data for n samples. This data must contain both the presence of a vehicle and not. Then, the training data is cluster into 2 classes; vehicle present and not present, using k-mean algorithm.

The k-mean is a data clustering algorithm by partition observation samples into k clusters in which each observation belongs to the cluster with the nearest mean. This algorithm is represented as an optimization problem (4), the goal is to partition sampling data f into k group while keeping the variance as low as possible. This automatic calibration algorithm is using $k = 2$, because it is a binary sensor that reporting the presence of a vehicle.

$$\underset{s}{argmin} \sum_{i=1}^{k} \sum_{f \in S_i} \|f - \mu_i\|^2 \qquad (4)$$

Finally, the centroid of both cluster are determined (μ_{S_1}, μ_{S_1}), the threshold is calculated by averaging both values ,as in:

$$\theta = \frac{\mu_{S_1} + \mu_{S_1}}{2} \qquad (5)$$

III. Experiments and Result

The actual circuit for testing scenario is shown in Fig. 3, the inductor loop was coiled 6 turns into a circle shape with a diameter of 80 cm using 17 AWG wire. The inductance value of this loop is 700µH and the resistance is 0.4 Ω. The inductive-loop was placed on the top of a steel reinforced concrete pavement.

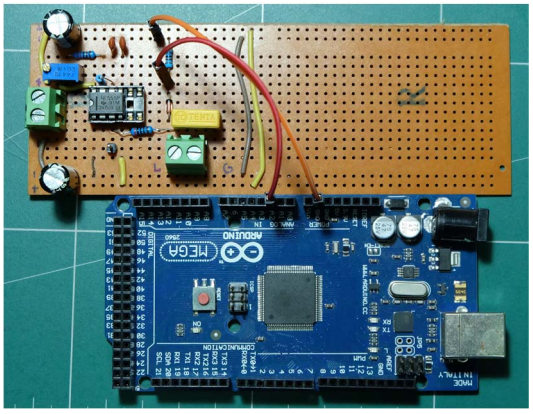

Fig. 3. The actual circuit used in this experiments

The oscillator frequency was tuned to 94kHz, the circuit producing the square wave with 64% duty cycle. The oscillator output signal is shown in Fig. 4.

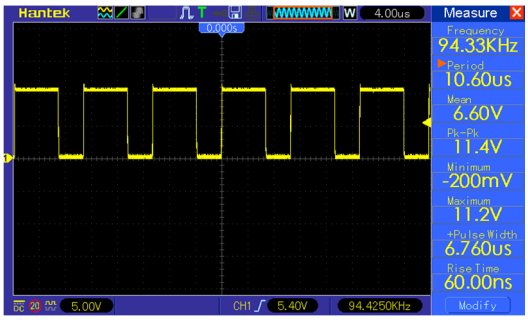

Fig. 4. The captured of the oscillator signal

The output from inductive-loop was deformed into AC sine wave with the 196 kHz, this signal is shown in Fig. 5.

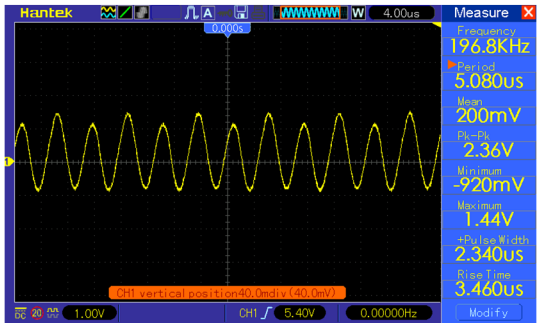

Fig. 5. The captured of the inductive loop output signal

The rectified signal from inductive-loop is shown in Fig. 6, the negative half is removed and the amplitude is smaller because 320mV is the loss in the diode.

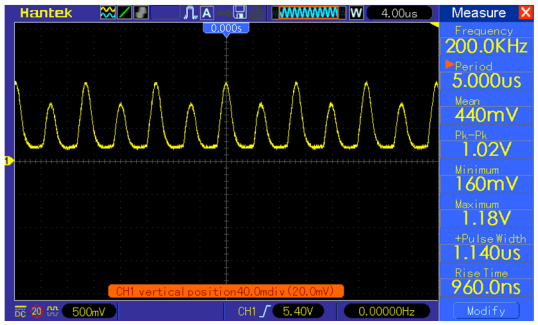

Fig. 6. The captured of the circuit output signal

The raw signal sampling by ADC is shown in Fig. 7, the microcontroller used in this experiment is ATmega2560 on an Arduino MEGA 2560 platform. The processor of this platform is running at 16 MHz capable of sampling analog signal at 10kHz[11].

The captured circuit output signal is heavily suffered from aliasing error caused by the insufficient sampling frequency. The original signal capture using the 200MHz oscilloscope is shown in Fig. 6.

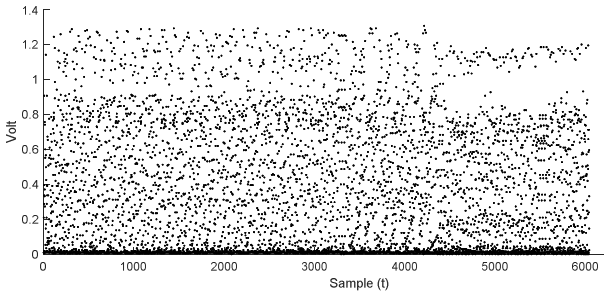

Fig. 7. The raw sample data from microcontroller build-in ADC

The envelope signal that recovered using proposed algorithm is shown in Fig. 8. The parameter $j = 400$ and the low-pass filter is implement using the moving average algorithm with 20 samples window size. The result shows that the shape of the magnetic signature is correctly recovered.

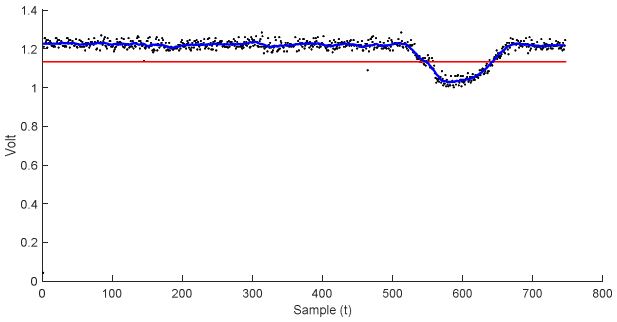

Fig. 8. The magnetic signature recovered by proposed algorithm, point data show the individual data of f_i', the magnetic signature (f_s) shown as the blue line and the threshold θ determined by automatic calibration algorithm shown as the red line.

A horizontal red line is threshold determined by automatic calibration algorithm and final sensor result is shown as a blue line.

This proposed vehicle sensor was tested 30 times with subcompact car in both directions, the bottom frame height of this car is 10 cm. The result is shown that this sensor can detect with a 100% accuracy. The complexities of automatic calibration algorithm is $O(n^3)$, however, the detection process was finished in real-time. This power consumption of this circuit is 0.1mA in idle and when a vehicle is present over the inductive-loop.

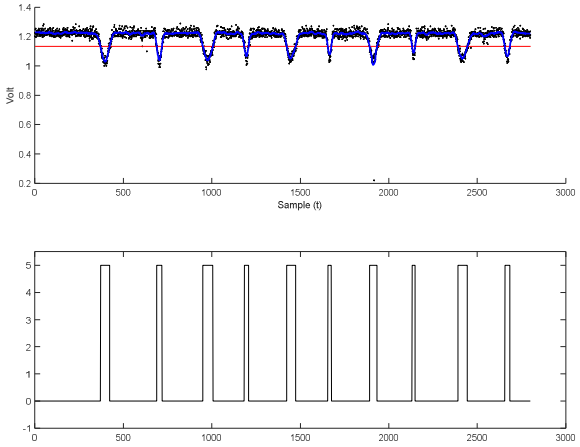

Fig. 9. The sample magnetic signature (top) and sensor output (bottom) signal $f(t)$ of 10 cars passing over the detector loop, where the detected is reported as 5 volts.

IV. Discussion

This circuit is designed to output a type of signal that possible for low-speed ADC. The inductor is used as a tank filter to pass non-resonant signal to the ground. This technic allows microcontroller to detecting a missing loop wire and providing a reference signal in the automatic calibration algorithm. However, this configuration also limited the sensitivity of the circuit. Increase the oscillator voltage to gain more sensitivity is possible but do not recommend because it will damage resistor R3. This circuit cannot detect small vehicles such as bicycle, the signal amplifier circuit is needed in order to overcome this problem.

V. Conclusion

In this research, the vehicle sensor is proposed. the sensor is based on the inductive-loop detector circuit. The circuit is proposed based on the resonant circuit implementation. The digital signal analysis for detecting a magnetic signature is proposed, the algorithm is designed for a low-speed ADC and low-cost microcontroller. The automatic calibration algorithm based on k-mean clustering algorithm is proposed. This process allows changing the inductive-loop without re-tune the oscillator. The experimental results show that the proposed sensor is low power consumption and produces 100% accuracy detecting the subcompact car.

Acknowledgment

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References

[1] Z. Marszalek and K. Duda, "Vehicle Magnetic Signature Compatibility for Inductive Loop Sensor with Various Signal Conditioning Systems," in *2018 International Conference on Signals and Electronic Systems (ICSES)*, 2018, pp. 33-36.

[2] Y. Ki and D. Baik, "Vehicle-Classification Algorithm for Single-Loop Detectors Using Neural Networks," *IEEE Transactions on Vehicular Technology,* vol. 55, pp. 1704-1711, 2006.

[3] K. Yong-Kul and B. Doo-Kwon, "Model for accurate speed measurement using double-loop detectors," *IEEE Transactions on Vehicular Technology,* vol. 55, pp. 1094-1101, 2006.

[4] R. L. Anderson, "Electromagnetic loop vehicle detectors," *IEEE Transactions on Vehicular Technology,* vol. 19, pp. 23-30, 1970.

[5] J. Gajda, P. Piwowar, R. Sroka, M. Stencel, and T. Zeglen, "Application of inductive loops as wheel detectors," *Transportation Research Part C: Emerging Technologies,* vol. 21, pp. 57-66, 2012/04/01/ 2012.

[6] Z. Marszalek, R. Sroka, and M. Stencel, *A New Method of Inductive Sensor Impedance Measurement Applied to the Identification of Vehicle Parameters* vol. 18, 2011.

[7] Z. Marszalek, R. Sroka, and T. Zeglen, "Inductive loop for vehicle axle detection from first concepts to the system based on changes in the sensor impedance components," in *2015 20th International Conference on Methods and Models in Automation and Robotics (MMAR)*, 2015, pp. 765-769.

[8] S. S. M. Ali, B. George, and L. Vanajakshi, "A simple multiple loop sensor configuration for vehicle detection in an undisciplined traffic," in *2011 Fifth International Conference on Sensing Technology*, 2011, pp. 644-649.

[9] L. A. Klein, *Traffic Detector Handbook*, 3 ed. vol. 1: Research, Development, and Technology Turner-Fairbank Highway Research Center, 2006.

[10] J. Gajda, R. Sroka, M. Stencel, A. Wajda, and T. Zeglen, "A vehicle classification based on inductive loop detectors," in *IMTC 2001. Proceedings of the 18th IEEE Instrumentation and Measurement Technology Conference. Rediscovering Measurement in the Age of Informatics (Cat. No.01CH 37188)*, 2001, pp. 460-464 vol.1.

[11] Arduino. (2018, 14/8/2018). *The Arduino Reference text*. Available: https://www.arduino.cc/reference/en/language/functions/analog-io/analogread/

Excessive Alcohol Craving Prediction Algorithm Using Smartphone Accelerometer Sensor

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Abstract— **This research presents the development of the algorithm that predict excessive alcohol consumption by using sensors on smartphones in order to solve problems of alcohol drinkers who is unaware of their own alcohol consumption level. Since this incident results in several problems such as, road accidents. Therefore, this algorithm was developed to replace Breathalyzer, which most people do not have. This algorithm will use data from the sensors on smartphones, which most people already have in possession, to forecast alcohol over dosage. The experiment conducted from 6 people of 23 sample groups, which is 100% accurate, revealed that this algorithm could be used instead of the Breathalyzer in a certain extent.**

Keywords— Excessive Alcohol, Intoxicate, Signal processing, Accelerometer sensor

I. INTRODUCTION

Excessive alcohol consumption is the leading cause of several deaths worldwide (population decline). Thus, part of it is caused by, drunk driving or having excessive alcohol intake while driving a vehicle, which causes road accidents. So, the problem stems from the alcohol drinkers' inability to recognize that they had consumed an excessive amount of alcohol. Since, other than using the Breathalyzer to measure the level of alcohol through one's breath, there is no other way to find out one's level of alcohol. Therefore, this article presents an algorithm for predicting alcohol over dosage from accelerometer sensor on smartphones. Then, the obtained data will be processed through the signal processing method. This algorithm has been developed using sensor data obtained from the body movement while sitting and drinking alcohol.

II. LITERATURE REVIEW

A. Effects of alcohol on human

One of the effects of ethanol intoxication is a general impairment of static balance control, characterized by an increased postural sway and the inability to coordinate postural and voluntary activity.

The average sway area and sway path changed in accordance with the Blood alcohol content, especially for the large alcohol dose group. There was a significant positive correlation between sway area increase and Blood alcohol content both. Little change was found in the small alcohol dose groups. Thus, it can be postulated that body sway does not increase significantly when the Blood alcohol content is less than 0.8%. [1]

Acute alcohol intoxication is associated with numerous health risks. For example, impaired driving due to alcohol was implicated in 28% of the 38,000 deaths from motor vehicle accidents in the US in 2016. These consequences largely stem from alcohol's detrimental effects on psychomotor performance. One measure of psychomotor performance that is particularly sensitive to alcohol is gait. Gait requires coordination of multiple sensory and motor systems. Both postural stability and gait are sensitive to blood alcohol concentration (BAC) levels. [2]

Shunpei Ando and colleagues have proposed acute alcohol ingestion is suggested to result in a large sway of low frequency in the medio-lateral direction. Not only neuromotor function but also attention and cognitive function are adversely affected by acute alcohol ingestion, both of which have implications for the ingestion of alcohol before driving a car. [3]

B. Detecting blood alcohol levels from gait

Andrew McAfee and colleagues have proposed the anticipated level of alcohol in the blood from walking (gait analysis), in which, the data is stored through accelerometer sensor and Gyroscope sensor on the smartphone of the alcohol drinker. The data is processed by using the method of Machine Learning, which resulted in an accuracy of 89.45%. [4]

Zachary Arnold and colleagues have proposed smartphones could infer the alcohol intoxication levels (how many drinks) of their users based on anomalies in their gait. Time and frequency domain features were extracted from accelerometer data of drinkers and used for classification in a machine learning framework. For a task of classifying the number of drinks consumed by a user into ranges of 0-2 drinks (sober), 3-6 drinks (tipsy) or >6 drinks (drunk), Random Forest yielded 56% accuracy on the training set, and 70% accuracy on the validation set. [5]

The previous research was conducted simply through alcohol detection while walking only. In reality, those alcohol drinkers might not be able to find an open space without any obstructions. Therefore, this research proposes an alcohol detection while the drinker is casually sitting and drinking alcohol instead. So, the magnitude will be measured while the drinkers swing their bodies.

III. METHOD

The proposed model is based on a sensor exist in smartphone, the overview of the system is shown in Fig.1

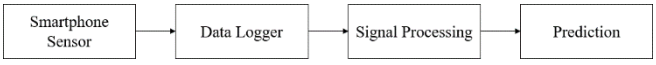

Fig. 1. System Overview

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A. Smartphone Sensor

The accelerometer sensor is used in this method, this sensor is used to sense the G-force. The smartphone used this sensor to determine the screen orientation. The shaking of the device also can be measure using this sensor.

The user must keep the smartphone in the pants pocket while the sensor is pulled. The sensor data is pulled collected 20 samples in 1 second (sampling-rate of 20 Hz).

B. Data Logger

The data logger is a process running on a smartphone to collected the data pulled from the accelerometer sensor. The data is stored locally with a timestamp. Since the smartphone only return the sensor data only when the sensor value is changing, then the timestamp data is used to reconstruct the data to the time-series signal. The example of raw sensor data collected in this process is shown in Table I.

TABLE I. SAMPLE SENSOR DATA OF ALCOHOL DRINKERS

Timestamp	X-Axis	Y-Axis	Z-Axis
1532442954	-11.381436	8.072051	0.45130703
1532442954	-11.106103	3.8750155	-7.28376
1532442955	-9.452309	3.803788	-1.4634558
1532442955	-8.194754	2.5833437	-1.3700819
1532442955	-7.425018	1.6059108	-1.9189527
1532442955	-8.280347	3.3333273	-2.9652188
1532442955	-7.367557	1.8112136	-5.768829

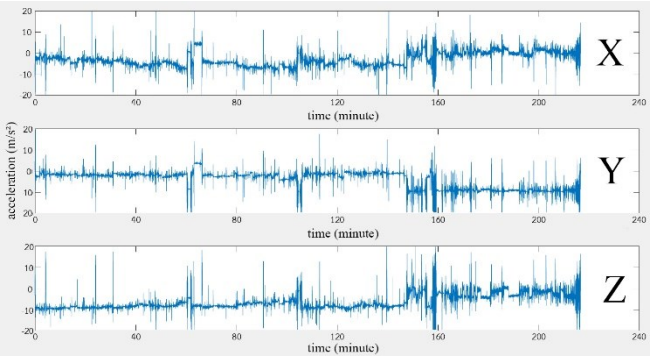

Fig. 2. Sample data sampling from accelerometer sensor.

C. Signal Processing

The signal processing module is used to analyze the raw sensor data collected from the smartphone to determine that the user is in a state of alcohol consuming or not.

The raw sensor data contains 3 axis of x, y, z. This data is varies deepened on the smartphone position, to standardize this signal the normalization process is used. This process combined all 3 axis into one signal that doesn't varies on the position of smartphone. The normalization signal is calculated based on (1), and the sample normalized signal is shown in the Fig. 3.

$$b_t = \sqrt{x_t^2 + y_t^2 + z_t^2} \tag{1}$$

- b is the normalized data.
- t is the time position.
- x is X-axis raw data from the accelerometer.
- y is Y-axis raw data from the accelerometer.
- z is Z-axis raw data from the accelerometer.

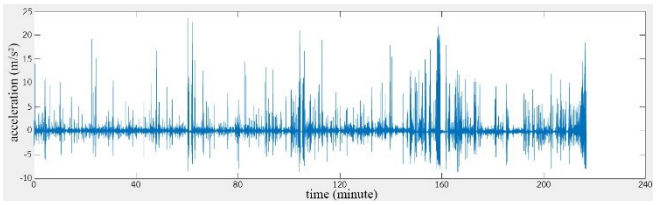

Fig. 3. The example of normalized data.

Then the Rate of Change is computed using (2), the example signal is shown in the Fig. 4.

$$r = |\Delta b| \tag{2}$$

- Δb is the rate of change of b.
- r is the result from computing the rate of change and convert into the absolute value.

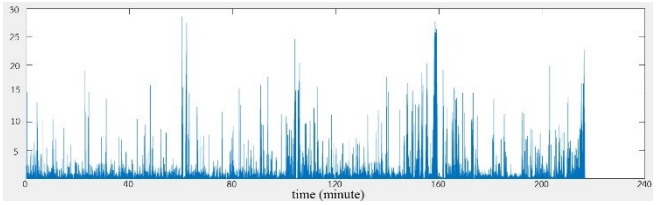

Fig. 4. Data from computing the rate of change and convert into the absolute value.

The rate of change signal is contained many small spike data. This spike is causing by the high sensitive of the sensor, this result in the sensor capturing the unwanted signal. For example, the small vibration causing by the breathing, some disturbance sound (noise) such as natural movement of the body are all result in a small spike in the signal. Thus, the Moving Average was calculated in order to reduce this noise by using (3) as shown in the Fig. 5.

$$m_t = \frac{\sum_{i=t}^{t+w} r_i}{w} \tag{3}$$

- m is the result of removing the noise.
- w is the window size of the Moving Average algorithm.

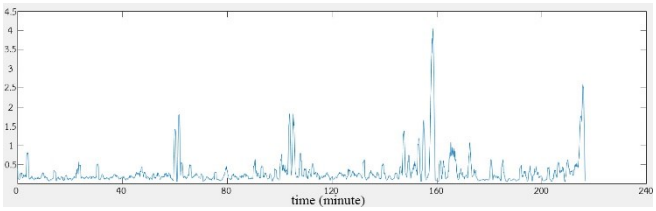

Fig. 5. The example of noise removed data.

According to the result in the Fig. 5, we had investigated the data gathering from the alcohol drinker sample. It was found that through the later of the signal, the over alcohol drinkers show higher value when they consumed more alcohol. In contrast, data from the under alcohol drinkers seemed to be less and stable. This was due to the over alcohol consuming caused the higher value in the graph. Therefore, the threshold l is used which represent the over alcohol consuming. It was the reference line in the graph (red line). In order to identify the alcohol consuming type, the Fig. 6 presented the graph of the over alcohol consuming samples and the Fig. 7 presented the under alcohol consuming samples.

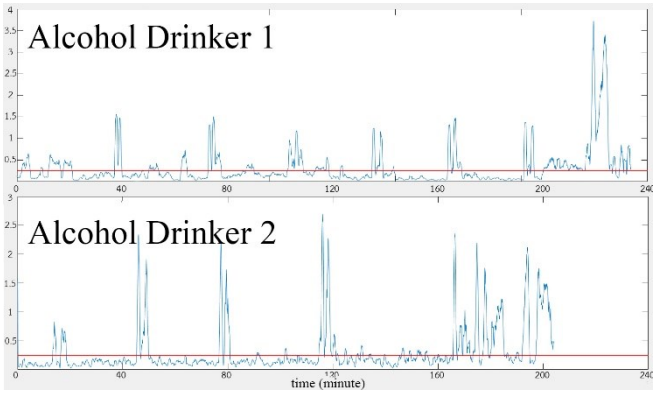

Fig. 6. Data of the over alcohol consuming drinkers.

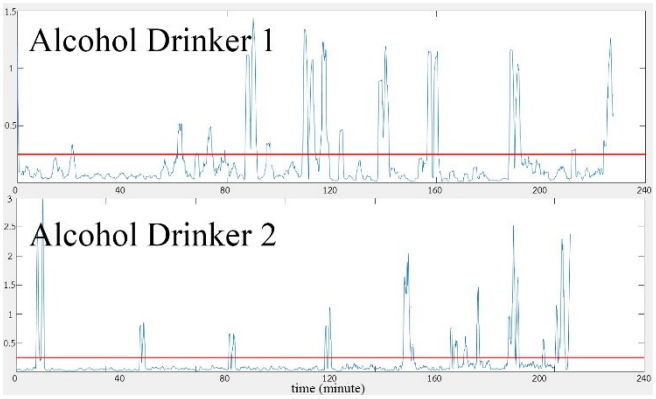

Fig. 7. Data of the under alcohol consuming drinkers.

Finally, the number of sample that exceed threshold l is used to identify the over alcohol consuming. It started from searching from the beginning to the end of the graph by moving 1 minute at a time on the horizontal. this range of this search is defined as m. The exceed values were in the green areas as shown in the Fig. 8, where range of m is shown in vertical green line.

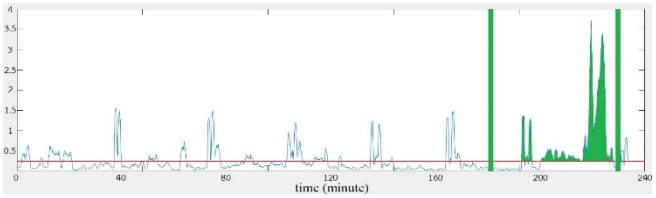

Fig. 8. The example of a search window.

The percentage of sample the exceed l is then calculated, as in (4).

$$p_t = \frac{f}{m} \times 100 \tag{4}$$

- p is the percentage of the value that exceed the l value.
- f is number of samples that exceed l.
- m are the size of search windows.

The p is then classified as over consuming or not base by comparing with the predefined threshold, as in (5).

$$s_t = \begin{cases} 1 & where\ p_t \geq \theta \\ 0 & where\ p_t < \theta \end{cases} \tag{5}$$

Where θ is the threshold to defined the over consuming value.

IV. Experiment and Results

The proposed model is evaluate by varies the θ from 40 to 50, the m is ranging from 12,000 to 36,000 , and l from 0.125 to 0.4. The dataset was acquired from 6 volunteers; the sensor data was recorded from start drinking until overconsuming. The Samsung Galaxy Note 8 used in this experiment. The blood alcohol concentration (BAC) of each volunteer was tested every 30 minute using a breathalyzer. The volunteer that has BAC value greater then 0.15 mg/l is considered as the overconsuming, this data is then used as a ground truth to evaluated the proposed model.

The results is shown in Fig. 9, Fig. 10 and Fig. 11, it is demonstrated that every m value can generated 100% accuracy if using the correct parameters. However, the parameter m is directly effecting the response time of the system, because it is determined the number of sample that required by this prediction model.

In this experiment, the recommend m value is 18,000 because it is using lowest number of samples while can still producing the result with 100% accuracy.

TABLE II. THE ACCURACY OF PROPOSED PREDICTION MODEL ($\theta = 40$)

m \ l	**0.125**	**0.15**	**0.175**	**0.2**	**0.225**	**0.25**	**0.275**	**0.3**	**0.325**	**0.35**	**0.375**	**0.4**
12,000	0.68	0.73	0.77	0.82	0.82	0.82	0.87	0.87	0.87	0.82	0.87	0.91
18,000	0.77	0.77	0.77	0.82	0.91	0.91	0.91	0.91	0.91	0.96	0.91	0.91
24,000	0.77	0.77	0.82	0.87	0.91	0.91	1	0.96	0.91	0.91	0.91	0.91
36,000	0.77	0.77	0.82	0.87	1	1	0.91	0.91	0.91	0.87	0.87	0.87

Fig. 9. The accuracy of proposed prediction model ($\theta = 40$).

TABLE III. THE ACCURACY OF PROPOSED PREDICTION MODEL ($\theta = 45$)

m \ l	**0.125**	**0.15**	**0.175**	**0.2**	**0.225**	**0.25**	**0.275**	**0.3**	**0.325**	**0.35**	**0.375**	**0.4**
12,000	0.68	0.73	0.77	0.82	0.82	0.87	0.87	0.91	0.87	0.91	0.91	0.87
18,000	0.77	0.77	0.87	0.87	0.96	1	0.96	0.96	0.91	0.91	0.91	0.91
24,000	0.77	0.77	0.87	0.91	0.96	1	0.91	0.91	0.91	0.87	0.87	0.87
36,000	0.77	0.77	0.91	0.96	0.96	0.96	0.91	0.87	0.87	0.87	0.87	0.87

Fig. 10. The accuracy of proposed prediction model ($\theta = 45$).

TABLE IV. THE ACCURACY OF PROPOSED PREDICTION MODEL ($\theta = 50$)

m \ l	**0.125**	**0.15**	**0.175**	**0.2**	**0.225**	**0.25**	**0.275**	**0.3**	**0.325**	**0.35**	**0.375**	**0.4**
12,000	0.73	0.73	0.82	0.82	0.87	0.91	0.96	0.96	0.91	0.91	0.91	0.91
18,000	0.77	0.77	0.91	0.96	0.96	**1**	0.91	0.91	0.91	0.91	0.91	0.91
24,000	0.77	0.82	0.91	0.96	**1**	0.91	0.91	0.91	0.87	0.87	0.87	0.87
36,000	0.77	0.82	0.96	0.96	0.96	0.91	0.91	0.91	0.87	0.87	0.82	0.77

Fig. 11. The accuracy of proposed prediction model ($\theta = 50$).

V. CONCLUSION

This research presents an algorithm for predicting excessive alcohol consumption from the accelerometer sensor data that is obtained while the user drinks alcohol. The sensor data is recorded using the smartphone and send to the signal processing unit to analyzed the predicted the over consuming. The recommend parameters are proposed and evaluated and compared the results with the ground-truth obtained using a breathalyzer. The results shown that this algorithm is produced 100% accuracy. However, this method is not able to produce the accuracy results in real-time, the 15 minutes lags are required in order to produce the high accuracy prediction.

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REFERENCES

[1] M. Nieschalk, C. Ortmann, A. West, F. Schmäl, W. Stoll, and G. Fechner, "Effects of alcohol on body-sway patterns in human subjects," 1999 International Journal of Legal Medicine

[2] B. Suffoletto, P. Gharani, T. Chung, H. Karimi, "Using phone sensors and an artificial neural network to detect gait changes during drinking episodes in the natural environment," 2018 Gait & Posture 60, 116-121.

[3] S. Ando, T. Iwata, H. Ishikawa, M. Dakeishi, K. Murata, "Effects of acute alcohol ingestion on neuromotor functions," 2008 NeuroToxicology 29, 735–739

[4] A. McAfee, J. Watson, B. Bianchi, C. Aiello, E. Agu, "AlcoWear: Detecting Blood Alcohol Levels from Wearables," 2017 IEEE SmartWorld, Ubiquitous Intelligence & Computing, Advanced & Trusted Computed, Scalable Computing & Communications,Cloud & Big Data Computing, Internet of People and Smart City Innovation.

[5] Z. Arnold, D. LaRose, E. Agu, "Smartphone Inference of Alcohol Consumption Levels from Gait," 2015 International Conference on Healthcare Informatics.

Pull-Based Algorithm for Parking Space Sensor Data Reading

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***Abstract*—This paper presents an algorithm for a sensor reading using in the parking status. The purpose of this algorithm is to reduce the number of parking space sensor ping. This research developed on the concept of using the previous raw sensor data as the model to predict the optimal sensor sleep time. The experiments and results are shown that the accuracy of this proposed algorithm is can reduce errors by maintaining the total sleep time.**

Keywords—Parking Space Sensor, Ultrasonic, Signal Processing, Data Pulling

I. INTRODUCTION

Today, the parking space is more sophisticated and the management requires a complex task. However, there is a system that can manage the car and the parking lot effectively called car park system or parking management system. This system is very commonly found in shopping malls. Not just shopping malls, as well as other areas, the car park system will have the equipment and programs that can work together mark parking is more convenient. Fig. 1 is Parking System. The sensor used in the parking lot detection system is the ultrasonic sensor because it consumes the low power and can run all any time in a day. Especially, it is inexpensive[1]. The device is shown in Fig. 2. The ultrasonic sensor must work 24 hours continuously, resulting in continuous power consumption and the high cost of electricity.

Fig. 1: The parking space sensor.

The ultrasonic sensor is a device for measuring distances without touching the object to be measured. It can measure the distance from 2 cm to 400 cm by sending the ultrasonic frequency signal 40 kHz to the object and receive the reflected signal and calculate the distance[2]. There are two main parts, the transmitter acts to generate sound waves to measure each phase. When to hit the object the sound waves are reflected back to the receiver and then processed in an electronic circuit within the module. They are two types of the ultrasonic ping signal. Continuous and Pulse, commonly used as a pulse because it can reduce the measurement error because there is a fixed number of pulse in each transmission. However, it may slow down the measurement sensitivity. Because it takes time to send the sound waves pulse periodically.

Fig. 2: The ultrasonic sensor installed inside the parking area.

A. Parking Space Sensor

A parking space sensor is proximity sensors for road vehicles designed to alert the driver of obstacles while parking. These systems use either electromagnetic or ultrasonic sensor. Parking space sensor consists of 4 major sections; the sensor unit, the signal unit, the controller unit, and the server unit. The sensor unit is installed on the ceiling of a parking slot. For detects the movement of the car in each parking lot. The signal light show status of parking the car. The controller unit to collect data from the sensor unit and send data to the server. The server unit is module analyzes and processes the information sent from the sensor to try and predict the time trial and the right to control for efficiently and reduce energy consumption.

B. Sensor Data Pulling

Sensor data pulling is an important operation step, where the sensor is sensing the environment. The ultrasonic sensor is performing a Ping to sense the distance and use this information to determine the status of the parking lot. This operation is done in a fixed interval. The short interval is generated most accurate, but require more energy and also limited the number of the sensor because short interval ping can create a cross-talk effect[3]. The long interval is great for eliminate sensor cross-talk and gain more energy saving, but it is losing the accuracy and adding a latency.

The 2 seconds pulling time is used in the previous research[3, 4], it is the shortest interval that does not produce sensor cross-talk. In this research, the sensor pulling algorithm is proposed. The algorithm is focused on maximizing the ping interval while maintaining the minimal data error.

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II. The Proposed Method

The proposed algorithm is based on a sensor sleep pattern shown in Fig. 3. This pattern is a sequence of short sleep (t_1) and long deep sleep (t_2). The t_1 and t_2 of each sensor is automatically adjusted to minimize the number of sensor read times while still maintaining the accuracy and latency.

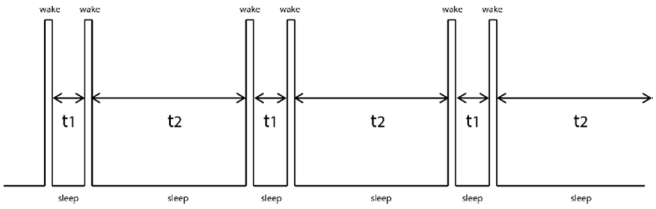

Fig. 3: The proposed sleep and wake up pattern.

The method for determining t_1 and t_2 is based on a statistical analysis for the previous sensor data. This method is divided into 2 parts, Model generation process and parameter prediction process as shown in Fig. 4.

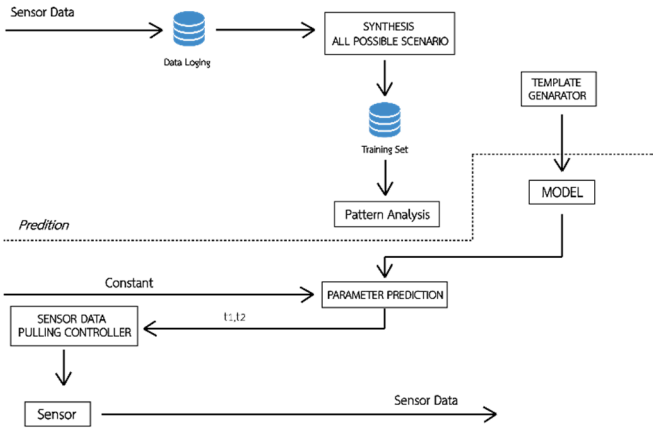

Fig. 4: The overview of the algorithm.

A. Model Generation Process

The learning process is the process of generating a prediction model based on static and used to predict the sleep parameter.

First, the previous sensor data received from the data recorder and sent into the data logging server. This data contained the raw data of each sensor while the sensor is operating fixed interval pulling mode. The example of raw sensor data is shown in Fig. 5.

Day	Slot	Unixtime	Status
1	1	1505733595	0
1	1	1505733597	0
1	1	1505733599	0
1	1	1505733601	1
1	1	1505733603	1
1	1	1505733605	1
1	1	1505733607	1

Fig. 5: The raw data example.

Then, the training set is created by synthesizing the result of sensor sleep with all possible scenario of t_1 and t_2 and store in the database. This new synthesis signal is the down-sampling version of original sensor data based on the parameter of t_1 and t_2. The performance is calculated in this process in the term of parking space status sensing error, parking status change latency and daily vehicle counting error. The sample of the training set is shown in Fig. 6.

Slot	t1	t1	Accuracy	Latency	Count Error
1	2	100	0.007392	103313	1
1	2	150	0.0141	70197	1
1	2	200	0.01894	98306	2
1	2	250	0.020267	131229	5
1	2	300	0.030495	96009	2
1	2	350	0.029082	156745	5
1	2	400	0.035613	130319	3
1	2	450	0.04103	138765	6
1	2	500	0.046419	134735	5
1	2	550	0.042141	138969	6
1	2	600	0.0548	144285	6

Fig. 6: The training set example.

Next, the training set is query based on the total sleep time constraint (T). This constraint defines how energy saving aggressively of each installation. All possible case group by constraining are queried and ranked based on the objective, such as minimal parking space status sensing error, minimal parking status change latency or minimal daily vehicle counting error.

The top-ranked of every possible constraint is used as a feature. The signal smoothing process is then applied to the feature vector; this process is based on the low-pass filter using Discrete Cosine Transform (DCT) described in Fig. 7.

Fig. 7: The signal smoothing process

Finally, the smoothed feature vector is used as a model to predict the optimal sleeping parameters.

B. Parameter Prediction Process

This process using a model as a lookup table to get the optimal t_1 and t_2. The constraint (T) is used as a key to search for t_1 and t_2 from a previously generated model.

III. Experiments and Results

In this research, the dataset was collected at the parking lot of a shopping mall in Chiang Mai. The car park building, 1st Floor, 9 parking spaces in the entire period of 10 days was selected. The data was divided into 2 parts to the slot **5** was used as a template for model generation. The slot 1 was used to evaluate the prediction performance of the model.

The model generation was created using an original ultrasonic sensor to detect parking status every 2 seconds. This data then used to synthesis the possible scenario with t_1 and t_2 ranging from 2 to 600 second. The synthesize data is then evaluating by compared with the original sensor data in the in terms of parking status sensing error, as in:

$$e = \frac{1}{n}\sum|f - f_s| \quad (1)$$

Where f is the raw sensor data, f_p is the synthesis sensor data, n is the number of sample data, and e is the error rate of synthesis data.

The next parameter is the sensor latency, this value is used to measure how long that sensor take until it notifies that the parking status is changed, this value is calculated as in:

$$l = \frac{\sum_{i=1}^{n} S(i) - T(i)}{n} \quad (2)$$

Where $T(i)$ is the timestamp on the original sensor data where changing event has occurred, $S(i)$ is the timestamp on the synthesis data where the changing is detected, n is the number of changing event, and l is the latency value.

The vehicle counting error is calculated by counting the number of sensor changing from 0 to 1 and changing back from 1 to 0. The total vehicle counting error is calculated as in:

$$k = \left|\frac{1}{2}\sum|\Delta f|\right| - \left|\frac{1}{2}\sum|\Delta f_s|\right| \quad (3)$$

Where k is the vehicle counting error.

These parameters of all possible case of slot 1 are calculated and stored in the database. Then the training set is query order by on the total sleep time constraint (T) sort by the minimum value of e, since the objective of this experiment is to minimize the sensor error.

Then, the lowest e of every T is used as the feature vector, the parameter t2 is used as the feature vector, this data is shown in Fig. 8. This vector is then smoothing with the low-pass filter. In this experiment, the Discrete Cosine Transform (DCT) is used. The DCT coefficients are 600 elements long, the 200 last elements are removed and then perform IDCT then used this data as a prediction model.

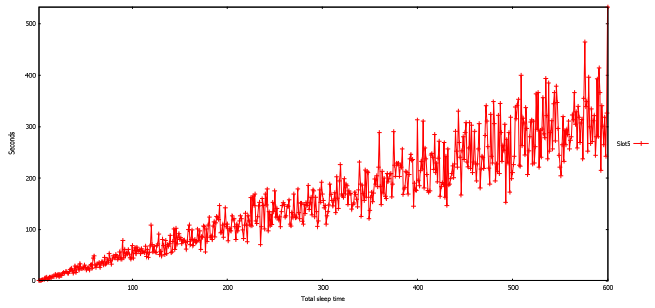

Fig. 8: The feature vector before DCT smoothing.

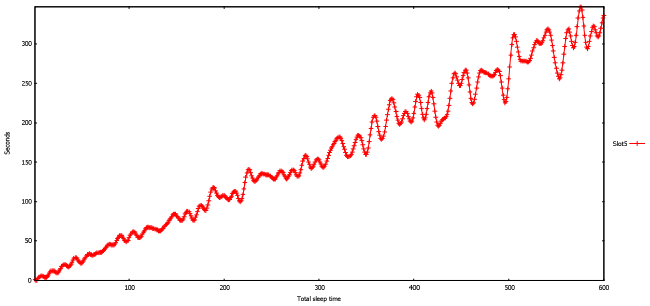

Fig. 9: The feature vector after DCT smoothing.

The performance of the prediction model is shown the performance of the fixed-interval ranging from 0 – 599 seconds. Fig. 9 is shown the performance of our proposed method. The result is shown that our proposed method is producing a better result than the fixed-interval.

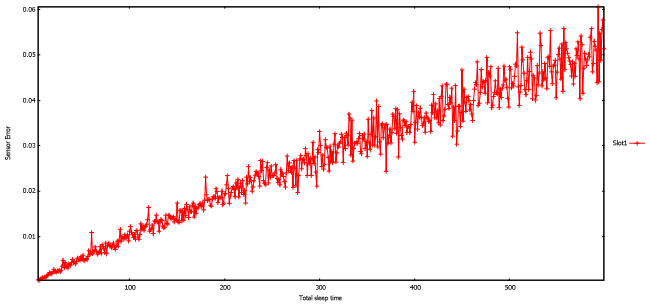

Fig. 10: The error of fixed interval.

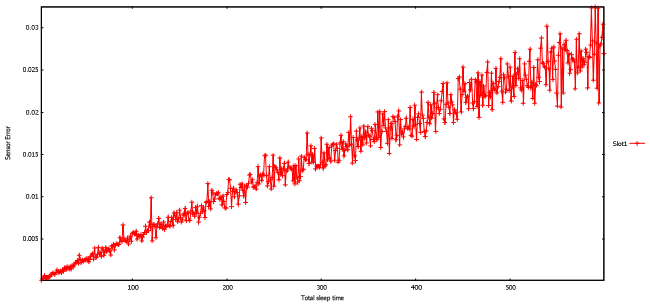

Fig. 11: The error of proposed method.

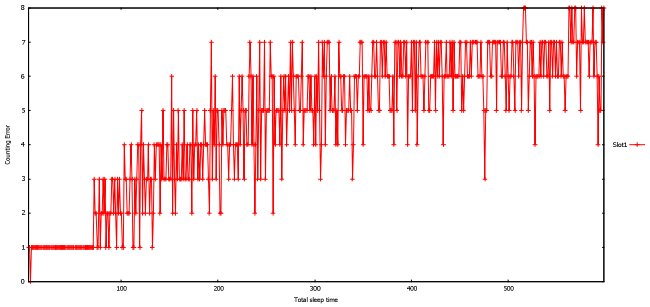

Fig. 12: The vehicle counting error of fixed interval.

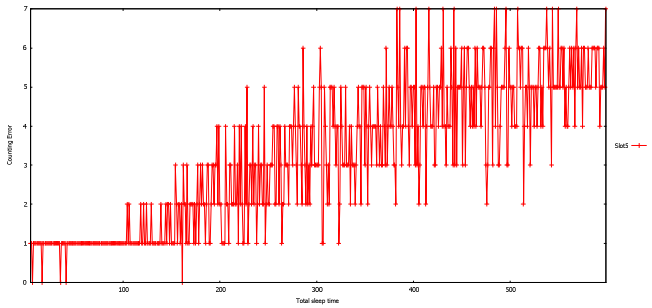

Fig. 13: The vehicle counting error of proposed method.

The averaged error of every t of the fixed-interval algorithm is 0.028, and the average error of the proposed method is 0.015. The result shown that our method is 187% better than fixed-interval. It is shown that our method can reduce errors by maintaining the total sleep time.

IV. Conclusion

In this research, the parking space sensor data pulling algorithm is proposed. The algorithm is using the previous sensor data as a model to predict the optimal sleeping sensor time. The raw sensor data is used to synthesize the all possible sleeping case and then select the best case as the prediction model. The DCT is used as a low-pass filter to clean the signal spike. The evaluation result shown that the proposed method is 187% better than the fixed-interval method.

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References

[1] P. Khoenkaw and P. Pramokchon, "A software based method for improving accuracy of ultrasonic range finder module," in *2017 International Conference on Digital Arts, Media and Technology (ICDAMT)*, 2017, pp. 10-13.

[2] *Ultrasonic Ranging Module HC - SR04*. Available: https://www.mouser.com/ds/2/813/HCSR04-1022824.pdf

[3] P. Khoenkaw, P. Pramokchon, and K. Osathanunkul, "Design and implement of a parking space sensor," in *2017 International Conference on Digital Arts, Media and Technology (ICDAMT)*, 2017, pp. 71-74.

[4] K. Hantrakul, S. Sitti, and N. Tantitharanukul, "Parking lot guidance software based on MQTT Protocol," in *2017 International Conference on Digital Arts, Media and Technology (ICDAMT)*, 2017, pp. 75-78.

Deep Learning Algorithms for Predicting Breast Cancer Based on Tumor Cells

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Abstract

This paper is the comparison of classification algorithms for breast cancer based on tumor cell. We focus on using deep learning algorithms to classify types of breast cancer with several of activation function: Tanh, Rectifier, Maxout and Exprectifier. And comparison with different machine learning methonds such as Decision tree, Naïve Bayes, Support Vector Machine, Vote, Random Forest and AdaBoost. Experimental data were downloaded from breast cancer Wisconsin dataset and using machine learning tool rapidminer. Using ten-fold cross-validation. We achieve that the best result of 96.99% accuracy with deep learning by Maxout and Exprectifier activation function.

Keywords: *Breast Cancer, Deep Learning Algorithms, Classification Methods*

I. INTRODUCTION

Breast cancer is one of the most common cancer in women around the world, which is about 16% in adult women that more than 50 year old (about 5% in less than 40 year old). Breast cancer develops from the breast tissue. They have different types of breast cancer classified my characteristic of tumor cells that are benign and malignant tumor [12].

- Benign tumors

Benign tumors are not cancer. They can grow anywhere in the body but cannot invade to other areas of body. They often respond to the treatment and can be easily removed.

- Malignant tumors

Malignant tumors are cancerous, which start from abnormal cells that highly grow in out of control and have ability to spread to other organs by circulating system or lymphatic system. We call that spread Metastasis.

The common symptoms of breast cancer include a lump in the breast has changed the shape of the breast skin with fluid flow from the dimpled nipples or skin has red flakes [13]. Moreover, cancer can invade to nearby lymph nodes and cause swelling.

There are different machine learning methods for data classification such as decision tree, naïve bayes, support vector machine, vote, random forest, adaBoost and Deep learning [7]. Each of the classification methods shows performance differentiation of accuracy based on characteristic of datasets.

In our research, we compared the performance result of various classification methods using deep learning method with activation function: Tanh, Rectifier, Maxout and Exprectifier [15]. Breast cancer dataset features consisting of 10 features in range (1-10) with clump thickness, uniformity of cell size, uniformity of cell shape, marginal adhesion, marginal adhesion, single epithelial cell size, bare nuclei, bland chromatin, normal nucleoli and mitoses. And one target class of benign tumor or malignant tumor with 698 number of dataset.

II. RELATED WORK

In our research, we focus on the problem of classification in major classes. Breast cancer is classified into two classes, (benign tumor and malignant tumor cells) [11]. And we developed a technique for breast cancer classification using deep learning with several of activation functions. Our technique was compared with other classification methods. Moreover, our technique effect to high accuracy and performance for breast cancer classification method, which easier than other methods [8].

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Deep learning

Deep learning is a branch of machine learning. The basis of the in-depth learning algorithm that is trying to create a model to represent the meaning of high level information by creating a data architecture that consists of several smaller structures and each of them has to come from the non-linear transformation. This method considered the high potential in dealing with feature for unsupervised learning or supervised learning [6]. It is based on a multi-layer feed-forward artificial neural network which is trained with stochastic gradient descent using back-propagation. The pre-activation neuron which is the form of a nonlinear combination of inputs with weights and bias were used by neurons in hidden layers [5]. And then it will pass into activation functions. That network contain a large number of hidden layers consisting of neurons with tanh, rectifier and maxout activation functions.

III. MATERIALS AND METHODS

1) Dataset

In the prepare dataset section of the research, we were extracted from breast cancer Wisconsin dataset (Available at https://archive.ics.uci.edu/ml/datasets/breast+cancer+wisconsin+(original)) to impute with the missing data values by average value before using the classification algorithm shown in table1.

Table1 Numbers and percentages of breast cancer based on tumor cells.

Class	Number of data set	Percentage (%)
Benign tumor	457	65.47
Malignant tumor	241	34.53
Total	698	100.00

2) Activation function of deep learning

a. Tanh

Tanh or Hyperbolic tangent function (like a scaled and shifted sigmoid) is a mathematical function. . L'Abbe Sauri first used in his work (1774). The tanh is simple function and better than the sigmoid that the output is between -1 and 1, which is to be centered on the center. The problem is not causing the zigzag of gradients. It defined as the relative with hyperbolic sine and cosine functions. This function is defined by

$$\tanh(z) == \frac{\sinh(z)}{\cosh(z)} == \frac{e^{z} - e^{-z}}{e^{z} + e^{-z}} \qquad (1)$$

where z is the point of half-deference and half-sum of two exponential functions

b. Rectifier

Rectified linear unit is popular function. This activation function has bounded from zero, but the above solution is not bounded vanishing gradient that it is bounded from zero. It will make a neuron with the center comes out so much that you are inactive neurons [10]. It chooses the maximum of (0, x) define as:

$$f(x) = \max(0, x) \qquad (2)$$

where x is the input to neuron

c. Maxout

The maxout model is type of activation function and a multilayer which applying the hidden activations [1]. Given an input vector $x \in \Re^{d}$ and the output of $h(x)$ will divide z into groups of k values [2].

$$h_{i}(x) = \max_{j \in [1,k]} z_{ij} \qquad (3)$$

where $z_{ij} = x^{T} W \ldots ij + b_{ij}$, and $W \in \Re^{dxmxk}$ and $b \in \Re^{mxk}$ are all learned parameters.

d. Exprectifier.

ExpRectifier or Exponential Rectifier Linear Unit function is a considered generalization of the mean activation to zero which learn in conditions. It is better than rectified linear unit for accuracy of classification [14].

$$f(x) = \begin{cases} x & \text{if } x >= 0 \text{ otherwise} \\ a(e^{x} - 1) & \end{cases} \qquad (4)$$

where a is a hyper-parameter to be tuned and $a >= 0$ is a constraint.

IV. RESULTS AND DISCUSSION

The evaluated performance of the different methods for classifying breast cancer into benign tumor and malignant tumor classes was performed on 698 number of dataset.

In Table 2 shows the comparison of several classification methods performance for breast cancer.

We used deep learning with activation function to classify and make ten-fold cross validation. Moreover, we compared methods with decision tree, naïve bayes, support vector machine, vote, random forest and adaBoost [9].

Table 2 Performance of breast cancer classification methods

Methods	Precision		Recall		F-measure		ACC
	Malignant	Benign	Malignant	Benign	Malignant	Benign	
Deep Learning (Tanh)	93.60	98.44	97.10	96.50	95.32	97.46	96.70
Deep Learning (Rectifier)	94.33	98.23	96.68	96.94	95.49	97.58	96.85
Deep Learning (Maxout)	94.35	98.44	97.10	96.94	**95.71**	**97.68**	**96.99**
Deep Learning (Exprectifier)	94.35	98.44	97.10	96.94	**95.71**	**97.68**	**96.99**
Decision Tree	91.27	97.53	95.44	95.19	93.31	96.35	95.27
Naive Bayes	91.09	**98.64**	**97.51**	94.97	94.19	96.77	95.85
SVM	**95.00**	97.16	94.61	**97.37**	94.80	97.27	96.42
Vote (DT+NB+SVM)	92.80	97.99	96.27	96.06	94.50	97.02	96.13
Random Forest	93.90	97.79	95.85	96.72	94.87	97.25	96.42
AdaBoost (DT)	93.06	97.13	94.61	96.28	93.83	96.70	95.70

The comparison performances with different classification methods are shown in Table 2, that use the deep learning with maxout and exprectifier activation function [4]. We achieved the best result of 96.99% accuracy which was better than other computational methods. The best precision performances of malignant were 95.00% for SVM [3] and benign were 98.64% for Naïve Bayes.

V. CONCLUSION

In our research, we show the classification methods can be applied to the breast cancer classification problem based on tumor cells. And table2 is summarizes of performance comparison methods to classified the breast cancer into malignant and benign tumor cell classes. We use the deep learning with activation functions to compare with other classifications methods such as, decision tree, naïve Bayes, support Vector machine, vote, random forest and adaBoost to classify breast cancer. The deep learning can proved to be successful and make high performance. Because this method will automatically select the features which are important for classification directly from data and then decide which of the features are responsible for achieving great results.

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REFERENCES

[1] Cai, M., Shi, Y., & Liu, J. (2013, December). Deep maxout neural networks for speech recognition. In Automatic Speech Recognition and Understanding (ASRU), 2013 IEEE Workshop on (pp. 291-296). IEEE.

[2] Goodfellow, I. J., Warde-Farley, D., Mirza, M., Courville, A., & Bengio, Y. (2013). Maxout networks. arXiv preprint arXiv:1302.4389.

[3] Guyon, I., Weston, J., Barnhill, S., & Vapnik, V. (2002). Gene selection for cancer classification using support vector machines. Machine learning, 46(1), 389-422.

[4] Ishii, Y., Hagawa, R., & Tsukizawa, S. (2015, November). Deep learning using heterogeneous feature maps for maxout networks. In Pattern Recognition (ACPR), 2015 3rd IAPR Asian Conference on (pp. 459-463). IEEE.

[5] Kiyan, T., & Yildirim, T. (2004). Breast cancer diagnosis using statistical neural networks. IU-Journal of Electrical & Electronics Engineering, 4(2), 1149-1153.

[6] Li, Y., Fan, C., Li, Y., & Wu, Q. (2016). Improving Deep Neural Network with Multiple Parametric Exponential Linear Units. arXiv preprint arXiv:1606.00305.

[7] Mekha, P., Osathanunkul, K., & Teeyasuksaet, N. (2017). Comparison of Gene Classification Methods for Dengue Virus Type Based on Codon Usage. วารสาร วิชาการ มหาวิทยาลัย ฟา ร์ อีส เท อ ร์ น (FEU Academic Review), 11, 7.

[8] Mekha, P., Osathanunkul, K., & Teeyasuksaet, N. (2016, December). Gene classification of dengue virus type based on codon usage. In Computer Science and Engineering Conference (ICSEC), 2016 International (pp. 1-6). IEEE.

[9] Mekha, P., & Teeyasuksaet, N. (2015, November). Using random forest based on codon usage for predicting Human Leukocyte Antigen gene. In Computer Science and Engineering Conference (ICSEC), 2015 International (pp. 1-6). IEEE.

[10] Nair, V., & Hinton, G. E. (2010). Rectified linear units improve restricted boltzmann machines. In Proceedings of the 27th international conference on machine learning (ICML-10) (pp. 807-814).

[11] Othman, M. F., & Yau, T. M. S. (2007). Comparison of different classification techniques using WEKA for breast cancer. In 3rd Kuala Lumpur International Conference on Biomedical Engineering 2006 (pp. 520-523). Springer Berlin Heidelberg.

[12] Shah, C., & Jivani, A. G. (2013, July). Comparison of data mining classification algorithms for breast cancer prediction. In Computing, Communications and Networking Technologies (ICCCNT), 2013 Fourth International Conference on (pp. 1-4). IEEE.

[13] Wahdan, P., Saad, A., & Shoukry, A. (2014). Comparing classification techniques to detect breast tumor. In Proceedings of the international conference on biomedical engineering and systems (pp. 1-6).

[14] Wang, P., Ge, R., Xiao, X., Cai, Y., Wang, G., & Zhou, F. (2016). Rectified-Linear-Unit-Based Deep Learning for Biomedical Multi-label Data. Interdisciplinary Sciences: Computational Life Sciences, 1-4.

[15] Zhao, H. Z., Liu, F. X., & Li, L. Y. (2017). Improving deep convolutional neural networks with mixed maxout units. PloS one, 12(7), e0180049.

A Study of Replicatd Thai Benchmark Dataset

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***Abstract*— Nowadays, Semantic similarity has a huge impact in several applications including ontology learning, information extraction, document clustering, information retrieval, the business sector and so on. Most work in word sematic similarity has concentrated on English and other European languages. However, for the Thai language, there has been little research about word semantic similarity. As the language evolves over a period of time. This study focuses on finding out how language development will effect the Thai benchmark dataset over past sever or not by presenting a replicate version of Thai benchmark data set as well as investigating the statistical difference between Replicate and Original Thai benchmark data set.**

Keywords— word-to-word similarity, word-to-word comparison, semantic similarity measures, Benchmark, Thai Dialog System.

I. INTRODUTION

Conversational Agents integrate computational linguistics techniques and natural language to support human-like communication with complex computer systems. There are a number of applications in business [1], education [2] and entertainment [3], including unmanned call centres, or personal shopping or navigation assistants. Initial research has been performed on Conversational Agents in languages other than English. Most CAs use English, however some work has been in done Arabic [4], Chinese [5] and Japanese [6]. Little works has been done in Thai.

Recently, a new generation of CAs has begun to emerge using Short Text Semantic Similarity measures to analyse user utterances [7,8]. The majority of these make use of word-to-word similarity measures based on WordNet [9]. As time goes by, languages are developed and change. It is necessary to see if its language has developed too quickly and impacted the performance of the CAs or not.

The most influential similarity dataset for English was produced in the 1960s [10] This Rubenstein and Goodenough's English Benchmark word similarity dataset has been replicated on several occasions [11], [12], [13]. These studies, coupled with that by [8] provide evidence to support the view that human similarity measures are at least ordinal, showing reasonably consistent ranking between individuals, groups and over time [14].

An Original Benchmark dataset of English 65 word pair collected by Rubenstein and Goodenough [10] using questionnaire-based has produced repeatable results [11]. This study is follows Miller, G.A. and Charles, W.G [11] to replicate Thai Benchmark Dataset [15].

This paper focus on the research question: Is a replicated Thai Benchmark dataset significantly different to the original benchmark dataset that was created 7 years ago since the language adapts day by day?

The rest of this paper is organized as follows: Section 2 describes the collection of a Thai word similarity benchmark data set from participants using a method based on [10]; Section 3 discusses original dataset and replicated dataset, human and machine similarity ratings and section 4 outlines directions for future work.

II. EXPERIMENT PROCEDURES

A. Participants

We received Replicated Dataset Similarity ratings from 40 Thai native speakers. Both Arts/Humanities and Science/Engineering students participated in equal numbers. From 4 different Thai universities, we surveyed 30 undergraduate students and 10 postgraduate students. With an average age of 22 years old, each participant showed a standard deviation of 2.8, with 21 for males and 19 for females. This can be compared to the English word similarity participant groups [10,11]. The report from the Original Dataset is noted on [15].

B. Materials

According to our previous research [15], 30 word pairs were chosen as a representative subset from the Rubenstein and Goodenough data set. A native speaker of Thai then translated the 30 word pairs, using the first listed definition according to a Thai-English dictionary [16]. Each word pair was printed out on separate cards using the commonly accepted Thai font. Then a questionnaire was produced which gave instructions to collect similarity ratings as well as collecting a small amount of personal information (Name, Confirmation of being a native Thai speaker, Age, Gender, and Academic background) [15].

C. Procedure

Following previous practice [15], The participants were asked to perform the following procedure:

- Please sort the cards in to four groups in a rough order of the similarity of meaning of the word pair.
- After sorting the cards into groups, order the cards in each group according to similarity of meaning. (i.e. the card that containing the lowest similarity of meaning is at the top of the group.)
- Please recheck the cards in every group. You may change a pair of word to other groups at this stage.
- Please rate the semantic similarity rating of each pair of words by writing a number between 0.0 (minimum similarity) and 0.9 for first group, 1.0 and 1.9 for second group, 2.0 to 2.9 for third group, 3.0 and 4.0 (maximum similarity) for fourth group on the recording sheet. You can use the first decimal place (e.g. 2.5) to show finer degrees of similarity. You also may assign the same value to more than one pair.

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The cards were shuffled into a random order before being given to the participants.

D. The Repicated Benchmark dataset

The benchmark data set is shown in Table 1. Column 1 is the number of word pair. Column 2 is R&G words, which are the original words from Rubenstein and Goodenough [10]. Translated words are the Thai words translated as described in [15]. Column 3 is the average Human rating for the original dataset [15]. Column 4 is the replicate average rating from 40 native Thai speaker.

TABLE I. THE AVERAGE OF SIMIRAITY RATING FROM 40 NATIVE THAI SPEAKERS

# Pair	Word Pair				Human Rating	Replicated Rating
	Word 1		Word 2			
	R&G Word	Translated Word	R&G Word	Translated Word		
1	Cord	สายไฟ	Smile	รอยยิ้ม	0.078	0.016
5	Autograph	ลายมือชื่อ	Shore	ชายฝั่ง	0.022	0.008
9	Asylum	ที่หลบภัย	Fruit	ผลไม้	0.068	0.046
13	Boy	เด็กผู้ชาย	Rooster	นกตัวผู้	0.682	0.151
17	Coast	ฝั่งทะเล	Forest	ป่าไม้	0.632	0.154
21	Boy	เด็กผู้ชาย	Sage	นักปราชญ์	0.598	0.163
25	Forest	ป่าไม้	Graveyard	สุสาน	0.548	0.146
29	Bird	นก	Woodland	ป่าเขา	0.595	0.114
33	Hill	เนินเขา	Woodland	ป่าเขา	2.162	0.531
37	Magician	นักมายากล	Oracle	คำทำนาย	1.260	0.254
41	Oracle	คำทำนาย	Sage	นักปราชญ์	1.298	0.379
47	Furnace	เตาหลอม	Stove	เตาไฟ	1.612	0.592
48	Magician	นักมายากล	Wizard	พ่อมด	1.570	0.370
49	Hill	เนินเขา	Mound	ภูเขา	2.420	0.599
50	Cord	สายไฟ	String	เชือก	0.882	0.209
51	Glass	แก้ว	Tumbler	ถ้วยแก้ว	3.125	0.601
52	Grin	ยิ้มกว้าง	Smile	รอยยิ้ม	2.330	0.659
53	Serf	ทาส	Slave	ข้ารับใช้	3.345	0.843
54	Journey	การเดินทาง	Voyage	การท่องเที่ยว	2.788	0.741
55	Autograph	ลายมือชื่อ	Signature	ลายเซ็น	3.223	0.858
56	Coast	ฝั่งทะเล	Shore	ชายฝั่ง	3.218	0.846
57	Forest	ป่าไม้	Woodland	ป่าเขา	2.830	0.766
58	Implement	อุปกรณ์	Tool	เครื่องมือ	3.335	0.855
59	Cock	ไก่ตัวผู้	Rooster	นกตัวผู้	1.515	0.596
60	Boy	เด็กผู้ชาย	Lad	เด็กหนุ่ม	2.425	0.658
61	Cushion	เบาะ	Pillow	หมอน	2.035	0.526
62	Cemetery	ป่าช้า	Graveyard	สุสาน	3.400	0.849
63	Automobile	รถยนต์	Car	รถเก๋ง	3.080	0.822
64	Midday	เที่ยงวัน	Noon	กลางวัน	3.008	0.788
65	Gem	อัญมณี	Jewel	เพรชพลอย	3.075	0.834

III. EXPERIMENT RESULT

A. Semantic Similarity Rating

The translated word pairs semantic similarity ratings are shown in Table 2. Column 1 is the number of the word pair as shown in table 1. Column 2 is the human rating form [15]. Column 3 is the human rating from the Replicate Benchmark dataset in Table 1. Column 4 is the machine rating for the Thai word pairs using the algorithm described in [17]. Human ratings are calculated as the mean of the ratings provided by the set of participants for each word pair. All of the measures have been scaled in the range 0 to 1 to aid comparison.

TABLE II. SEMANTIC SIMILARITY OF HUMAN RAITING AND MACHINE RATING

Pair Number	Original Rating	Replicate Rating	Machine Rating (TWSS) [15]
1	0.02	0.02	0.097
5	0.006	0.006	0.070
9	0.017	0.017	0.016
13	0.171	0.171	0.110
17	0.158	0.158	0.322
21	0.150	0.15	0.365
25	0.137	0.137	0.176
29	0.149	0.149	0.145
33	0.541	0.541	0.322
37	0.315	0.315	0.298
41	0.325	0.325	0.365
47	0.403	0.403	0.448
48	0.393	0.393	0.991
49	0.605	0.605	1.000
50	0.221	0.221	0.214
51	0.781	0.781	0.818
52	0.583	0.583	0.996
53	0.836	0.836	0.544
54	0.697	0.697	0.819
55	0.806	0.806	0.816
56	0.805	0.805	0.801
57	0.708	0.708	0.978
58	0.834	0.834	0.816
59	0.379	0.379	1.000
60	0.606	0.606	0.811
61	0.509	0.509	0.816
62	0.850	0.85	0.999
63	0.770	0.77	1.000
64	0.752	0.752	1.000
65	0.769	0.769	0.999

B. Discussion

The experimental results from section 2 suggest that the Original Benchmark Dataset and the Replicated Benchmark data set provided similar results. As shown in Figure 1, most of the correlation points are near the linear line with a correlation of 0.974.

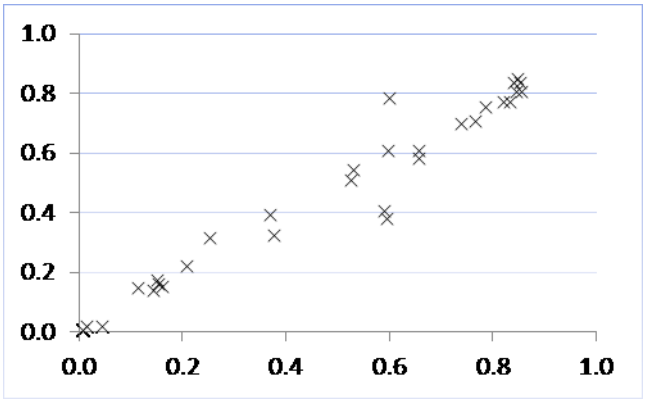

Fig. 1. The correlation between Original Beanchmark dataset and Replicated Beachmark dataset.

Table 3 illustrates the agreement of both of the machine measures with human ratings by calculating the correlation coefficients (*r*) between the human ratings and the machine ratings over the Original dataset and Replicate dataset.

TABLE III. CORRELATION COEFFICIENTS

Topics	Correlation *r*
Original Benchmark Dataset rating and machine similarity measure	0.823
Replicated Benchmark Dataset rating and machine similarity measure	0.847
Original Benchmark Dataset and Replicated Benchmark Dataset	0.974
Worst Thai native speaker participant from Replicate dataset and the least of the group	0.684
Best Thai native speaker participant from Replicate dataset and the least of the group	0.924

The Thai machine measure (TWSS) [17] is performed better with the Replicated Benchmark Dataset, with a different of 0.024 between the two correlation coefficients. TWSS is also performing better than the correlation between the worst performing human and the least of the group (r = 0.684) which supports the view that TWSS could be the basis of an effective algorithm for measuring Semantic Similarity in Thai.

The paired sample t-test was used to find whether or not the Original Benchmark Dataset and Replicated Benchmark Dataset ratings were significantly different (α=0.05) from the hypotheses:

- H0: There is no statistically significant difference between Original Benchmark Dataset and Replicated Benchmark Dataset ratings.
- H1: There is a statistically significant difference between Original Benchmark Dataset and Replicated Benchmark Dataset ratings

The result is:
- t = 1.799, df = 29 (P-Value > 0.05)

As a result, it fails to reject the null hypothesis, which means the ratings produced by
Original Benchmark Dataset and Replicated Benchmark Dataset. This means the Replicated Benchmark Dataset is not statistically significantly different from the Original Benchmark Dataset

IV. FUTURE WORK

The result of this study is support the view that language development over time does not affect the benchmark datasets. However, this study is only placed after seven years between two datasets. There is no guarantee that if 10 or more years pass that language development over time will not affect the Thai benchmark dataset. That said more works on Thai benchmark datasets will be produced. These are required to extend the range of knowledge in many areas in order to produce a meaningful benchmark datasets for be a standard for Thai language. The same producer will be used to find the statistical difference in Thai Sentence Benchmark datasets [17] as well.

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REFERENCES

[1] Lemon, O., Liu, X.: DUDE: a dialogue and understanding development environment, mapping business process models to information state update dialogue systems. EACL '06 Proceedings of the Eleventh Conference of the European Chapter of the Association for Computational Linguistics, Stroudsburg, PA, USA (2006)

[2] Kopp, S., Gesellensetter, L., Kramer, N.C., Wachsmuth I.: A Conversational Agent as Museum Guide – Design and Evaluation of a Real-World Application. IVA 2005, LNAI 3661, pp. 329--343 (2005)

[3] Ibarhim, A., Johasson, P.: Multimodal Dialogue Systems for Interactive TVApplications. ICMI '02 Proceedings of the 4th IEEE International Conference on Multimodal Interfaces, Washington DC, (2002)

[4] Almarsoomi, Faaza A., et al. "Arabic word semantic similarity." *Proceedings of World Academy of Science, Engineering and Technology*. No. 70. World Academy of Science, Engineering and Technology, 2012.

[5] Huang, F., et al: Language understanding component for Chinese dialogue system. International Conference on Spoken Language Processing, pp. 1053--1056, Oct. 16-20, Beijing (2000)

[6] Ehsani, F., Bernstein, J., Najmi A**.:** An interactive dialog system for learning Japanese. Elsevier Science B.V. (2000)

[7] O'Shea, J., Bandar, Z., Crockett, K. & McLean, D.: A Comparative Study of Two Short Text Semantic Similarity Measures. KES-AMSTA 2008: p. 82--91 (2008)

[8] Li, Y., et al.: Sentence Similarity Based on Semantic Nets and Corpus Statistics. IEEE Transactions on Knowledge and Data Engineering, vol. 18, no.8, pp. 1138--1150 (2006)

[9] Miller, G.A.: WordNet: A Lexical Database for English. Comm.Acm, vol.38, no.11, pages 39--41 (1995)

[10] Rubenstein and Goodenough.: Contextual Correlates of Synonymy. Communication of the ACM, vol. 8, No. 10, pp. 627--633 (1965)

[11] Miller, G.A. and Charles, W.G.: Contextual Correlates of Semantic Similarity. Language and Cognitive Processes, vol. 6, No. 1, pp. 1--28 (1991)

[12] Charles, W. G. (2000) Contextual Correlates of Meaning. Applied Psycholinguistics 21, 505-524.

[13] Resnik, P. (1999) Semantic Similarity in a Taxonomy: An Information-Based Measure and its Application to Problems of Ambiguity in Natural Language. Journal of Artificial Intelligence Research, Vol. 11, 95-130.

[14] O'Shea, James, et al. "Benchmarking short text semantic similarity." *International Journal of Intelligent Information and Database Systems* 4.2 (2010): 103-120.

[15] Osathanunkul, Khukrit, James O'Shea, Zuhair Bandar, and Keeley Crockett. "Semantic similarity measures for the development of thai dialog system." In *KES International Symposium on Agent and Multi-Agent Systems: Technologies and Applications*, pp. 544-552. Springer, Berlin, Heidelberg, 2011.

[16] Trakultaweekoon, K., Porkaew, P., Supnithi, T.: LEXiTRON Vocabulary Suggestion System with Recommendation and Vote Mechanism. Proceedings of conference of SNLP- 2007, Thailand, (2007)

[17] Osathanunkul, Khukrit (2014) *Semantic similarity framework for Thai conversational agents.* Doctoral thesis (PhD), Manchester Metropolitan University.

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Impact of Mobile Application on Student Enguagement and Public Consciousness Toward Computer Laboratory Use

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***Abstract*—The study was carried out to determine whether computer science students at Maejo university would prefer to use a checklist mobile application for computer laboratory care and maintenance and also whether their engagement and public consciousness could be boosted by the use the checklist application with an instructor repeatedly guidance. The study used a purposive sampling method to collect data from 81 sophomores who attended the 2018 database system class. Non-parametric methods were used to test hypotheses. The results revealed that student engagement and public consciousness toward computer laboratory care were significantly improved after using the checklist application. The students indicated that they satisfy with the application and suggested that the department should continue to use it.**

Keywords—Public Consciousness, Student Enguagement, Mobile Application, Computer Laboratory

I. INTRODUCTION

There is growing concern over the way the computer science students at Maejo University do not engage in computer laboratory care and maintenance. This lack of student engagement left the computer laboratory in bad conditions on both hardware and software. Consequently, several computers are not working and the dynamic of the class is disrupted. Besides, games, social networks, or other software that do not supposed to be in the laboratory computers can cause negative effects in a class. The aforementioned problems are easy to solve if we can persuade students to help take care of the computer laboratory. This research proposed an instrument to improve student engagement and public consciousness. Two research question consist of 1) is there significant difference between the engagement in computer laboratory care of the students who use our checklist mobile application and those who do not? And 2) is there significant difference between the public consciousness of the students who use our checklist application and those who do not? The answers of these questions will be useful for developing a policy recommendation.

II. LITURELATURE REVIEW

Mobile phones have become a learning tool with great potential in both classrooms and outdoor learning [11,10]. It promotes learning outcomes because it allows students to increase his or her engagement in learning [3]. Student engagement is considered a valuable construct that can indicate the quality of the educational environment [8]. Since, most students have positive perception of collaborative learning using the mobile phone in their learning processes [6]. Mobile-phone-based classroom response systems can be used to encourage students' perceptions of engagement in a large undergraduate course [5]. Mobile user engagement is affected by user's motivations, perceived value and satisfaction [7]. Althrough the study shows that Thai undergraduate students has high level of public awareness on university environment [1], the public awareness of computer science at Maejo is still not known. This research has been focus on using mobile application to cultivate student public consciousness and engagement. Public consciousness not exclusively includes of maintenance and avoid damaging public properties [12]. One key characteristic of students' public consciousness is the awareness that they should participate in public activities [4]. The study at Suan Sunandha Rajabhat University found that sex or year do not affect the public consciousness of undergraduate students [9]. To cultivate public consciousness of the university students, the university should have a clear policy to include the topic of public consciousness in the courses offered and encourage to use information technology with digital gadgets and social media to cultivating public consciousness of its students [2].

III. METHODOLOGY

A. Sample

Eighty-one computer science students who attended the 2018 database class were purposive sampled. Forty-six student from class section 1 was assigned to use a checklist mobile application and the 35 students from section 2 were not assigned but may if they will use a checklist mobile application.

B. Definition

The student engagement in this study means that the students check and maintain computer systems and other devices in the computer lab throughout a semester. Public consciousness in this study means that student aware that they should help taking care of computer laboratory.

C. Research Instruments

This research instrument deployed the online pre-test/post-test questionnaires and the online checklist to collect students' attitude and public consciousness data. An online satisfaction questions were given to students at the end of the study to obtain their opinions about the usability, usefulness, and whether the application should be used in the future at their institution. All questionnaires were evaluated by three experts. The evaluation gave all question

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an Item-Objective Congruence value of 1. Reliability test of the instrument gave a Cronbach alpha value of 0.789

D. Data Collection

Data collection occurred in 5 phases. The 1st phase I was to test validity and reliability of questionnaires. In the 2nd phase, pretest questionnaires were given to 81 students to check students' attitude and public consciousness before using the checklist mobile application. In the 3rd phase, the checklist mobile application was introduced and trained how to use it to all 81 students at the first week of the semester. The students were then divided into 2 groups (1st group 45 and 2nd group 36 students) according to their class session. Data was collected for 14 weeks. While the 1st group was reminded about the application every week by an instructor, the 2nd group was not. The number of time that each check or take care of the computer was recorded to assess the engagement of the students toward laboratory care. In the 4th phase, pretest questionnaires were given to 81 students to check students' attitude and public consciousness at the end of the semester. At the last phases, satisfaction questionnaires were given to the 1st group to test usefulness and usability of the checklist mobile application.

E. Data Analysis Procedure

Since the sample data obtained in the current study was non-normally distributed, the Mann–Whitney U test was used to compare means between two independent groups of students. The Wilcoxon signed-rank test is used to test differences median before and after the students had used the checklist mobile application (level of significance of 0.05)

Table I. Satisfaction Rate

Score	Satisfaction rate
4.21-5.00	very satisfied
3.41-4.20	satisfied
2.61-3.40	fair
1.80-2.60	unsatisfied
1.00-1.80	Very unsatisfied

IV. RESULT

Table II. enguagement score between the 1st student group and the 2nd student group

Group	Median	Mean Rank	Mann-Whitney U-test
1st group	12	57.78	-7.539*
2nd group	3	18.94	

Table II. shows that the students from the 1st group who use the application is significantly more often participate in laboratory care and maintenance than those from the 2nd group who do not use the application.

Table III. public consciousness score before and after using the application of the students from the 1st group

Test	Median	Mean Rank	Wilcoxon Signed Ranks test
Pretest before Using the Checklist mobile application	2	9.17	-1.952*
Posttest after Using the checklist mobile application	2	11.07	

Table III. shows that the public consciousness score of the students after using the checklist application is significantly higher than the score before they use the application.

Table IV. mean and standard deviations of student's engagement and public consciousness

Questions	Mean	S.D.	Results	Mean	S.D.
1. The students think that laboratory care and maintenance are their duty. (public consciousness)	4.15	0.73	agree	4.14	0.58
2. The students would like to help maintaining the computer laboratory. (public consciousness)	4.12	0.60	agree		
3. The students think that an extra grade would urge them to help maintaining the computer laboratory. (engagement)	3.80	1.13	agree	3.61	0.47
4. The students think that they have been reassured by Instructors and peers to help maintaining the computer laboratory. (engagement)	2.07	1.00	disagree		
5. The students agree that students should take care and maintain the university computer laboratory. (engagement)	4.35	0.81	Strongly Agree		
6. The students think that taking care of computer laboratory will be useful to them in the future. (engagement)	4.21	0.88	Strongly Agree		

Table IV. shows that the overall public consciousness and engagement are at a high level. They strongly agree that students should help taking care the computer laboratory and this will be useful to them in the future.

Table V. mean and standard deviations of student satisfaction with the checklist mobile application

Questions	Mean	S.D.	Results
1. The letters size is appropriate	4.02	0.64	good
2. The letters color is appropriate	4.04	0.63	Good
3. The layout is appropriate	3.93	0.68	Good
4. The program is easy to install.	3.90	0.99	Good
5. The program is easy to use.	3.98	0.88	Good
6. The application does not have any error.	4.37	0.74	Very good
7. The application direction is clear and easy to understand.	4.13	1.00	Good
8. The application is useful.	3.98	0.77	Good
9. The application can improve students's public consciousness	3.87	0.74	Good
10. The application can improve students's engagement	4.00	0.84	good
11. The department should to use this application	4.11	1.01	good

Table V. shows that students overall are very satisfied with the application. Application does not have error and direction is clear receive the highest satisfaction rates. Moreover, the students express that the department should continue to use this application

V. CONCLUTION

Student engagement in taking care of computer laboratory is essential to both the institution and its students. The current study confirms that using a checklist mobile application with an instructor guidance can significantly encourage student engagement and increase their public consciousness. The study find that the students see the usefulness and strongly agree with the use of it. The future study could be concentrated on testing with other non-computer science students.

VI. Acknowledgment

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REFERENCES

[1] Apichati butarapong, S. (2018). Factor Affecting on Public Awareness Concerning University Environment. In *Multidisciplinary Digital Publishing Institute Proceedings* (Vol. 2, No. 22, p. 1369).

[2] Ayudhya, V. S. N., & Chayanuvat, A. (2018). Cultivating Public Consciousness of University Students. Walailak Journal of Social Sciences, 11(2), 171-193.

[3] Domingo, M. G., & Garganté, A. B. (2016). Exploring the use of educational technology in primary education: Teachers' perception of mobile technology learning impacts and applications' use in the classroom. *Computers in Human Behavior*, *56*, 21-28.

Duangduan Pantunawin.(2001). Ethical tree theory: research and development. Bangkok: Academic Promotion Program. National Institute of Development Administration. (In Thai)

[4] Dunn, P. K., Richardson, A., Oprescu, F., & McDonald, C. (2013). Mobile-phone-based classroom response systems: Students' perceptions of engagement and learning in a large undergraduate course. International Journal of Mathematical Education in Science and Technology, 44(8), 1160-1174.

[5] Heflin, H., Shewmaker, J., & Nguyen, J. (2017). Impact of mobile technology on student attitudes, engagement, and learning. *Computers & Education*, *107*, 91-99.

[6] Kim, Y. H., Kim, D. J., & Wachter, K. (2013). A study of mobile user engagement (MoEN): Engagement motivations, perceived value, satisfaction, and continued engagement intention. *Decision Support Systems*, *56*, 361-370.

[7] Kuh, G. D. (2001). Assessing what really matters to student learning inside the national survey of student engagement. Change: The Magazine of Higher Learning, 33(3), 10-17.

[8] OtaNum, N. (2017). The Study of Public Consciousness of Undergraduate Students, Suan Sunandha Rajabhat University. World Academy of Science, Engineering and Technology, International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering, 9(12), 4431-4434.

[9] Shonola, S. A., Joy, M. S., Oyelere, S. S., & Suhonen, J. (2016). The impact of mobile devices for learning in higher education institutions: Nigerian universities case study. *International Journal of Modern Education and Computer Science*, *8*(8), 43.

[10] Sung, Y. T., Chang, K. E., & Liu, T. C. (2016). The effects of integrating mobile devices with teaching and learning on students' learning performance: A meta-analysis and research synthesis. *Computers & Education*, *94*, 252-275.

[11] Weerachai khumthorn. (2016). Public Mind: Meanings, Measurement, Components as well as Indicators of Students In Rajaphat University. *Journal of MCU Humannities Review)*, *2*(2).

Using Similarity Measurement based on Image Feature for Gesell Figure Drawing Test Application

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***Abstract*—This paper reviews important issues in image retrieval research. To developed application the Gesell figure drawing test and evaluate the validity of in measuring IQ among children aged 6-10 years by using tools for evaluating efficiency of application, such as similarity measurement based on image feature, precision and also discussed.**

Keywords—Similarity Measurement, Gesell figure drawing test, Image retrieval, Recall, Precision

I. INTRODUCTION

These issues are the basic science of digital imaging, image retrieval structure and discriminate features and methods to compare and differentiate images for image retrieval system. Tools for evaluating efficiency of an image retrieval system, such as precision and recall.

Standard intelligence quotient (IQ) tests, such as the Wechsler Intelligence Scale for Children-III (WISC-III) and the Stanford-Binet Intelligence Scale, are not universally applicable in general pediatric practice. The Gesell figure drawing test is one of the most widely used assessments of intelligence in children. The Gesell Drawing Test (GDT) [1] is frequently used as an easy, expeditious and effective screening measure of intelligence for clinical populations. such as, children with mental handicaps, hearing impairments and other communication disorders. The ability of children to imitate/copy geometric forms is a recognized index of their cognitive maturation and/or intellectual level [2]. Various age graded intelligence scales reflect different normative mental age levels of children's drawing performance [3-5]. To evaluate the validity of the Gesell figure drawing test in measuring IQ among children aged 6-10 years. Tools for evaluating efficiency of application, such as precision and similarity measurement based on image feature, and also discussed.

User interactive systems have attracted a lot of research interest in recent years, especially for content-based image retrieval systems. Recent approaches have introduced human-computer interaction, Assuming that a user is looking for a set of images with similar feature using the query concept within a database. Proposed system focus on the retrieval of images within a huge image collection based on customized IRM and color histogram technologies. This technique obtained fast and efficient results comparatively previous methods [17]. The aim is to build a fast and efficient strategy to retrieve the query concept. In the whole retrieval process, feature extraction is crucial; it is closely related to all aspects of the future, such as color, shape, texture and space.

A. Color Feature

The color feature is considered to be the most visible human feature [6]. The color model is a structure defined to organize the color system into order. With a scale to help identify and control color changes easier and was created to help determine the color to meet the same standards. Which the current color model has been created to support various devices or applications. The popular color models include the RGB color model, which is a model for use in display cameras, etc. Simulate CMY and CMYK colors as the format used in printing. And the HSV color model is a color model that can separate the color elements from the light intensity and the HSV color model is still close to the perception and interpretation of the human color.

Computing distance measures [7-8] based on color similarity is achieved by computing a color histogram for each image that identifies the proportion of pixels within an image holding specific values. Current research is attempting to segment color proportion by region and by spatial relationship among several color regions. Examining images based on the colors they contain is one of the most widely used techniques because it does not depend on image size or orientation. Color searches will usually involve comparing color histograms.

B. Texture Feature

There have been different definitions of surface features by Parker [9] said that the distinctive feature of being a surface is to have a duplicate pattern in one area. However, even if the surface is a colored surface. But in surface analysis, it focuses only on the gray surface. Tamura, et al. [10] have discovered the relationship between human perceptions and calculate the difference between 6 surfaces, such as coarseness, contrast, directionality, line-likeness, regularity and roughness.

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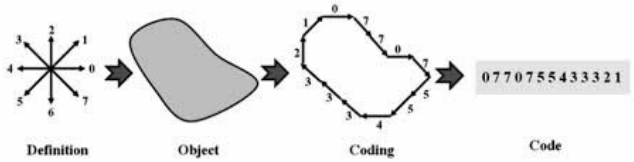
Texture measures look for visual patterns [11] in images and how they are spatially defined. Textures are represented by texels which are then placed into a number of sets, depending on how many textures are detected in the image. These sets not only define the texture, but also where in the image the texture is located.

C. Shape Feature

The method used to analyze the shape of the object that appears in the image is used in two ways [12]. The first method is boundary-based and the second method is region-based, both of which give the image coding scheme to represent the content of the image principles of analyzing the shape of both methods, showing as Figure 1 and Figure 2.



Boundary-Based Method.

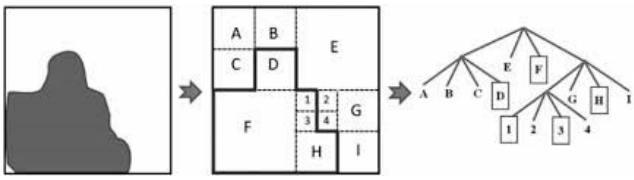


Fig. 1. Region-Based Method.

II. Related Work

A. RGB Projections

The RGB color model is an additive color model in which red green, and blue light are added together in various ways to reproduce abroad array of colors. The name of the model comes from the initials of the three additive primary colors red, green, and blue. Main purpose of the RGB color model is for the sensing, representation, and display of images in electronic systems. An image histogram is a type of histogram that acts as a graphical representation of the tonal distribution in a digital image. It plots the number of pixels for each tonal value. By looking at the histogram [13] for a specific image a view will be able to judge the entire tonal distribution at a glance. RGB Projections is used to find the size of the image vertically and horizontally.

B. Image Service

Whenever minimizing the error of classification is interesting for CBIR, this criterion does not completely reflect the user satisfaction. Other image service criteria closer to this, such as precision, should provide more efficient selections.

C. Comparable Image

Reselection technique used to speed up the selection process, which leads to a learning process. All these components are integrated in retrieval system, the user gives new labels for images and they are compared to the current classification. It the user mostly gives relevant labels the system should propose new images for labeling around a higher rank to get more irrelevant labels.

D. Similarity Measure

The results in terms of mean average precision according to the training set huge image databases. Classification-based methods [14] gives the best results, showing the power of statistical methods over geometrical approaches.

Similarity and dissimilarity as shown in Figure 3. There are 4 circles in all images. The image (a) is the same as the picture (c). The image (a), (b) and (c) are images of the same size and image (a), (c) and (d) are images of the same color. So will find the size and color are a characteristic used to measure the similarity of images.But the similarity is difficult to measure. With the same value as the quantity that reflects the strength of the relationship between two objects or two features. If the value of the similarity of objects i and object j is Sij, measure as in many different ways, depending on the information available.

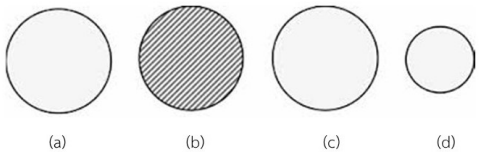


Fig. 2. Example of a circle image.

For the distance value is used to measure the dissimilarity which is a measure of the difference between two things that should be the discrepancy by using that feature. In addition, the dissimilarity can also be used to measure anomalies between two objects or two images. There are many ways to measure similarities and dissimilarity. Which each method has a unique characteristic of each method.

E. Integrated Region Matching

This method computers histograms of every image in the database and takes one input image to search from the database. It gives feasible solution consisting finite number of images (like 'M') having minimum IRM distance [15]. Then by taking minimum IRM distance image (Say 'N', where N IM) as input and remaining images in the feasible solution set as a database of images applies region matching technique using color. Hence, it computes single image having minimum IRM distance with 'N'. after finding the minimum distances related image is deciding as a similar to the query image.

F. Performance Measures

a) Precision: Precision [16] is the fraction of the images retrieved that are relevant to the user's information need.

$$\text{precision}=\frac{|\{\text{relevent images}\}\cap\{\text{retrieved images}\}|}{|\text{retrieved images}|} \quad (1)$$

Recall is the fraction of the images tat are relevant to the relevant to the query that are successfully retrieved.

$$\text{recall}=\frac{|\{\text{relevent images}\}\cap\{\text{retrieved images}\}|}{|\text{relevant images}|} \quad (2)$$

b) Mean Average Precision: Mean average precision for a set of queries is the mean of the average precison scores for each query.

$$MAP = \frac{\sum_{q=1}^{Q} AveP(q)}{Q} \quad (3)$$

Where Q is the number of queries.

III. APPLICATION FRAMEWORK

This section presents our Gesell Figure Drawing Test Application framework which are composed of 3 processes; Drawing image, query image from database, RGB projection for matching image. Proposed work provides an interface where user can give query images as input, which uses the visual contents of an image such as color, shape, texture and spatial layout to represent the image compared with the images in database as shown in Figure 4.

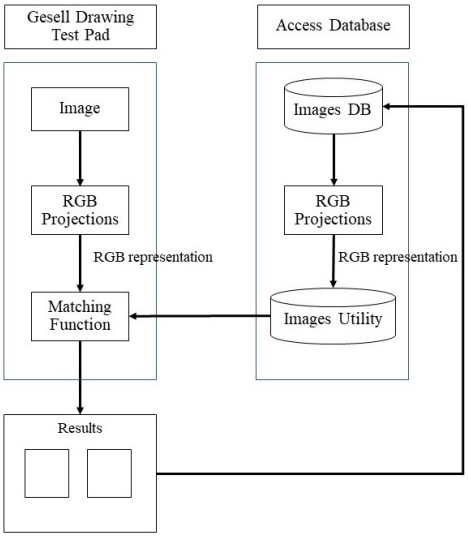


Fig. 3. The Framework of Gesell Figure Drawing Test Application.

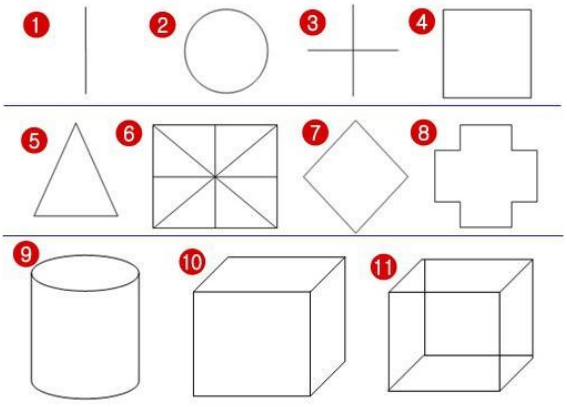


Fig. 4. Gesell Figure Drawing Test image (1-11 years).

IV. WORK IMPLEMENTATION

In this work, we have developed Gesell Figure Drawing Test application by using similarity measurement based on image feature. For our implementation, the following software and hardware requirement are used. The system as window application was developed by C# programming language edited all programs with Microsoft Visual Studio 2017 and used Microsoft Access database for storing data, statistic results along with drawing Gesell test by using the pen mouse feels like a traditional pencil or paintbrush, and it even respond to our drawing pressure.

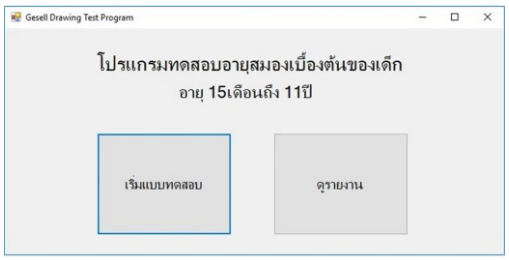


Fig. 5. Main page of Gesell Figure Drawing Test (GDT) application.

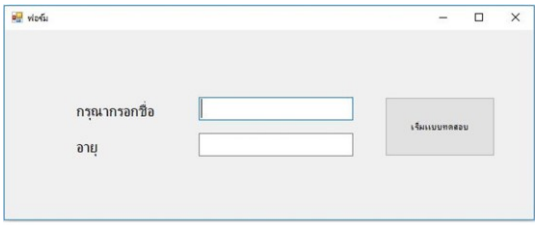


Fig. 6. A page adding name and age.

Fig. 7. A page Gesell figure drawing test of test image 1.

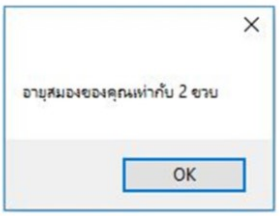


Fig. 8. A page showing result after drawing 11 test images.

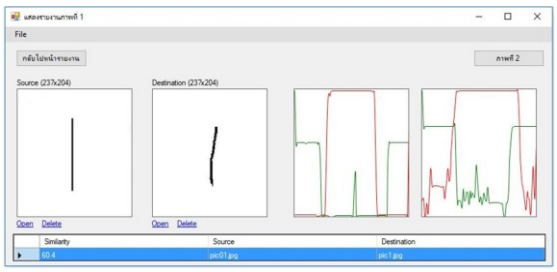


Fig. 9. A page graph of test image 1 by similarity is 60.4

Details and descriptions for Figures 6-10 are as follows:

1) Figure 6: Display of Gesell Figure Drawing Test application that show two functions; (1) start to drawing test, (2) open a report.

2) Figure 7: Display of user detail that can be added name and age.

3) Figure 8: Display of test image 1. The left hand shows the test image 1 that is query data from the database. The right side is a drawing board. To allow users to draw pictures like the left image. After drawing, press the next button. To draw the second test image respectively until the last test are complete that the image show in Figure 5.

4) Figure 9: Display of result when complete the test.

5) Figure 10: Display of example of graph that showing percentages of similarity measurement based on image feature.

V. METHOD AND PROCEDURE

The result of experiment and analysis between use Gesell Figure Drawing Test Application and specialist analysis show on Table I and Table II.

TABLE I. MEAN AVERAGE IMAGE SIMILARITY

Age	Gesell Figure Drawing Test Images										
	1	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***	***11***
6	70.5	79.6	66.2	77.2	69.2	50.2	44.2	45.2	41.6	40.2	30.1
7	79.4	78.8	70.8	69.5	68.5	66.2	59.6	59.7	62.2	54.3	31.4
8	83.1	80.1	69.3	72.2	73.3	72.3	72.5	76.7	57.2	40.8	30.9
9	85.1	78.9	72.4	70.4	70.2	81.8	77.8	77.2	79.4	62.8	45.1
10	70.9	62.4	60.1	64.1	60.8	66.2	64.3	67.8	63.2	56.8	37.6

TABLE II. RESULT ANALYSIS

Age	Comparison of results from applications and Specialist		
	Amount	***Application (%)***	***Specialist (%)***
6	4	100	100
7	4	75	100
8	3	67	100
9	5	80	100
10	4	50	75

A. Page Graph

From Table I, to determine relationships between the two Images. The precision and recall values are measured by simulating retrieval scenario. For each simulation, an image category is sequence chosen. Next, one images is selected, which returns a ranking of the database. After that user drawing a first test until the last test and save image to a database. The average precision is then computed using the ranking. These simulations are repeated 1000 times, and all values are averaged to get the Mean average precision. Next, we repeat ten times these simulations to get the mean and the standard deviation of the map.

B. Dataset

This work utilizes information of 20 children between 6 to 10 years by comparing performance between application and specialist for age 6 showing the same result as specialist and age between 7 to 10 years the result is less than specialist. Specialist told that one of them may have intellectual problems.

C. Experimental Results

The image will take the relevant image what the user drawing. The performances go from few percentages of Mean average similarity. One can see that we have selected concepts of different levels of complexities such as age. The concepts that are the most difficult to retrieve are very small and/or have much diversified visual content.

VI. CONCLUSION AND FUTURE WORK

The Gesell Drawing Test Application could measurement intelligence of children by using similarity measurement based on image feather is used as an easy, unfortunately this drawing test has been validated only on a small sample (N:20) of children between 6 to 10 years. The future work, we will improve the algorithm/method or using machine learning technique to be more effective.

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REFERENCES

[1] Vernam, S.k., Pershad, D., & Kaushal, P. (1972). Gessell Drawing Test as measure of intelligence in the mentally retarded children. Indian Journal of Mental Retardation. 5. 1 & 2. 64-68.

[2] Chattell, R.B. (1946). Guide to Mental Testing. London: University of London Press.

[3] Goodenough, F.L. (1936). Measurement of intelligence by drawings. New York: Harcourt, Brace and World.

[4] Sutphin, F.E. (1970), a Perceptual Testing-Training Handbook for First Grade Teachers. Winter Haven Lions Research Foundation.

[5] Sharma, B. K. (1977). Draw a bicycle test of intelligence Lucknow: Psychological Corporation.

[6] Arnheim, R. (1974). Art and Visual Perception: A Psychology of the Creative Eye. The new version (The expanded and revised edition of the original publication of 1954). Berke ley: University of California Pres.

[7] Androutsas, D et al,"Image retrieval using directional detail histograms", in Storage and Retrieval for Image and Video Databases VI, Proc SPIE 3312, pp. 129-137, 1998.

[8] D. Mahidhar, "MVSN, Maheswar A NOVEL APPROACH FOR RETRIEVING AN IMAGE USING CBIR", International Journal of computer science and information technologies vol. 1(5), 2010, pp. 329-331.

[9] Parker, J. R. (1997). Algorithms for image processing and computer vision. John Wiley and Son.

[10] Tamura, H., Mori, S., & Yamawaki, T. (1987). Texture feature corresponding to visual perception. IEEE Transaction on Systems, Man and Cybernetics, 8(6), 460-472.

[11] Smeulders, A.W.M., Worring, M., Santini, S., Gupta, A., Jain, R., "Content based image retrieval at the end of the early years", IEEE Trans. Pattern Anal. Intell. 22, pp. 1349–1380 2000.

[12] Watt, A., Policarpo, F. (1998). Computer Image. Harlow: Addison Wesley Longman.

[13] M. L. Kherfi, D. Ziou, A. Benard, "Image retrieval from the World Wide Web: Issues, techniques and systems", ACM Computing Surveys, 36(1), pp. 35-67, 2004.

[14] P.L. Stanchev, D. Green Jr., B. Dimitrov, "High level color similarity retrieval", Int. J. Inf. Theories Appl. 10 (3), 2003 pp. 363–369.

[15] A. Natsev, R. Rastogi, K. Shim, "WALRUS: A Similarity Retrieval Algorithm for Image Databases", in Proc. ACM SIGMOD Int. Conf. Management of Data, pp. 395–406, 1999.

[16] Stricker, M, Orengo, M, "Similarity of color images", in Storage and Retrieval for Image and Video Databases III (Niblack, W R and Jain, R C, eds), Proc SPIE 2420, pp. 381-392, 1995.

[17] R.Venkata, D. Rajya, K. V. N, "Image Retrieval and Similarity Measurement based on Image Feature", International Journal of computer science & Technology vol. 2(4) , pp. 385-389, 2011.

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Using Classification Data Mining Techniques for Students Performance Prediction

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***Abstract*—The big problem of retired or drop out students is about academic achievement. The educational institution needs to follow up the advising system since advisers should guide the planning curriculum to their advisees. The data mining techniques are applied to anaylze the performance of the students and to impart the quality of education in the educational institutions. This paper focuses on classification models for applying in Education Data Mining. The classification models are applied to identify the suitable subject to the science students. The experiment is set to improve the student performance which comparing the performance of five classification models and then predicting the appropriated academic achievement in each major. To examine the experiment, we used 17,875 academic achievements within 483 students. Four measures; precision, recall, f-measure, and accuracy are evaluated the models. For the result, the best accuracy is Gradient Boosted Trees: GBT at 92.41% and F-measure value equals to 84.59%.**

***Index Terms*—Decision Tree, ID3, Random Tree, Gradient Boosted Trees, Education Mining**

I. Introduction

Education is an essential factor for developing a country. Academic achievement is the part evaluation in education management. An advisor system could help the student to get the performance better since the number of retired or dropped students out is less. If the curriculum planning in each semester will be proposed quickly, the number of retried students possibly decrease. Data mining technology can apply in the education for improving a learning such as the associating a knowledge gaps, the predicting the student achievement, and the discovering the suitable major. Data mining provide us with tools to analyze large set of data to derive meaningful data known as knowledge. This help us to get insight of data and reach to meaningful conclusion. Initially, the application of data mining were restricted to business domain but know it is extended to education and is known as EDM.

Educational data mining (EDM) deals with the application of data mining tools and techniques to inspect the data at educational institutions for deriving knowledge [1]. In order to analyze large amount of education information, the area of Knowledge Discovery in Databases (KDD) provides methods at the point of machine learning, statistics and database systems. KDD is interesting to extract the important pattern from the large databases. While an efficient algorithms is a core of application to detect the desired patterns contained within the given data.

In machine learning and data mining, the classification is the problem of recognizing to a new case belongs to a set of categories based on a training set of data containing observations whose category membership is known. Examples are assigning a given email to the ”spam” or ”non-spam” class, and assigning a diagnosis to a given patient based on observed attributes of the patient (sex, blood pressure, presence or absence of certain symptoms, etc.).

A decision tree is used in a decision tree learning. The branches in the tree are represented theirs item value which belong to the characteristic, the attribute, or the feature. While the leave nodes show the item's target value (class or label). Decision trees where the target variable can take continuous values (typically real numbers) are called regression trees.

This paper studies the classification techniques in data mining. Five classification models are used to predict the appropriated subject in each major and then compares the performance with four measures; (1) precision, (2) recall, (3) f-measure, and (4) accuracy scores. The purpose of this work, we introduce data mining process in Section III, represent the classification model in Section III-A. Method and procedure are shown in Section IV. Experimental results and discussions are described in Section V. Finally, conclusion and future work are represented in Section VI.

II. Related Work

Data mining, also called Knowledge Discovery in Databases (KDD), is the field of discovering novel and potentially useful information from large amounts of data. Educational Data Mining (EDM) is still in a part of interested mining. Many data mining approaches are used to study in EDM such as the classification algorithm, the association rule discovery, or the clustering. For the classification algorithm, many researchers reviewed that the decision tree algorithm is quite to use for predicting on student's academic performance [3]. They implemented various decision tree algorithm ID3, J48/C4.5, random tree, multilayer perception, rule based and random

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forest with Weka tool. To evaluate the performance percentage split method or cross validation method is used. The results could improve the student's academic achievement. In the research [4], they studied the the capabilities of information mining within the context of the next Education Institute and tries to get new specific information by applying data processing techniques to academic knowledge of Technological academic Institute of Athens. They used the decision tree algorithm to analyze the student's questionnaires within the categories inside the analysis method of every department of the Institute. Other hands, Ahmed and his team [5] focused on the classification models to predict the final grade of students. They selected the decision tree (ID3) method for their experiment. Including to the research [6] of Kaur and his team, they studied the classification and prediction based data mining algorithms to predict slow learners in education sector. They applied applied on various classification algorithms such as Multilayer Perception, Naïve Bayes, SMO, J48 and REPTree using WEKA potential tool. The latest research is created by the new framework, called cloud-service decision tree classification for education platform [7]. This research studied the ideological education model of university students, provided the multi-objective weight self-adaptation form, and introduced the cloud-service decision tree classification algorithm. To verify the algorithm with measures.

III. Data Mining

Data Mining (DM) or Knowledge Discovery in Database (KDD) is a process to find patterns and relation from large data sets with the various methods such as machine learning, statistics, and database systems [16]. There are three processes of data mining as the described following:

1) Preprocessing: prepare the suitable dataset and will arrange in a useful format. A noise data should be eliminated from raw dataset. The remaining dataset which having a relation, will be used for creating a model.
   - Data cleaning: eliminate a unimportant dataset or an error data.
   - Data integration: collect the dataset from multiple sources.
   - Data selection: select the relative attribute which can be predicted the good performance.
   - Data transformation: adjust the format of attributes that is easy to use or predict.
2) Modeling: use the selected data for creating a model. A problem or business understanding is guided to choose the appropriate technique. Then, the model should be evaluated with the new cases.
3) Postprocessing: deploy the model to the real situation as the application.

A. Classification Methods

The classification [8] is called supervision which uses the training data (observations, measurements, etc.) are accompanied by labels indicating the class of the observations. A new data is classified based on the training set. This method predicts categorical class labels (discrete or nominal) or classifies data (constructs a model) based on the training set and the values (class labels) in a classifying attribute and uses it in classifying new data. There are many methods for classification. We can study four examples in our research as the following;

1) Decision Tree: a collection of nodes which the nodes describe the characteristic, branches display the testing result, and the leaf nodes represent the specific attribute [9].
2) Decision Tree Weight-based: a concept of the decision tree with weight-based works exactly like the decision tree method with one exception: it uses an arbitrary attribute relevance test criterion instead of the information gain or gain ratio criteria [10].
3) ID3: Iterative Dichotomiser 3 is an algorithm [11] to used to generate a decision tree from a dataset. ID3 is the original of the C4.5 algorithm. Its method is famous in the machine learning and natural language processing domains.
4) Random Tree: The Random Tree operator works similar to C4.5 algorithm [12] but it selects a random subset of attributes before it is applied. The size of the subset is specified by the subset ratio parameter like the stochastic process [13].
5) Gradient Boosted Trees: GBT algorithm is a machine learning technique for regression and classification problems, which produces a prediction model in the form of an ensemble. A gradient boosted model is the forward-learning ensemble method that obtain predictive results through gradually improved estimations [14].

IV. Method and Procedure

In this research, we study the classification methods to identify the suitable subject to each major in science students and then evaluate the performance with the precision, recall, f-measure, and accuracy. The experiment in this research, we focus on the data mining process such as preprocessing, modeling, and postprocessing which are described below;

A. Preprocessing

- Data cleaning: 17,875 records within 483 persons examine the performance of academic achievement, we only focus on the students of Faculty of Science and Agricultural Technology from Rajamangala University of Technology Lanna Nan from 2009 to 2013 since the curriculum is the same period.
- Data selection: the registration data is used to analyze such as year, semester, subject id, subject name, department id, department name, grade, and credit are used. However, the experimental dataset only selects the records which having the active status ('Y'). Grade 'I' is eliminated while the missing values are set to 'N/A'.
- Data transformation: A to F grade level are changed into three group i.e., 'High' equals A, B+, or B level, 'Middle'

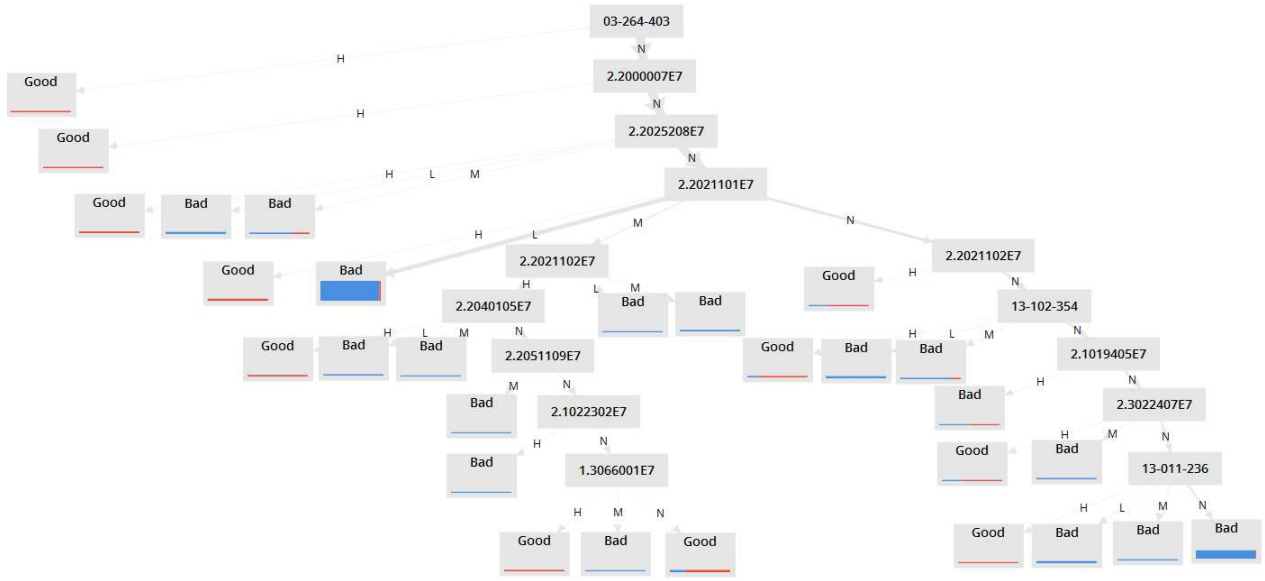

Fig. 1. The Tree Model from Rapid Miner Environment

displays C+ or C, and 'Low' represents D+, D, or F. Then, we prepare the dataset in a excel file for RapidMiner tool [18].

B. Modeling

In this experiment, five classification methods (Decision Tree, Decision Tree Weight-based, ID3, Random Tree, and GBT) used to create the models and then compare the performance with the measures. Here, the model will be shown in Tree format and generated into the rules later. Each of leaf node is classified into two classes (Good and Bad). Here, the *good* class means the GPA of student which is over than 40% at the top ranking. The opposite of the *good* class, the *bad* class equals to the accumulated GPA which is under the 40% of the below ranking. The 40% value can be changed since it depends on the frequency of data. In this experiment, the dataset is divided by a cross-validation test called 10-fold cross-validation. The training set is used to create the model and the testing set predicts the class, respectively. The tree model shows in Figure 1. It is changed the tree to rules as shown in Figure 2. We can use the rules to implement or predict the new case (the student achievement). After getting the models, the performance measures used in our experiment are precision, recall, f-measure, and accuracy [19]. Eq. (1) shows the calculation of F-measure value.

$$F - measure = \frac{2 \times \ Precision \times Recall}{Precision + Recall} \tag{1}$$

C. Postprocessing

In this process, the experiment considers the subjects which are suitable to the science students in order to the condition or class that occurring from a root node to the leaf node. If the number of the good class is more than the bad, it is possible that the new student who has the same record may gets the good achievement as well. In Figure 1, the number of good class equals to 15 which is less than the bad class (11 classes). The number is quite similar so that if the student will attend the class carefully, the performance will be increase or good. We can start the output from the root to the leaf node. For example, in the Figure 1 shows the root node is the subject code.03264403. If the students get the grade in high level (B, B+, and A) of the subject code.03264403 (Farm Field and Plant Food Management) then they will get the good achievement or this subject is suitable to the science students. In opposite of the high grade, the students have not studied in the 03264403 (N value) but they get the high achievement in the 22000007. The output class is shown the good. The other case, the students have not studied the subject code.03264403 and 22000007 and gotten the middle grade (C and C+) in the subject code.22025208 so that the class will quite return the bad class. For the Figure 2, the rules of those conditions are generated respectively as below;

1) Class Good: If 03264403 in {High}
2) Class Good: If 03264403 in {None} and 22000007 in {High}
3) Class Bad : If 03264403 in {None} and 22000007 in {None} and 22025208 in {Middle}.
4) Class Bad : If 03264403 in {None} and 22000007 in {None} and 22025208 in {None} and 22021101 in {Low}.

V. Result and Discussion

To examine the root relative square error and compare the performance of five models in the classification for each major. Each of the classification model should consider the root relative square error (see in Figure 4) since the root relative

Tree

```
03-264-403 = H: Good {Bad=0, Good=5}
03-264-403 = N
|   2.2000007E7 = H: Good {Bad=0, Good=4}
|   2.2000007E7 = N
|   |   2.2025208E7 = H: Good {Bad=0, Good=9}
|   |   2.2025208E7 = L: Bad {Bad=14, Good=0}
|   |   2.2025208E7 = M: Bad {Bad=5, Good=2}
|   |   2.2025208E7 = N
|   |   |   2.2021101E7 = H: Good {Bad=0, Good=13}
|   |   |   2.2021101E7 = L: Bad {Bad=224, Good=5}
|   |   |   2.2021101E7 = M
|   |   |   |   2.2021102E7 = H
|   |   |   |   |   2.2040105E7 = H: Good {Bad=0, Good=7}
|   |   |   |   |   2.2040105E7 = L: Bad {Bad=5, Good=0}
|   |   |   |   |   2.2040105E7 = M: Bad {Bad=2, Good=0}
|   |   |   |   |   2.2040105E7 = N
|   |   |   |   |   |   2.2051109E7 = M: Bad {Bad=2, Good=0}
|   |   |   |   |   |   2.2051109E7 = N
|   |   |   |   |   |   |   2.1022302E7 = H: Bad {Bad=2, Good=0}
|   |   |   |   |   |   |   2.1022302E7 = N
|   |   |   |   |   |   |   |   1.3066001E7 = H: Good {Bad=0, Good=6}
|   |   |   |   |   |   |   |   1.3066001E7 = M: Bad {Bad=2, Good=0}
|   |   |   |   |   |   |   |   1.3066001E7 = N: Good {Bad=4, Good=12}
|   |   |   |   |   2.2021102E7 = L: Bad {Bad=3, Good=0}
|   |   |   |   |   2.2021102E7 = M: Bad {Bad=8, Good=0}
|   |   |   |   2.2021101E7 = N
|   |   |   |   |   2.2021102E7 = H: Good {Bad=1, Good=2}
|   |   |   |   |   2.2021102E7 = N
|   |   |   |   |   |   13-102-354 = H: Good {Bad=1, Good=5}
|   |   |   |   |   |   13-102-354 = L: Bad {Bad=15, Good=0}
|   |   |   |   |   |   13-102-354 = M: Bad {Bad=5, Good=1}
|   |   |   |   |   |   13-102-354 = N
|   |   |   |   |   |   |   2.1019405E7 = H: Bad {Bad=1, Good=1}
|   |   |   |   |   |   |   2.1019405E7 = N
|   |   |   |   |   |   |   |   2.3022407E7 = H: Good {Bad=1, Good=2}
|   |   |   |   |   |   |   |   2.3022407E7 = M: Bad {Bad=5, Good=0}
|   |   |   |   |   |   |   |   2.3022407E7 = N
|   |   |   |   |   |   |   |   |   13-011-236 = H: Good {Bad=0, Good=2}
|   |   |   |   |   |   |   |   |   13-011-236 = L: Bad {Bad=14, Good=0}
|   |   |   |   |   |   |   |   |   13-011-236 = M: Bad {Bad=3, Good=0}
|   |   |   |   |   |   |   |   |   13-011-236 = N: Bad {Bad=89, Good=1}
```

Fig. 2. The Ruled Tree Model of Each Subject

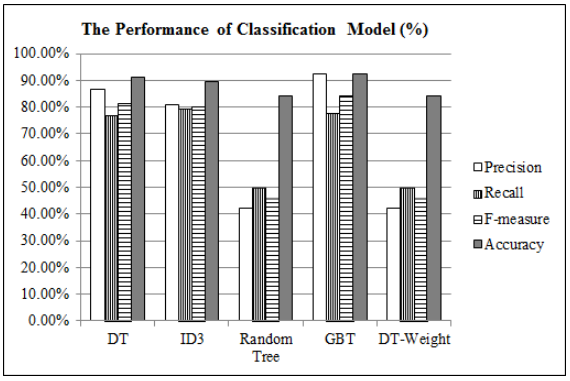

Fig. 3. A Graph of Precision, Recall, F-measure, and Accuracy Score

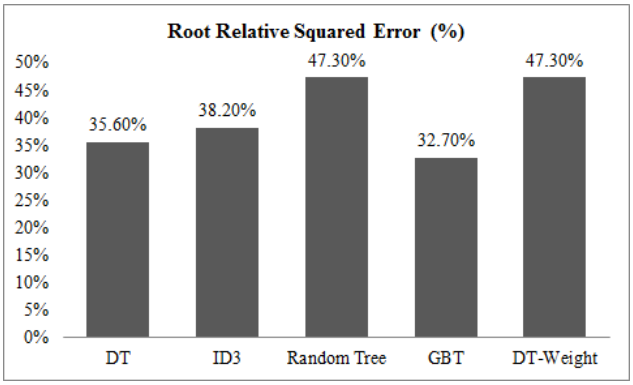

Fig. 4. Comparison of the Root Relative Squared Error

square error can describe the relied performance of each model in the percentage. According to Figure 3, it compares the performance of each classification models. Each measures are evaluated and displayed in the figure. Here, the light bar shows

TABLE I
THE PERFORMANCE OF FIVE CLASSIFICATION MODELS

Model	Precision	Recall	F-measure	Accuracy
DT	86.75	77.03	81.60	91.03
ID3	80.84	**79.74**	80.29	89.66
Random Tree	42.07	50.00	45.69	84.14
GBT	**92.62**	77.85	**84.59**	**92.41**
DT-Weight	42.07	50.00	45.69	84.14

the precision, the vertical bar displays the recall, the horizontal bar represents the f-measure, and the gray bar illustrates the accuracy value. In the Figure 4 shows that the GBT has minimum root relative square error in order to the maximum accuracy (see the gray bar in Figure 3). Both of the random tree algorithm and decision tree with weight based get the maximum root relative square error. So that, the precision, recall, f-measure, and accuracy are the same scores.

The performance of five classification models is represented in Table I. The experiment found that the GBT algorithm gets the highest precision while the random tree and decision tree with weight-based are lowest. The recall score, the maximum is ID3 (79.74%) while the recall of decision tree (77.03%) is close to the GBT (77.85%). To consider the f-measure score which is calculated from the ratio of precision and recall scores. The result displayed that the highest performance is the GBT (84.59%) while the decision tree equals to the second ranking (81.60%). According to the accuracy, the maximum score equals to 92.41% of the GBT algorithm. Finally, the gradient boosted tree: GBT is the best classification model for considering the suitable subject to each major.

VI. CONCLUSION AND FUTURE WORK

In our research, we applied the data mining classification techniques for improving the student performance. We focus on the classification for predicting the suitable subject in the faculty of science and agricultural technology student. Then, the famous evaluations; the precision, recall, f-measure, and accuracy scores are used to measure the performance of each model. To use 17,875 records of student registration in Faculty of Science and Agricultural Technology, Rajamangala University of Technology Lanna Nan. The classification results illustrated that the best model is the gradient boosted tree: GBT algorithm at 92.41%, and the decision tree model get the second ranking (91.03%). While the lowest is both of the random tree and decision tree with weight-based. In the future works, we will evaluate with other data mining technique for improving the student performance.

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REFERENCES

[1] M. Al-Razgan, A. S. Al-Khalifa, and H. S. Al-Khalifa, "Educational data mining: A systematic review of the published literature 2006- 2013", In Proceedings the 1st International Conference on Advanced Data and Information Engineering, 2013, pp.711–719.
[2] R.h Agrawal and R. Srikant, "Fast algorithms for mining association rules". Proceedings of the 20th International Conference on Very Large Data Bases, VLDB, pp. 487–499, Santiago, Chile, September 1994.
[3] Kaur, Hardeep. "A Literature Review from 2011 TO 2014 on Student's Academic Performance Prediction and Analysis using Decision Tree Algorithm." Journal of Global Research in Computer Science 9.5 (2018): 10-15.
[4] Rao, NV Krishna, et al. "A Review on Data Mining Approach used in Education Data Mining using Decision Tree Algorithm." (2018): 1735-1738.
[5] Ahmed, Abeer Badr El Din, and Ibrahim Sayed Elaraby. "Data Mining: A prediction for Student's Performance Using Classification Method." World Journal of Computer Application and Technology 2.2 (2014): 43-47.
[6] Kaur, Parneet, Manpreet Singh, and Gurpreet Singh Josan. "Classification and prediction based data mining algorithms to predict slow learners in education sector." Procedia Computer Science 57 (2015): 500-508.
[7] Chao, Wang, and Wang Junzheng. "Cloud-service decision tree classification for education platform." Cognitive Systems Research 52 (2018): 234-239.
[8] J. Han, M. Kamber, Data Mining Concepts and Techniques, Morgan Kaufmann, 2000.
[9] B. Kamiński, M. Jakubczyk, P. Szufel. "A framework for sensitivity analysis of decision trees". Central European Journal of Operations Research, 2017.
[10] Markus Hofmann, Ralf Klinkenberg,"RapidMiner: Data Mining Use Cases and Business Analytics Applications (Chapman and Hall/CRC Data Mining and Knowledge Discovery Series)", CRC Press, October 25, 2013.
[11] J. R. Quinlan. "Induction of Decision Trees". Mach. Learn. 1, 1 (Mar. 1986), 81–106.
[12] Joseph L. Doob. "Stochastipoic processes". Wiley. p. 46 and 47, 1990.
[13] Ionut Florescu. "Probability and Stochastic Processes". John Wiley and Sons. pp. 294 and 295, 7 November 2014, ISBN 978-1-118-59320-2.
[14] J. H. Friedman. "Greedy Function Approximation: A Gradient Boosting Machine". February 1999 (PDF).
[15] C. Shearer, "The CRISP-DM model: the new blueprint for data mining", Journal of Data Warehousing, vol.5, 2000, pp.13–22.
[16] "Data Mining Curriculum", ACM SIGKDD. 2006-04-30. Retrieved 2014-01-27.
[17] G. Piatetsky-Shapiro, Discovery, analysis, and presentation of strong rules, in Piatetsky-Shapiro, Gregory; and Frawley, William J.; eds., "Knowledge Discovery in Databases", AAAI/MIT Press, Cambridge, MA, 1991.
[18] M. Hofmann and R. Klinkenberg. "Rapidminer: Data Mining Use Cases and Business Analytics Applications". Chapman and Hall/CRC, 2013.
[19] Powers, David M W. "Evaluation: From Precision, Recall and F-Measure to ROC, Informedness, Markedness and Correlation" (PDF). Journal of Machine Learning Technologies. 2 (1): 37–63, 2011.

Designing a Questionnaire for English Teachers,Morejoy Education, Chongqing, China to Figure out Teachers' Need of Training

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***Abstract*—The small scale K12 English training center occupies a sizable market in Chinese Education industry, with the K12 Education, which refers to the Education stage from primary school to high school, is the fundamental and greatest concern part of whole Education Form. Just because the vast market of small scale K12 English training center they are, problems of training center constantly spring up. The most common and unresolved issues of the overwhelming majority of small scale training center are teachers training process, which means that teachers are not satisfied with the existed training process and complained about the low achievement it is. The case study, Morejoy Education in Chongqing, China, is representative among smallest scale K12 English training center. The author would like to use Morejoy Education as an example, with the help of previous research, to design an appropriate questionnaire to find out what do teachers' real need acquiring from teachers' training process.**

Keywords—Small scale K12 English training center, Questionnaire, Teachers' training process, Knowledge Management.

I. INTRODUCTION

Education is the fundamental rights of man, and also the principal element in the development of people, society and countries. In China, Education is the fundamental task for the coming generation [1]. Thus, the Chinese Government gives sufficient support and help to citizens who engaged in the Education industry. Chinese's market size demonstrates a continually growing trend from 2010[2]. The Education System in China can be divided into formal education and informal education. Formal education includes basic education, secondary vocational education, higher education, adult education and others. There are four terms of basic education, also be called K12 education, which are preschool education, primary education, secondary education and high-school education. K12 Education takes possession of 47.1% of, which accounts 10,600 yuan in 2017, Education investment, more than higher education, vocational education and others [3](Fig.1).

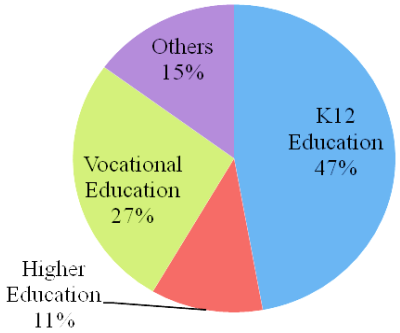

Fig. 1. *The Market Size of Chinese Education in 2017(Qiao, 2017)*

After "two-child" policy has been promulgated in China, which is a policy that allowed couples who meet the requirements have the rights to have a second child, the primary school-age population have to peak 101, 850,000[4]. The influence of "two-child" policy is that the increasing number of children leads to the shortage of educational resources. This kind of shortage in public school brings about the prosperity of training center[5].

A training center is a place where people required knowledge or skill through teaching or training for their own purpose, emerges, with 97% of parents would like to send their child to out-school study in it[6] to meet cultivating an interest and improving English skills [7]. Among all K12 Education training center, small-scale training center which has 10 to 100 staffs and has less than 3.5 million yuan per year, occupies 86% of the whole training center.

The key success factor of a training center is teachers' teaching quality, which directly influences parents' opinion of one training center[8]. Teachers in training centers are the direct provider of training centers' service, which has great influence on an organization's development. Thus, with the help of teachers' training to improve teachers' teaching quality is of great importance. But the existed teachers' training model is the demonstration and collective teaching only[9], which could not meet the requirement of teachers[10]. This is the commonly existed problem among small scale training center in China.

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Since that large and medium scale training center lay emphasis on students and parents who resided in the main district of Chongqing, the market size of small scale training is the districts and counties except for main urban zone of Chongqing. Morejoy Education, which is the market post of small scale training center in Chongqing, provides English class mainly. It has one headquarter in Rongchang, Chongqing and has 8 branches in different districts of Chongqing. Its headquarter has 4 experienced English teachers who have at least 5 years teaching experienced in K12 training center and their job is holding English classes for students, and 7 zero-year experienced English teachers who at least got bachelor's degree and their job is helping experienced teachers to hold English classes and with the help of teachers' training to become a qualified English teachers. It also has 2 Math teachers, 2 Chinese teachers and 14 course consultant staffs. Morejoy Education provides 10 English classes which are English phonetic alphabet (5), Primary New Concept English (2), Middle New Concept English (2) and Advanced New Concept English (1), 4 Math classes, 2 Chinese classes and some individual classes, which is some classroom has one teacher teach directly to only one student)

With the prevalent problem existed in large number of small scale training center, and this problem demand prompt solution, researchers would like to find out the problem existed in Morejoy Education also or not, and design a questionnaire to find out what does English teachers' requirement of training, such as training content and training form, as the first step of solving the common problem of training center for subsequent studies of building a suitable teachers' training process for small scale K12 training center.

II. Literature Review

A. Knowledge Management

Knowledge Management may simply be defined as doing what is needed to get the most out of knowledge resources[11]. The effect of knowledge management is solving the problem and increasing the effectiveness of the organization. Essentially, knowledge management is aimed at using the systematic knowledge of one organization to achieve the goal of the workforce[12]. People, process and technology are the three components of knowledge management. The commonly existed problem of the training center is teachers' teaching quality cannot be improved through observation only, belongs the area of knowledge management, which can be seen like teachers could not use systematic knowledge to improve their teaching quality then cause the low student source for a training center.

B. Knowledge Worker

People who doing their jobs and then creating the company needed or social needed value with the help of their brain rather than labor are knowledge worker[13]. Teachers in training center are knowledge worker also, because they are learning during the whole teaching class to improve their teaching quality constantly to adapt different students' style and teachers' mature teaching quality can help one training center to attract more students to study in.

Teachers' teaching quality needs two parts knowledge, which are practical orientation knowledge and subject orientation content knowledge[14]. Subject orientation content knowledge is explicit knowledge, which is easily acquired knowledge through some books, videos, or the Internet. But practical knowledge is one part of tacit knowledge, which can be cultivated through communication with others, or own daily teaching experience.

C. E-learning

E-learning refers to online learning or network learning by using digital technology platform, which set up on the foundation of the teaching platform. The advantage of E-learning is high efficiency and low cost[15]. For a small-scale company, to decrease operating costs and provide training courses for staffs is of particular importance, in consideration of less capital investment than medium and large scale companies. Thus, E-learning becomes the principal choices about training for small-scale companies.

D. Communities of Practice

Communities of Practice (CoPs) is an activity that inviting same interest or same domain people together to solve some problem of their related area, share and gain professional knowledge or create something new[16]. And there are virtual CoPs and face-to-face CoPs to satisfy different people needs.

Communities of Practice for teachers is a channel for teachers to talk and discuss with experts about teaching experienced and improve individual teachers' competency[17].

E. Questionnaire

As a standardized, indirect and written survey method, Questionnaire is a method that researcher using a unified questionnaire to ask respondents for information or opinion [18]. The question posed with a written form by a researcher, and the answer also shows with a written form by respondents. Because of the form of written, the process of doing an investigation and answering a question is less influenced by personal emotions comparing with interview. Owing to the objectification and standardization, a questionnaire is more realistic to response informant's personal thought. Thus, the questionnaire is the most frequently used, cheaper and time-saving method during investigation process.

There are nine step of designing a questionnaire[19]:

- Decide the aim of a questionnaire;
- Define the target respondents;
- Choose the methods of reaching target respondents;
- Decide on question content
- Develop the question wording;
- Put questions into a meaningful order and format;
- Check the length of the questionnaire;
- Pre-test the questionnaire;
- Develop the final survey form.

III. METHODOLOGY

This article is based on the steps of designing a questionnaire to programme a suitable questionnaire for finding out English teachers' need for training.

A. *Define the aim target respondents and method of questionnaire*

With the problem of Morejoy Education is zero-year experienced teachers' teaching quality could not be improved with the help of existing training process by the previous interview, the aim of the questionnaire is setting about finding out what dose experienced teachers real need of training and what kind of training method is suitable for them.

The respondents of questionnaire do not focus on zero-year experienced teachers only, owing that teachers who have teaching experience in training center, could reveal what kind of tool or method is not only improving teachers' teaching quality but also adapting the situation of small-scale training center than public schools.

Taking into consideration that small scale training center has a limited budget about an investigation, mobile phone becomes an essential part of human, and teachers who worked in training center has the intensive workload, one online and no paper investigation form could meet all of the requirements. SO JUMP™ is a professional platform for online questionnaire survey, evaluation and voting which can easily be filled with the mobile phone. The significant advantage of fast, easy uses and low-cost letting SO JUMP is extensively used by both individuals and enterprises.

Thus, a questionnaire to investigate teachers' training need is released on SO JUMP website for both zero-year experienced teachers and experienced teachers.

B. *Decide meaningful order question contents*

Firstly, the first part of the questionnaire is getting the basic information of respondents, such as name, gender, age, educational background and so on.

The second part of the questionnaire is aiming at finding out what does teachers' sincerely need of training. Thus, there are some questions for them to select, such as teaching style, curriculum requirement and so on.

Finally, the questionnaire is designed to seek out what kind of training method or form can satisfy with teachers' need and at the same time, according to the situation of small scale training center.

With there are previous research survey about finding out an appropriate teachers' training method for teachers in public school and large scale training center, those research are talking about E-learning method, Blended-learning method, Online Communities of Practice training method, and etc., then that new training process got the good result.

Combining with the advantage of E-learning and Communities of Practice and the real situation of small scale training center, researcher came up with some contents of the questionnaire. This part of investigating intended to decide the form of the new training process which both meets the requirement of zero-year experienced teachers and reaches the aim of training.

C. *Pre-test and develop the survey*

After the questionnaire is designed, researcher invited the officer of Education Bureau of Rongchang district, which is responsible for training teachers who worked in public primary school. The objective of inviting officer is examing the questionnaire can find out the training method for teachers or not.

This questionnaire opened for teachers in Morejoy Education to fill from 5th July, 2018 to 10th, July, 2018.

IV. RESULT

This part exhibits what the questionnaire it is and the result of it.

A. *The contents of the Questionnaire*

The questionnaire is divided into two parts: one is the basic information of teachers. There are six contents and 2 questions for teachers to fill, which are: name, gender, age, education background, teaching period and self-evaluation of teaching performance. The other is the content of the questionnaire, with the necessity of training which has two questions, the contents of the new training process which has 7 questions and the way of training which has one questions. The two parts of the questionnaire were distributed into 12 questions (Fig. 2).

As the objective of building a questionnaire is finding out what do English teachers' real need of training, the crucial part of the questionnaire is discussing the contents of new training process.

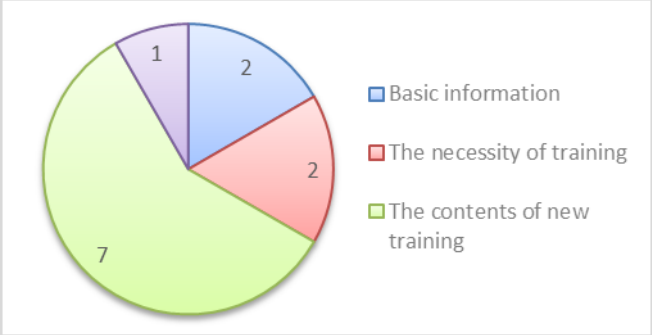

Fig. 2. *The Contents of the Questionnaire*

B. *The result of the Questionnaire*

After 11 English teachers filled the questionnaire, the result of comparing with the background information between experienced teachers and zero-year experienced teachers, it is obvious that experienced teachers are having at least 5 years teaching experienced in training center, thus, all of them are satisfied with their teaching level. Owing to zero-year experienced teachers are lack of teaching experience, 86% of them are not satisfied with their teaching level.

100% of English teachers in Morejoy Education indicates the importance of teachers' training, but the existed teachers'

training process is difficult to satisfy teachers' needs. Thus, all of the English teachers mentioned the aim of training is gaining teaching skills through discussion activities(Fig.3). The bar in blue represents 4 experienced teachers, and the bar in red is on behalf of 7 zero-year experienced teachers.

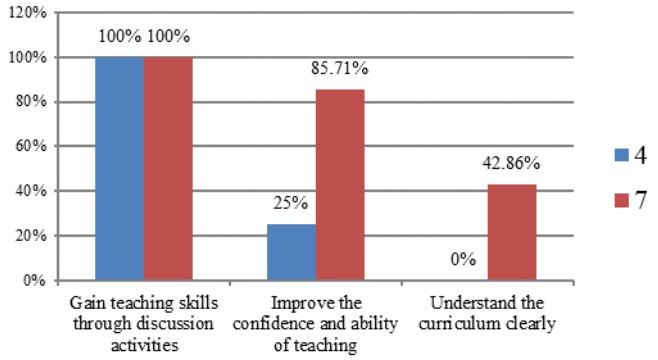

Fig. 3. *The Aim of Training*

From the result of the questionnaire, the large number of teachers are mostly preferred group discussion, and E-learning takes the second place. (Fig. 4)

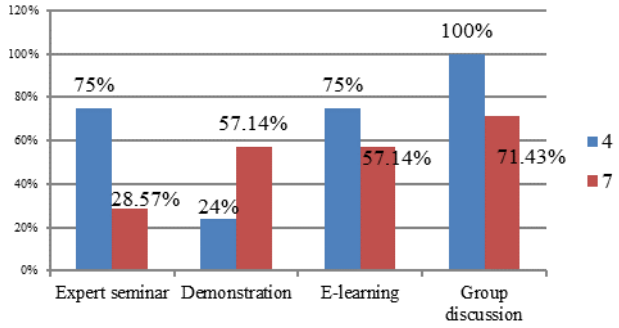

Fig. 4. *The Form of Training*

As teaching is a long and lasting process, it could appear some divinable and unpredictable question of teaching. When facing about problems, experienced teachers are willing to discuss with colleagues to solve this problem, but zero-year experienced teachers do not have the systematic problem-solving method. (Fig.5)

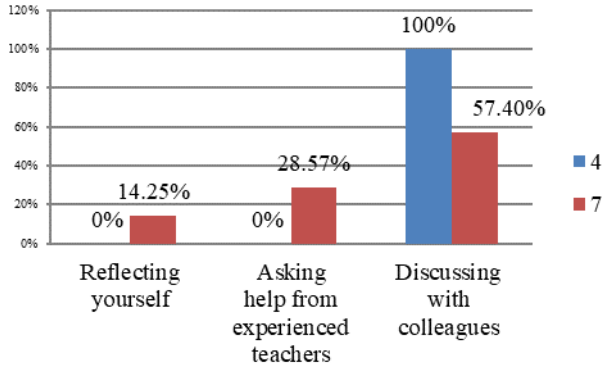

Fig. 5. *The Way of Solving Problems*

Despite some of the zero-year experienced teachers realized the benefit of group discussion, the large number of zero-year experienced teachers are lack of the consciousness of utilizing it, but this is the point that why experienced teachers have sufficient teaching experienced. (Fig. 6)

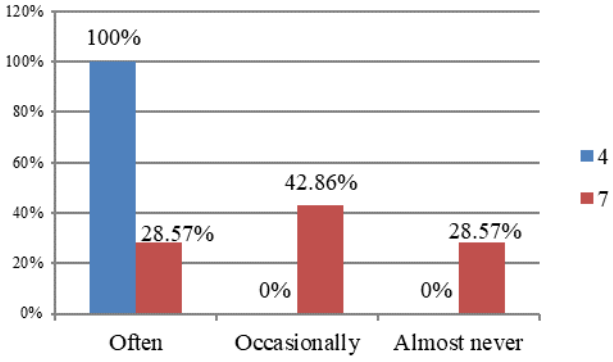

Fig. 6. *The Frequency of Group Discussion*

With the high intensive workload of teachers in Morejoy Education, to find out the receptive and convenient discussion form for teachers is crucial. All of the experienced teachers and a majority of zero-year experienced teachers are preferring to use fixed cycle face-to-face seminars and irregular online discussion. (Fig. 7)

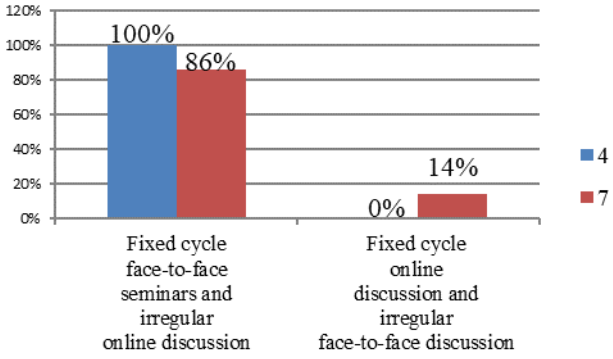

Fig. 7. *The Form of Group Discussion*

Combining with all the data of the questionnaire, the result of the questionnaire can be summarized into four items, which are:

- To build a new teachers' training model is extremely urgent;
- The main contents of the training process are imparting teaching skills;
- The form of training is E-learning in which experienced teachers can impart teaching skills and group discussion;
- The frequency or way of group discussion is fixed period face-to-face seminars and irregular online discussion.

CONCLUSION

This research is aimed at designing a questionnaire to figure out what do English teachers need of training process, in accordance with the steps and principles of designing a questionnaire.

The existed teachers' training process in Morejoy Education is the demonstration only, and the reason why this kind of training process is of no avail, is that it cannot satisfy what do teachers' real need. Thus, the crucial part of building an appropriate teachers' training process is understanding teacher's requirement clearly, which is the guide to design a questionnaire.

Questionnaire as one investigation method having the advantage of low-cost, relatively objective and convenience, could be one choice for a small-scale training center to conduct a survey. The way of building an appropriate questionnaire should completely satisfy the aim of doing research. Thus, the foremost part of the questionnaire is digging out what contents do teachers need and what kind of training form that teachers prefer.

The result of questionnaire truly reflects what do English teachers need of training process, for both experienced teachers side and zero-year experienced teachers side, which is they would like to acquire teaching skills rather than the gaining the confidence of teaching, and they would like to with the help of group discussion to solve the problems when zero-year experienced teachers are facing with teaching problem in class. With one part of teaching problem can be predicted, but others may uncertain, teachers would like to build the fixed-time face-to-face seminar to solve the predictable problems, and with the help of Wechat online group discussion to work out the unpredictable problems at any time. In all, the result of the questionnaire provides the contents for a researcher to build an appropriate and satisfied training process for teachers in Morejoy Education.

In view of the result of the questionnaire, it can summary that the questionnaire is a suitable choice for the researcher put to use as a survey tool in the small-scale training center.

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REFERENCES

[1] Xi Jinping, Video message of congratulation of the first anniversary of the United nation's advocacy campaigns, People's Daily, 2013.

[2] Adam and Huang, Analyzing ICT Policy in K-12 Education in Sudan, World Journal of Education, 2017.

[3] Qiao Xiaoyong, The final report of Education investment, quality-oriented education and vocational education, YIOU Basic Education, 2017.

[4] Yao Yimei, Li Fen and Yin Wenyao, A research of education populations' variation trend in China, under the poliy of "two child", 2015.

[5] Bao Wenwen, The influence of "Two-child" Policy in China, New Area Educaion, 2017.

[6] Zheng Rong, The White Paper on Education in 2016, Learning.sohu.com, 2016.

[7] So Jump, Questionnaire on current situation and teaching methods of English training institutions (parent version), Wen Juanxing, 2017

[8] Chinese society of Education, Investigation report of tutoring education professional teachers' professional development status and training demand, 2017.

[9] Zhao Gang, Research Report of Teacher Training Status and Needs of Teachers in Yushan District, Anhui University, 2013.

[10] Chinese society of Education, Investigation report of tutoring education professional teachers' professional development status and training demand, 2017.

[11] Irma Becerra-Fernandez, Avelino J. Gonzalez & Rajiv Sabherwal, Knowledge Management: Challenges, Solutions and Technologies,Pearson/Prentice Hall, 2004.

[12] Géraud Servin, ABC of Knowledge Management, NHS National Library for Health: Knowledge Management Specialist Library, July 2005.

[13] Marilyn Leask, Caren Lee, Tim Milner, Michael Norton and Dimple Ratho, Knowledge Management Tools and Techniques, Improvement and Development Agency for Local Government, 2008.

[14] Feng Jiang, New Rural Elementary School Teachers' Professional Development Present Situation and Countermeasure Research, School of Educational science, Ludong University, 2017.

[15] Ge Jixue, E-learning: Application in teachers training of national training program, The Ministry of Education of Changsha Normal University, 2015.

[16] Jane Skalicky and Melody West, UTAS Community of Practice Initiative: Readings and Resources, Centre for the Advancement of Learning and Teaching, 2010.

[17] Feng Juan and Xu xin, The research about teachers' communities of practice for teachers' professional development, China Educational Technique & Equipment, 2009.

[18] Fan Xing-kun, The questionnaire design of investigation of library user's satisfication rage, The library of Henan University, 2005.

[19] I.M.Crawford, Marketing Research and Information Systems, FAO Regional Office for Africa, 1997.

The process of developing work potential of village health volunteers and caregivers for caring for home bound and bed bound elderly in community

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***Abstract*— The problem of homebound and bed-bound elderly is significant problem all over the world, including Thailand. Thailand has been interested in solving the elderly problem for the long period time by The National Elderly Plan which is the first 20-year plan that has been in place since 1982. Nowadays, the Department of Health recognizes the importance of this problem so they had implemented training course of the 70-hour Caregiver Program which is being held in 2016 for village health volunteers and supports the operation and development with them as well.**

By the policy of the long-term care system development project in part of public health for dependent elderly in long term care district to develop caregiver's performance to enable their knowledge and understanding, support to practical health care for the elderly efficiency and provide the elderly with a better quality of life. However, there are some limitations in village health volunteers and care givers, depending on their ability.

This research will study the creation of process of develop potential of village health volunteers and caregivers in order to caring for home bound and bed bound elderly and evaluate the performance of village health volunteers and caregivers for caring for home bound and bed bound elderly in community.

Keywords*— *homebound elderly, bed-bound elderly, caregivers, village health volunteers, long-term care, dependent elderly

I. INTRODUCTION

Currently, the world's elderly population has increased by almost 12 percent in 2014 and is projected to increase to 21 percent by 2050, and if compared to others country in ASEAN member in 2015, Thailand has the second highest proportion of elderly people which the number is 15.8%, followed by Republic of Singapore which has the first highest proportion of elderly people. The proportion of Thai population in 2015 is 65.1 million has the population aged 60 and over at 11 million or 16 percent of the total population.

More than 10 million of elderly people, there are a number of elderly people who are dependent on the deterioration of the body and from diseases that cause disability, such as from stroke, resulting in paralysis or from various accidents. By periodic surveys, about 10 percent of the elderly are dependent or about 1 million dependents. It is about 85% or about 850,000 people are home bound elderly which is partial dependent and fully dependent or bed bound about 15 percent or about 150,000 people, the elderly who are attached to the home bound or bed bound tend to be higher. Meanwhile, the proportion of the elderly population is growing and the proportion of older people who are more than 80 years old is growing as well because the average life expectancy of Thai people is higher.

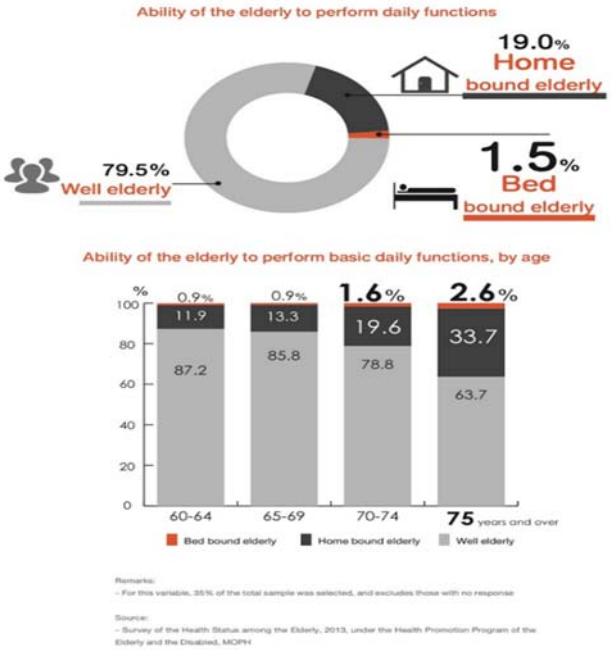

Figure 1: Ability of the elderly to perform daily functions

The 2013 Survey of the Elderly in Thailand under the Health Promotion Program of the Elderly and the Disabled, had studied the health status and problems of the elderly. The survey was conducted among 13,642 persons in 28 provinces, covering the 12 health service networks of the MOPH (Ministry of Public Health's Core Value = Mastery, Originality, People centered, Humility). They had divided by 3 types of Ability of the elderly to perform daily functions, 1) "Bed bound" denotes elderly who cannot perform essential daily functions by themselves. 2) "Home bound" denotes elderly who can perform basic essential functions in their home, but have limited mobility and cannot easily venture outside their home and 3) "Well elderly" denotes

elderly who can perform essential daily functions in their home and also be able to perform social relations outside their home. The survey found that 1.5% of elderly were bed bound, 19.0% were home bound, and 79.5% were well elderly, i.e., they could function independently inside and outside their home.

The problem of home bound and bed bound elderly is significant problem all over the world, including Thailand. Thailand has been interested in solving the elderly problem for the long period time by The National Elderly Plan which is the first 20-year plan that has been in place since 1982. During prime minister Prem Tinsulanond's government, it is currently the second Plan (2002-2021) and also has The Elderly Act since 2003, but the system of care for home bound and bed bound elderly also needs a lot of development.

Figure 2: Thai family's size of number

Figure 2 shows the pattern of Thai residential living has changed dramatically in the past 2-3 decades as the average size of the Thai household has declined sharply. Thirty years ago, there was an average of 5 persons per Thai household, and this declined to 4 persons in 2000 and 3 persons in 2014.

The role of community in the care of the elderly in health is to have a community health center, Sub District Health Promotion Hospital, Primary Care Unit, Family Medical Team, The Elderly Club, Public Health volunteers or village health volunteers. In general, if they need the potential to care for elderly people in the community, they can do. For example, have a training course which relate with care for elderly by invite the elderly care instructor from the hospital, Campaign to promote the value of the elderly, build up the networking between public and private organizations such as community hospitals, center hospital, general hospital and private health facilities in order to support the rehabilitation of the elderly in the community instead of traveling so far to restore health in remote health facilities.

Sub-district Health Promotion Hospital serves as a public health service, health control and health prevention, medical treatment and rehabilitation including risk management for health in individual, family, community and society levels in the area responsible.

The role of community in caring for the elderly in part of social are the duties of the volunteer of public health, volunteer of public health of village and other public health officials. They have the social role of the elderly in the community. Specifically, visit home to provide knowledge about primary care for the elderly and also talks to help loosen the loneliness for the elderly. At the same time, they provided the physical activities which motivate the elderly to interact with the community. In the housing, some communities help to repair the homes of elderly people in order to live safely. These activities will be accomplished through the collaborative work of the network of working elderly people. However, from the project evaluation of the implementation of the village health volunteers project has concerned about the small number of village health volunteers and still need to be developed knowledge to care for the elderly correctly. Even though, village health volunteers work with willingness and still do not have money return in 2015.

Thai society is an elderly society. It has an impact on the economy, society and health. 95 per cent of the elderly are sick with diseases and health problems. Only 5% were healthy. One in two elderly is fat and obese but 26% were desirable health behavior. The number of elderly people who live alone is 600,000 or 7.7%. and elderly people with spouses of 1.3 million or 16 percent. In 2012, the elderly with dependence tend to have the growth number. In 2010, it was found that 19.7% and 58.3% respectively in 2015. while the percent of elderly access to public health services is only 56.7%. The Department of Health recognizes the importance of this problem so they had implemented training course of the 70-hour Caregiver Program which is being held in 2016 for village health volunteers and supports the operation and development with them as well. By the policy of the long-term care system development project in part of public health for dependent elderly in long term care district to develop caregiver's performance to enable their knowledge and understanding, support to practical health care for the elderly efficiency and provide the elderly with a better quality of life.

II. RESEARCH PROBLEM

Due to primary care unit which are Sub District Health Promotion Hospital have care manager, village health volunteers and caregivers, a form of public participation in their own health care, family and community through the training process from public health officer and practical working from village health volunteers and caregivers. It is an important manpower from the group of people who work with public health workers actively. However, they may also be limitations in village health volunteers and care givers, depending on their ability. The role enhancement process to village health volunteers and caregivers have different potentialities. To be appropriate to the context of the community. Therefore, it is important for the development of the performance of village health volunteers and caregivers to care for home bound and bed bound elderly more efficiently.

By finding in document analysis from government publications, government documentations, mass media and related research, as well as participant observation in the community with village health volunteers, caregivers, care manager and director who are responsible for the care of the home bound and bed bound elderly. In additionally, using deep unstructured interview and focus group interview to village health volunteers, caregivers, care manager and director. We found that there are three main aspects that affect the caring for home bound and bed bound elderly in

community, such as the family structure in the community, government policy and related personnel as the detail at below (Figure 3).

For government policy aspect, there are 2 main interesting problems which had found. Long-term care is in the early stages of finding the appropriate long-term care for Thailand. Next, there is no long-term care low for elderly people who are dependent and do not focus on long-term care. For family structure in the community aspect, the size of family has decreased which compare to 10 years ago and the trend living of the elderly with their child has lower proportion numbered as well. For related personnel aspect, the potential for the work of village health volunteers and caregivers are not sufficiently effective.

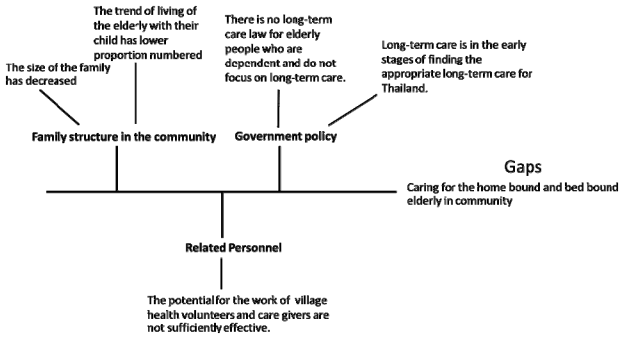

Figure 3: Gap Analysis of caring for home bound and bed bound elderly in community

This research study will focus on related personnel in primary care unit (Sub-district Health Promotion Hospital) which involved in caring for home bound and bedbound elderly people in community. By using Participant observation of village health volunteers, caregivers and care manager for home visits. From deep unstructured interview and focus group interview to village health volunteers, caregivers and care manager, we found that the potential for the work of village health volunteers and caregivers is inadequate. There are two main causes for this problem. Firstly, village health volunteers and caregivers had never any experience in that field before. Secondly, most of training course from public health officers are in the lecture room and also lacking in self-practice. Moreover, both of main causes had never used quality assessment on the job site in order to prove the quality of skill of them on caring for the home bound and bed bound elderly in community.

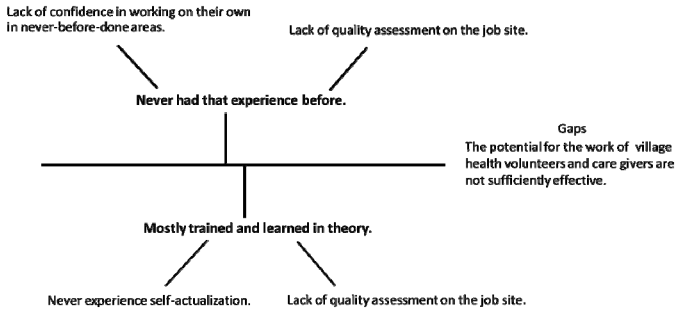

Figure 4: Gap Analysis of human performance of caring for home bound and bed bound elderly in community

III. Methodology/Experimental Design

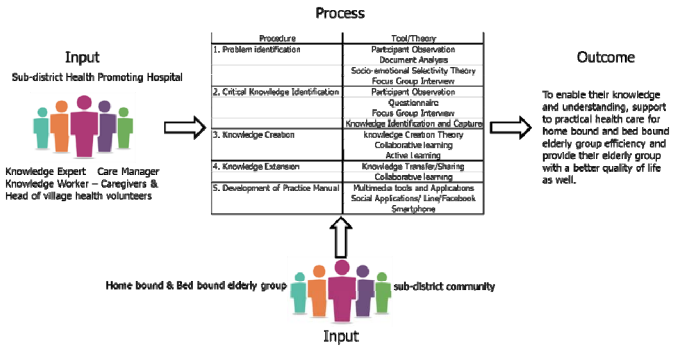

Figure 5: Research Framework

In Figure 7 provides the overview of research framework. For the input, there are 2 main groups came from sub-district health promoting hospital and sub-district community, the knowledge expert is care manager who responsible to create the knowledge in part of tacit knowledge and explicit knowledge into their knowledge worker who are caregivers and head of village health volunteers. Another group is home bound and bed bound elderly group, they will be obtained care from an caregivers and head of village health volunteers at home or sub-district health promoting hospital. For the total processes in the figure, it will be developing the potential of work for caregivers and head of village health volunteers in order to caring home bound and bed bound elderly group efficiency and providing these elderly group with a better quality of life as well.

The population will be selected from Sub-district Health Promoting Hospital and sub-district community which consist of Director (1), Care manager (1), Caregivers (6) and Head of village health volunteers (10) and the key information's selection with criteria is considered from the department of health policy. The sub-district health promoting hospital prototype is the organization which provide the long-term care standard for home bound and bed bound elderly in community, provide an update of the activity daily lives information for classify the number of well elderly, home bound and bed bound elderly and also have care manager, caregivers and village health volunteers to serve them. So we had decided to choose Krawmoong sub-district Health Promoting Hospital because this organization has been selected from department of health to be the sub-district health promoting hospital prototype in the early navigation in Thailand.

The data collection instrument development in this research consists of questionnaire (opened form), Participant observation, deep interview (None-structured) and focus group interview of care manager, caregivers and head of village health volunteers.

The following is the methodological design of this study

Procedure	Tool/Theory	Expected Output
1. Problem Identification	Participant Observation Document Analysis Socio-emotional Selectivity Theory Focus Group Interview	Organization Analysis and Critical Problem
2. Critical Knowledge Identification	Participant Observation Questionnaire Focus Group Interview	Critical Knowledge requirement for resolve the critical problem
3. Knowledge Creation	knowledge Creation Theory Collaborative learning Active Learning	The new knowledge base kit
4. Knowledge Extension	Knowledge Transfer/Sharing Collaborative learning	The new knowledge skill
5. Development of Practice Manual	Multimedia tools and Applications Social Applications/ Line/Facebook	E-learning which contain the critical knowledge base of the caring for bed bound and home bound elderly in Thai community

Figure 6: Research Design/Methodology

There are 5 important steps of research methodology and the stakeholders are knowledge expert (Care manager) from Sub-district Health Promoting Hospital, knowledge worker (Caregivers and Head of village health volunteers) from sub-district community and home bound elderly and bed bound elderly group from sub-district community.

Firstly, look at the problem identification procedure, this procedure is divided by 4 sub-procedure. At first, using questionnaire (open ended) to director and care manager. There are 3 priority issues which had concerned. The first priority needs to create and develop human resources for elderly health care. The second priority needs to build the strength of network partners, supported by government and private organizations, municipalities, elderly clubs, and elderly care volunteers. The third priority needs to support allowance for village health volunteers. Next, using focus group interview (none structured) to care givers and head of village health volunteers, we found that there are 2 interesting issues. There is lack of confidence at work in part issue of they had never done before. Another one is lack of confidence at work in part issue of they had done only with the model in the training room which is differ from the real situation. Next, using document Analysis which found from government publication and mass media. Long-term care is in the early stages of finding the appropriate long-term care for Thailand, the size of family has decreased and the trend living of the elderly with their child has lower proportion numbered. This procedure can apply socio-emotional selectivity in order to explain the major causes such as life is more independent, housing starts more uncomfortable and moving to find a job in a big city are the components to affect the coexistence of family members and become to have the living separately.

Secondly, in critical knowledge identification procedure, using participant observation, It found that the knowledge of each individual is unequal. There are fewer caregivers who are expert in every knowledge based for caring home bound and bed bound elderly group in community. Family care team from community hospital cannot provide adequate support with caregivers and village health volunteers in community for home visit because they have to do their job routine almost every day. So, they can available support for home visit around one time per month. By using Questionnaire which based on Caregiver Training Guide 70-hours course from Department of Health, we found that from 7 knowledge-based criteria for caring home bound and bed bound elderly which are (1) Environmental Management and Housing for the Elderly (2) Prevention of complications (3) Wound (Clean, Dirty or infected wound and Pressure) (4) Rehabilitation and (5) Personal Hygiene. Most of them (4 from 6 caregivers) had never done by themselves before in (3) Wound & (4) Rehabilitation. Next, using Focus Group Interview to verify the problem again with caregivers and head of village health volunteers. There are two main causes for this problem. (1) village health volunteers and caregivers had never any experience in that field before. (2) most of training course from public health officers are in the lecture room and also lacking in self-practice. Both of main causes had never used quality assessment on the job site in order to prove the quality of skill their skill on caring for the home bound and bed bound elderly in community. So, the output for this procedure are 2 main issues, they need support from knowledge expert (care manager or public health officers) in order to sharing the especially knowledge based (3) & (4) at more detail in the training room both lectures and practicing. Then after finished training, caregivers and village health volunteers were evaluated from care manager in order to make sure the result is satisfied.

Thirdly, Knowledge creation procedure, this section will be divided by 4 main processes of knowledge spiral in SECI model which are socialization, externalization, combination and internalization.

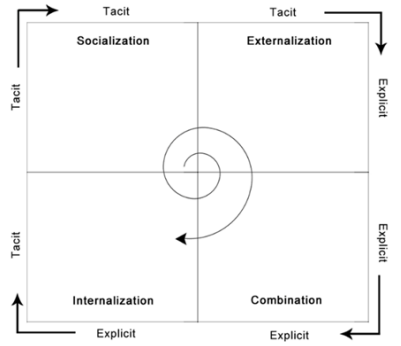

Figure 10: SECI model

In the training room, care manager can also use active learning in order to apply case studies, brainstorming, informal groups, peer review and interactive lecture demonstrations and use collaborative learning in order to establish clear group goals, keep groups midsized, build trust and promote open communication and also create a pre-test and post-test with care givers and head of village health volunteers. So the output for this procedure is to selected knowledge based criteria (3) for developing the material and then care manager who is the knowledge expert. By now, care manager had already taught to caregivers and after finished the class, caregivers group feel confidence better than before and can apply this knowledge based in the real situation by themselves. Likewise, care manager still had monitored and evaluated the performance until the result has completed.

Fourthly, Knowledge extension procedure can be deployed into others community by using knowledge transfer and knowledge sharing. This process, others community will be using the same knowledge base kit and do the same activity as the first community had done before and then evaluate their performance in the final step. After that, they will be having the new skill of caregivers and head of volunteers for caring home bound and bed bound elderly group.

Finally, Development of practice manual procedure will be creating and deploying into their social application like Line on smartphone. Using the combination of multimedia files such as video record, pictures or important information and URL Link which relate into the knowledge base kit. Then, it will be integrating all of these components and creating E-learning kit for caring of bed bound and home bound elderly group in order to anyone in the community can learn anytime.

IV. RESULTS/DISCUSSION

The first output has been collected from director, care manager, caregivers and head of village health volunteers by participant observation, using questionnaire (open ended) and deep interview one-on-one and focus group (None structured). We found that there are some interesting issues from caregivers and head of village health volunteers below:

1. Caregivers and head of village health volunteers had a lack of practicing in some part of knowledge base for caring of bed bound and home bound elderly group.
2. Caregivers and head of village health volunteers had never done before in some part of knowledge base for caring of bed bound and home bound elderly group.
3. Caregivers and head of village health volunteers usually learn the material of knowledge base for caring of bed bound and home bound elderly group from lecture (passive learning) only.

The second output has been collected from care manager and caregivers using participant observation and deep interview after they had learned from knowledge base kit of the different types of wound which care manager used for teaching. So we found that there are some interesting issues from caregivers below:

1. They can understand for different types of wound better than before and already enable the practicing in the real situation with bed bound and home bound elderly by themselves confidently.
2. Caregivers and head of village health volunteers still has evaluated for different types of wound with home bound and bed bound elderly group from care manager in order to make sure that the result has already complete.

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REFERENCES

[1] Antonucci, T. C. 1990. Social Support and Social Relations. In R.H. Binstock & L.K. George, Handbook of Ageing and the Social Sciences (Third Edition), pp. 205 - 226. San Diego: Academic Press.

[2] Ageing in the Twenty-First Century: A Celebration and A Challenge: United Nations Population Fund: UNFA & HelpAge International

[3] Barnes, Douglas (1989). Active Learning. Leeds University TVEI Support Project, 1989. p. 19

[4] Bloom, B. S., Krathwohl, D. R., & Masia, B. B. (1956). Taxonomy of educational objectives: The classification of educational goals. New York, NY: David McKay Company.

[5] Bonwell, Charles; Eison, James (1991). Active Learning: Creating Excitement in the Classroom (PDF). Information Analyses - ERIC Clearinghouse Products (071). p. 3. ISBN 978-1-878380-08-1. ISSN 0884-0040

[6] Carsrtensen, L. 1995. “Evidence for a life span theory of socioemotional selectivity: Current directions.” Journal of Psychological Science. 4: 151 – 156

[7] Dillenbourg, P. (1999). Collaborative Learning: Cognitive and Computational Approaches. Advances in Learning and Instruction Series. New York, NY: Elsevier Science, Inc.

[8] Foundation of Thai Gerontology Research and Development Institute, 2014

[9] Lee, H.; Bonk, C.J. (2014). "Collaborative Learning in the Workplace: Practical Issues and Concerns". International Journal of Advanced Corporate Learning

[10] Nonaka, Ikujiro; Takeuchi, Hirotaka (1995). The knowledge creating company: how Japanese companies create the dynamics of innovation. New York: Oxford University Press. p. 284.

[11] Phillips, D., Siu, O., Yeh, A., & Cheng, K. 2004. Informal social support and older persons’ psychological well - being in Hong Kong.” Paper presented at the conference on the changing Asian Family: A support system with holes. 24 - 26 May. 2004. Malaysia.

[12] Thai Health Promotion Foundation, ThaiHealth Centre, 99/8, Soi Ngamduplee, Thung Maha Mek, Sathorn, Bangkok 10120, Thailand

[13] World Health Organization. (2011). Hypertension fact sheet. Retrieved March 10, 2012, from http://search.who.int/search?q=Hypertension&ie=utf8&site=default_collection&client=_en&proxystylesheet=_en&output=xml_no_dtd&oe=utf8

[14] เกรียงศักดิ์ ธรรมอภิพล และคณะ.(2555). รูปแบบการจัดการดูแลระยะยาวกลุ่มผู้สูงอายุติดเตียงโดยชุมชน.วารสารวิทยาลัยราชสุดาเพื่อการวิจัยและพัฒนาคนพิการ.8(11)

[15] กระทรวงการพัฒนาสังคมและความมั่นคงของมนุษย์.(2558). สถานการณ์ผู้สูงอายุไทย พ.ศ. 2550. Retrieved Oct 8, 2015, from http://www.m-society.go.th.

[16] ชิดสุภางค์ ทิพย์เที่ยงแท้, กฤษฎา เปรมวงค์ และ ทิพวรรณ ผ่องศิริ.(2558).ทีมหมอครอบครัวเห็นทุกข์สร้างสุข ด้วยจิตอาสา.กรุงเทพฯ: จรัลสนิทวงศ์การพิมพ์ จากัด

[17] ฉรงค์ สหเมธาพัฒน์.(2557).สถานการณ์ผู้สูงอายุติดเตียง.Retrieved July 9, 2015 from https://www.hfocus.org/content/2014/03/6726

[18] ดวงฤดี ลาศุขะ, ทศพร คำผลศิริ, กนกพร สุดำวัง, และโรจนี จินดนาวัฒน์. (2554). การพัฒนาศักยภาพผู้นำในการสร้างเสริมกระบวนการพัฒนาสุขภาวะแบบองค์รวมของผู้สูงอายุในชุมชน. วารสารสภาการพยาบาล, 26(พิเศษ), 59-68.

[19] สายพิณ เกษมกิจวัฒนา, และปิยะภรณ์ ไพรสนธิ์. (2557). ญาติผู้ดูแลผู้ป่วยเรื้อรัง: กลุ่มเสี่ยงที่ไม่ควรมองข้าม. วารสารสภาการพยาบาล, 29(4), 22-31.

[20] สำนักงานคณะกรรมการพัฒนาการเศรษฐกิจและสังคมแห่งชาติ สำนักนายกรัฐมนตรี.(2555). แผนพัฒนาเศรษฐกิจและสังคมแห่งชาติ ฉบับที่ 11 (พ.ศ. 2555–2559).

[21] สำนักงานคณะกรรมการพัฒนาการเศรษฐกิจและสังคมแห่งชาติ สำนักนายกรัฐมนตรี.(2560). แผนพัฒนาเศรษฐกิจและสังคมแห่งชาติ ฉบับที่ 12 (พ.ศ. 2560–2564).

[22] สำนักนโยบายและยุทธศาสตร์ กระทรวงสาธารณสุข. (2554). กรอบยุทธศาสตร์งานสร้างเสริมสุขภาพและป้องกันโรคระดับชาติ ปี 2554-2558. กรุงเทพฯ: สามเจริญพาณิชย์

[23] สำนักงานกองทุนสนับสนุนการสร้างเสริมสุขภาพ.(2555). นวัตกรรมเพื่อผู้ป่วยติดเตียงต่อยอดแผนพัฒนาระบบสุขภาพชุมชน. Retrieved July 18, 2015, from http://www.thaihealth.or.th.

DECISION SUPPORT SYSTEM FOR SUBJECTS REGISTRATION OF COMPUTER SCIENCE STUDENT

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***Abstract*—Nowadays, the concept and theory to support the educational system have been continuously developed. One of the major problems of the educational system that has to be solved is that the grade point average (GPA) of student are reducing when studying at higher levels. This problem arises from students choosing to study subjects that are not consistent with their learning ability. This paper presents the process of analyzing and solving the problem of gradual decline. Based on the statistical technique, the method presented in this article can recommend students that should register any subject that will likely get good grades performance. The results of performance investigation show that the proposed method can accurately recommend student choosing subjects that will achieve good or higher grades with 86.67% accuracy.**

Keywords—educational progression, student support, data mining, course registration suggestion, learning performance

I. INTRODUCTION

At present, the information is increasing more and more based on information technology developed especially in educational institutions. Analysis of educational data is very popular nowadays. The people are known as knowledge discovery from very large databases or data mining. It is very popular nowadays. It has been used extensively in various forms, particularly in relation to education. Such factors that affect student learning level, find the most appropriate department for students. This paper presents techniques using statistical models. The objective is to solve the problem of lower grades students. Because the results grades are important, it is an opportunity to graduate. Scholarship and choose a future job.

The curriculum standard for computer science student requires that each student must register at least 40 subjects. Information of computer science students between 2012 – 2013 it was found that the most registered period was the second to third-year students. In addition, it was found that 35% of students with GPA lower. The result of this search, this knowledge will allow students to choose subjects that make their academic performance is good quality.

Data mining has been applied in many fields, such as business education, medical. In this paper, we present the data mining techniques used in the development of education.

This paper presents an effort to solve the problem of having a reduced grade of students. By introducing the method for selecting the subjects that students are expected to achieve a good quality academic result. The good quality favorably means grade is B or up by measuring the level of basic education courses in Thailand.

This paper is organized as followers. Section 2 we present the literature review. In Section 3 we present the method and experiment. Conclusions and future work are presented in Section 4.

II. LITERATURE

A. Education Development

Past research has used data mining techniques to analyze information about the school. Such as the analysis of relationship student factors affecting the level of academic [1]. This paper presents Decision Analysis Techniques with Decision Tree Techniques as one technique for data mining. This objective relies on the relationship of the student to indicate the grade of the student.

The association rule mining is used to predict Student Learning Outcome [2]. The system can suggest students adjust the method of learning the remaining subjects. The results show that the system increases the overall average outcome of students. This system supports students to be able to completely graduate their courses.

Applying a data mining technique can also help students in selecting their majors [3]. The objective is students can choose based on their skills. This paper is using data mining techniques using K-fold cross-validation and find out an important factor influencing the decision of students choose main study program.

Use data mining techniques to analyze pre-test results and skills to increase student potential[4]. This paper applies K-mean clustering algorithm for grouping students into two groups, students learning bad or good. The first objective is to provide information to faculty, advisors or faculty members to take advantage of student care. The second objective is to reduce the risk of students who fail to success the educational criteria.

B. CRISP-DM Framework

CRISP-DM is like a blueprint that is widely used. Similar to the ISO process in industrial plants CMMI is a standard process in software development. Standard process for data analysis in data mining Developed in 1996, the collaboration of 3 companies is DaimlerChrysler SPSS and NCR This process is called "Cross-Industry Standard Process for Data

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Mining" or "CRISP-DM"[5]. This process consists of 6 steps as shown in Figure 1.

At present, research has become more popular with CRISP-DM in data mining, especially in education. Such as the application of data mining technology to predict student success and failure[6]. Along with offering the use of CRISP-DM with data sets. The objective is to separate the hidden form from student information. These patterns can be seen in relation to the variables of the students. After that, the model was created and tested using the sample data set of undergraduate students.

Predictive analysis of the academic performance of student [7] selected CRISP-DM process for the design of data mining. The objective is to predict student data at the end of one year of study. In this process, descriptive statistics are analyzed to obtain in-depth information. Then compare the results to predict the class with other models.

Analyzing college graduation rates in higher education institutions has become the main focus in measuring institutional performance [8]. This article a hybrid data envelopment analysis (DEA) combined with the Cross-Industry Standard Process for Data (CRISP-DM).The objectives to evaluate the effectiveness of undergraduate college students. These analyzes provide useful information and policy support for university administrators.

III. EXPERIMENT

From student data from computer science graduated during the academic year 2012 – 2013. We divide the operation method into 6 parts according to the CRISP-DM Framework as shown in Figure 1.

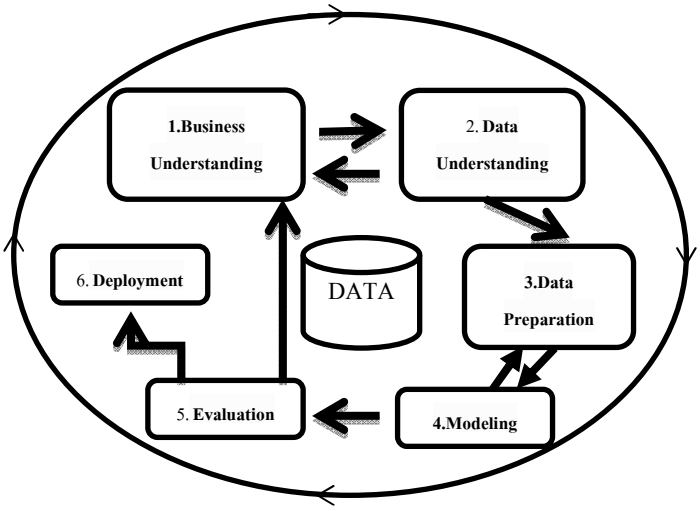

Fig. 1. CRISP-DM Framework

A. Business Understanding

The first step in the CRISP-DM process is to understand the problem. This paper means to solve the grades lower. We discuss the application of data mining and education data. The objective is to help guide the subjects that should be registered because it will result in good grades results. The solution reduced academic performance by using data mining can be done in various methods. This paper presents statistical modeling techniques.

We propose performance measurement. We have divided the data into two parts to measure the efficiency of the system. The year 2013 data is analyzed and the 2012 data is compared to measure the performance of the statistical model.

B. Data Understanding

The data used in the analysis is the registration students of 12,000 row. Information is computer education information. We choose from only the information of the graduate students. The information consists of student code, major, subject name, subject code, grade as shown in Table I. This step starts from collecting data. After that, it will check the data that has been collected to see the accuracy of the data. And consider whether to use all the data or need to select some data for analysis.

TABLE I. DISPLAY ALL STUDENT REGISTRATION INFORMATION.

Stu_code	Year of study	Major	Subjects	Sub_Code	grade
00001	2012	Computer science	Computer Science 1	CS 211	B
			Introduction to Object-Oriented Programming	CS 217	C+
00002	2013	Computer science	Principles of Thai language	TL 211	D+
...	...	…	…	...	...

C. Data Preparation

This step is a step to convert the data that has been collected. The objective is to become the next step in the analysis. This data conversion must be done correctly by deleting and edit information. Such as converting data to the same range or missing information. This step is the most a long time step of the CRISP-DM process. Table II is an example of the data that has already been converted. The first variable is stu_code, is the student code. The next variable is the subject code. The objective is to collect data on grades.

TABLE II. DISPLAY ALL STUDENT REGISTRATION INFORMATION.

number	Stu_code	CS 321	CS 200	JP 313	JP 315	...
1	00001	A	B+	B	C	...
2	00002	B	B+	C	C+	...
...	…	…	…	…	…	...

The data in Table III are classified into two sections. The first part is Subjects in the field, meaning subjects that are in the group that compels students to study. Most of them are subjects that are directly related to computer science. The second part is Subjects outside the field. Most subjects require students to register from other disciplines. The next step after dividing the course and separate the data is the 2nd and 3rd academic year for easy analysis.

TABLE III DISPLAY ALL STUDENT REGISTRATION INFORMATION.

Year of study 2012	
Number	**Stu_code**
1	00001
2	00002
…	…

Subjects in the field					
2nd academic year			**3rd academic year**		
CS 321	**GCH 321**	**…**	**CS 200**	**GD 200**	**…**
A	C+	…	B+	C+	…
…	…	…	..	…	..

Subjects outside the field					
2nd academic year			**3rd academic year**		
CS 321	**GCH 321**	**…**	**CS216**	**JP400**	**…**
B	B+	…	C+	D+	…
…	….	…	…	…	…

D. Modeling

This step will be the process of analyzing data with techniques. Sometimes, it may be necessary to go back to the Data Preparation step to convert the data appropriately. From the information mentioned in the introduction .It was found that 35% of the students in the grades decreased during the 2nd and 3rd academic year because this period from the survey results was the most registered period. For this reason we use this information to analyze the cause of the problem. Figure 2 is an analysis of the data from Table 3, by means of a numerical grade A = 8, B + = 7, B = 6, or F = 1. Next step, then find the percentage of each group of subjects. Found that 169 computer science students percentage of students in Subjects in the field reduced to 119 up to 50. And percentage of students in Subjects outside the field reduced to 149 up to 50. We therefore choose to introduce the subjects registered in the Subjects outside the field because there is a result that results in a reduced in student results.

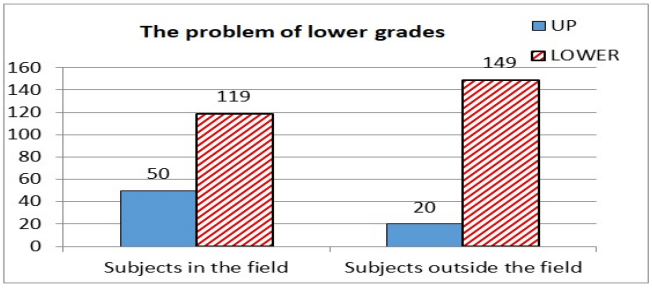

Fig. 2. Compare subjects in and outside of the field.

Figure 3 is an image histogram to study Subjects outside the field. The X axis is the number of students enrolled. The y axis is the number of subjects that students register. Because there are some subjects that are taught less and therefore can't be analyzed in this section. This graph shows data from our study is registered at least 10 of the 23 subjects. For this reason, we therefore take subjects that is in this frequency range discarded.

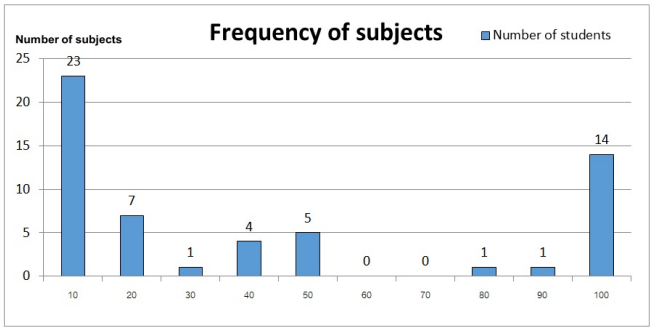

Fig. 3. Graph showing the frequency of study selection subjects outside the field

Figure 4 is a graph showing the percentage of subjects after removing subjects that haven't been analyzed. The data from the eliminated consisted of subjects with a student enrollment of less than 10, and some of which are registered in the year 2012, but not registered in 2013. The results of the study subjects 56 reduced to just 36.

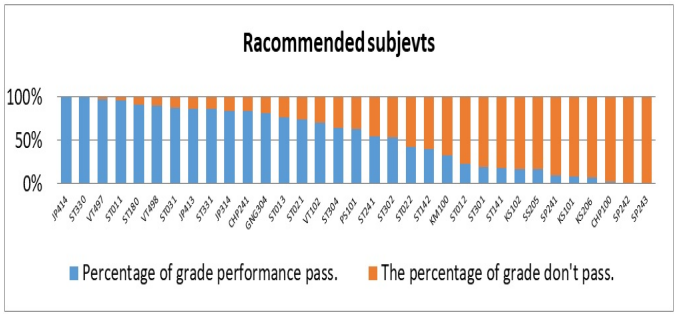

Fig. 4. Graph showing percentage of study selection subjects outside the field ascending.

Figure 5 is a survey of students studying in computer science from a total of 94 data. Topics that if the system supports the introduction of any one subject. The topic of the question is "How much will choose to believe that percentages are recommended?". The results show that most students choose to believe that the recommended percentage is 70 percent. We therefore used this result as a criterion for cutting subjects with a percentage of students getting good grades below 70 percent leaving as shown in Figure 6.

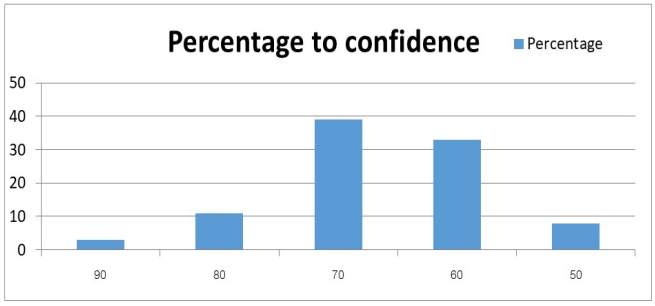

Fig. 5. Survey of students to choose percentage to confidence.

E. Evaluation

Figure 6 uses the model created from the year 2012 data to introduce the course to the year 2013 data. Figure 7 select the specific information of the subjects that are registered as well to compare. Found that if students choose 15 subjects as recommended by the system. There are 13 subjects that most

students study on a good basis. That is system can recommend the correct subjects 86.67%

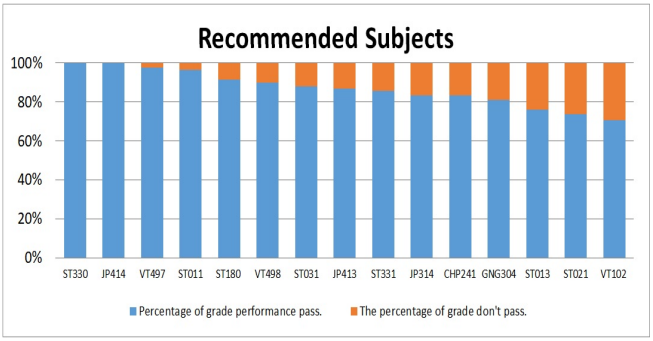

Fig. 6. Recommended subjects compared to the year 2013 information

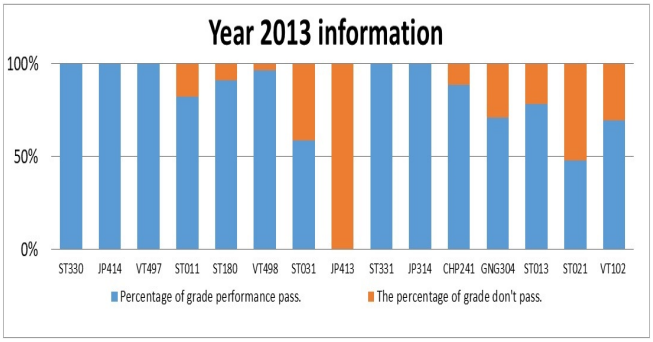

Fig. 7. Recommended subjects compared to the year 2013 information

F. Deployment

The results of analyzes of computer science students. We can recommend subjects to new students through the website. Students can choose to study subjects that will enable students to achieve good grade results (grade B up) with the subject guidance system 86.67% accurate.

IV. Conclusion

This research applies data mining techniques to solve the problem of lowering the academic performance of computer science students. The proposed method can recommend subjects that students can get a good or higher academic grade. By using prior data to analyze and create decision support systems for subject registration in the later years. The results of this recommendation are quite satisfactory. Statistic based method can select some subjects that students can study well with 86.67% accuracy. However, this paper does not mention the analysis of various factors that may affect the performance of the model, such as gender, age, etc. Thus, the proposed method still has to be improved in order to develop the suggestion system to be the most effective. The performance compared with relevant research is also investigated in the future.

Refesrences

[1] Osmanbegović, Edin & Suljic, Mirza. (2012). DATA MINING APPROACH FOR PREDICTING STUDENT PERFORMANCE. Journal of Economics & Business/Economic Review. 10. 3-12.

[2] Al-Hatem A.I., Masood M., Al-Samarraie H.Fostering student nurses' self-regulated learning with the Second Life environment: An empirical studyJournal of Information Technology Education: Research, Volume 17, 2018

[3] Sugiyarti, Eka & Jasmi, Kamarul Azmi & Basiron, Bushrah & Huda, Miftachul & Maseleno, Andino. (2018). Decision Support System of Scholarship Grantee Selection using Data Mining. International Journal of Pure and Applied Mathematics. 119.

[4] Bansal, Arpit & Sharma, Mayur & Goel, Shalini. (2017). Improved K-mean Clustering Algorithm for Prediction Analysis using Classification Technique in Data Mining. International Journal of Computer Applications. 157. 35-40. 10.5120/ijca2017912719.

[5] Leventhal, B. (2010). An introduction to data mining and other techniques for advanced analytics. Journal of Direct, Data and Digital Marketing Practice, 12(2), 137-153, doi:10.1057/dddmp. 2010.35.

[6] Behzad Nakhkob1, M. K. (2016). "Predicted Increase Enrollment in Higher Education Using Neural Networks and Data Mining Techniques." Journal of Advances in Computer Research

[7] Asif, R., Merceron, A., Ali, S., & Haider, N. (2017). Analyzing undergraduate students' performance using educational data mining. Computers & Education, 113(Supplement C), 177–194.

[8] Chen, Ya & Chen, Yao & Oztekin, Asil. (2016). A hybrid data envelopment analysis approach to analyse college graduation rate at higher education institutions. INFOR: Information Systems and Operational Research. 55. 1-23. 10.1080/03155986.2016.1262584.

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