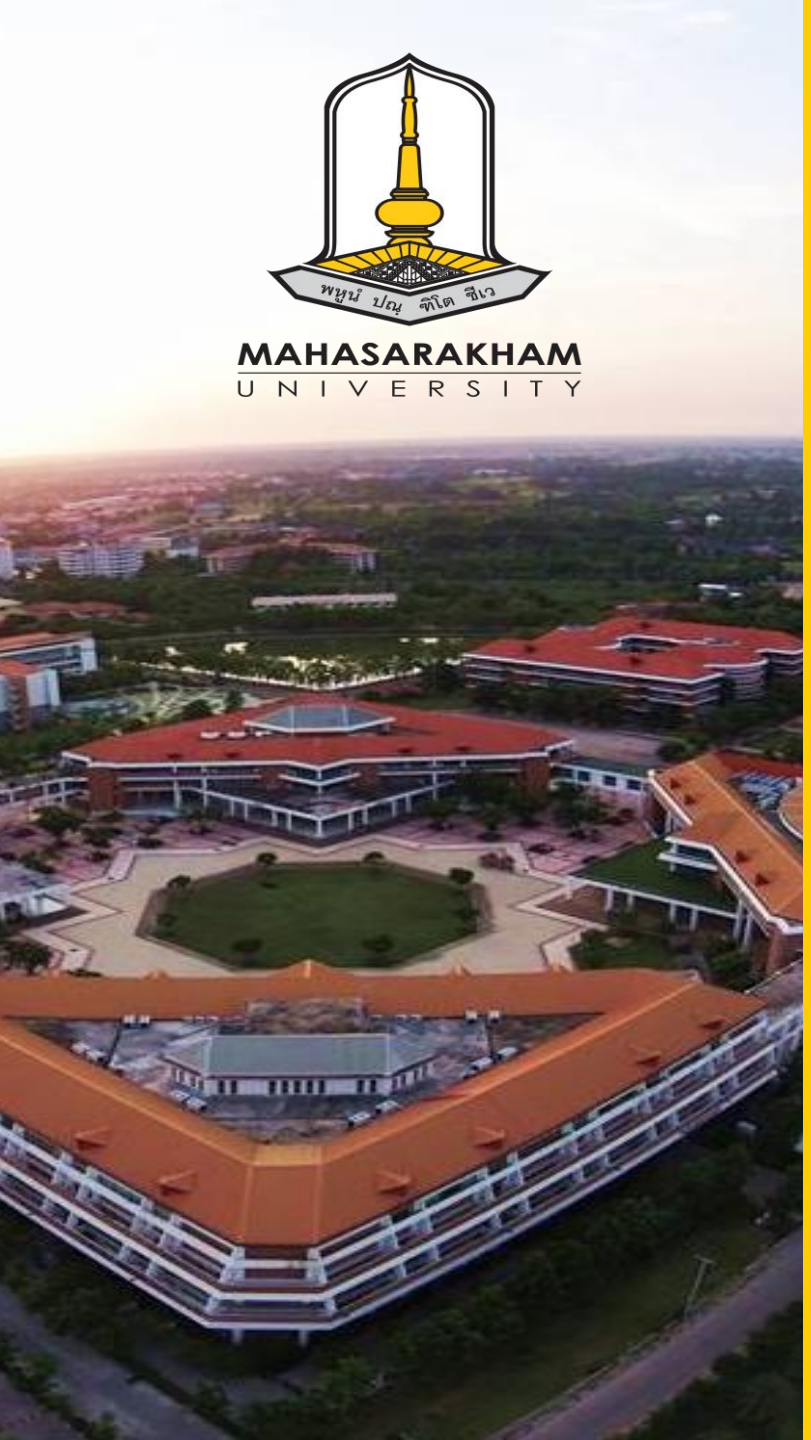

EFFECTIVE FACE VERIFICATION SYSTEMS BASED ON THE HISTOGRAM OF ORIENTED GRADIENTS AND DEEP LEARNING TECHNIQUES

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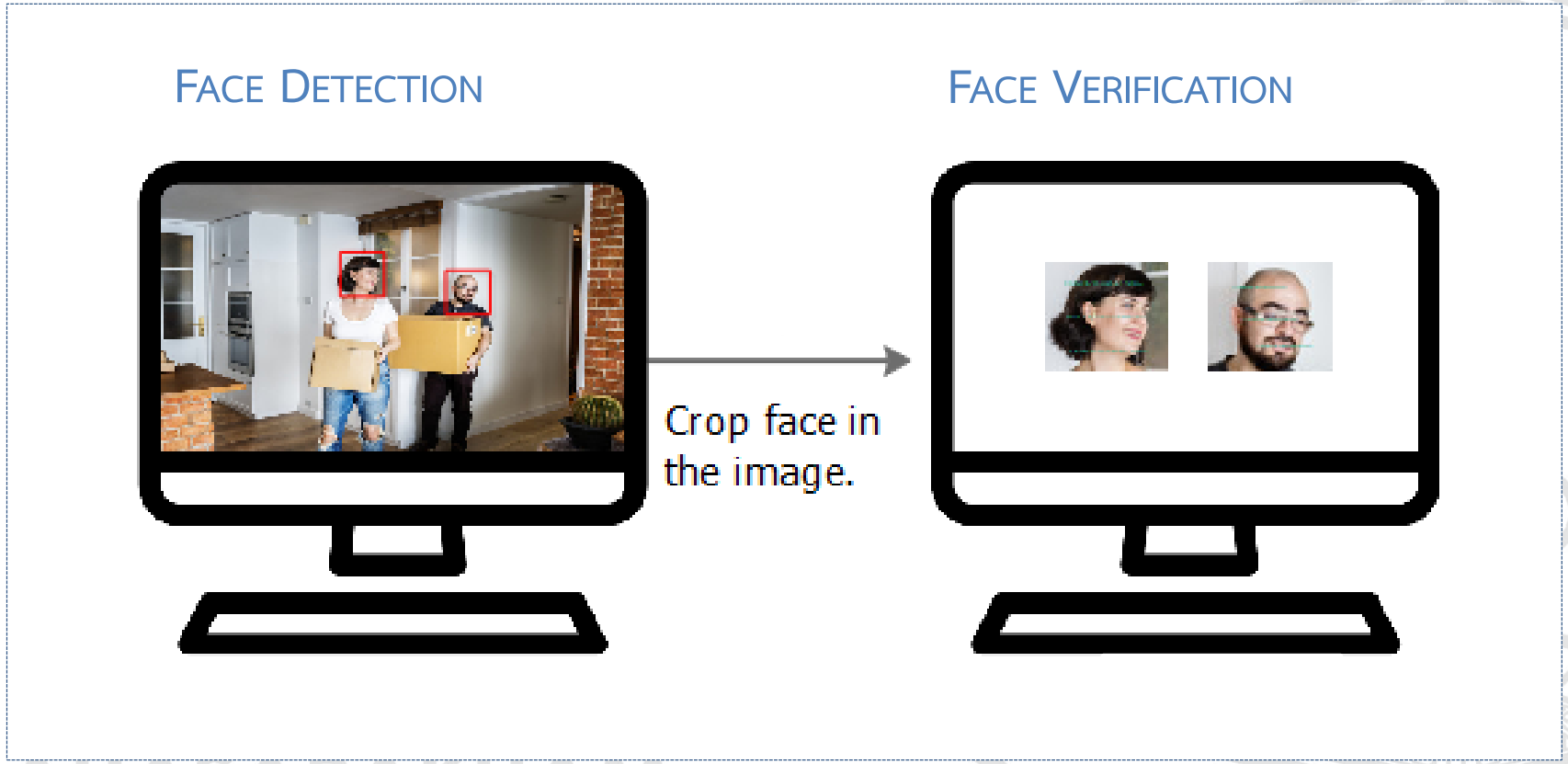
Outline

- Face Verification Systems
  - Face Detection
  - Face Encoding
- Face Image Dataset
- Experimental Results
- Conclusion and Future Work

Face Verification Systems



Face Image Datasets

The BioID Face Dataset

- The BioID face dataset used in the face detection experiment includes 1,513 frontal In this dataset from 21 subjects.
- The image resolution is 384x286 pixels.
- Image is the grey level.

Face Image Datasets

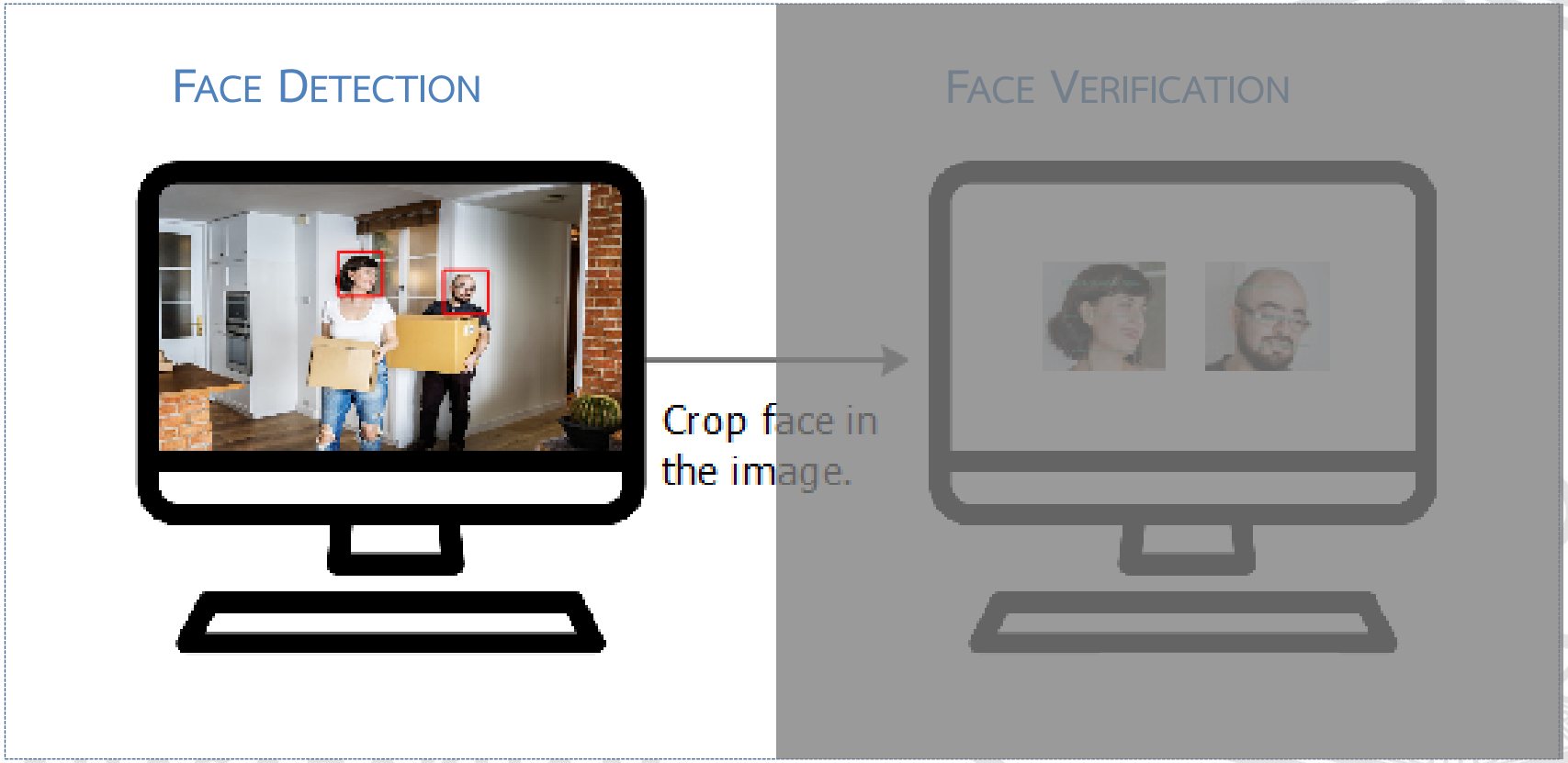
The FERET and ColorFERET Datasets

- The FERET and ColorFERET used in face verification experiment.
- The FERET dataset includes 1,372 images from 196 subjects.
- The ColorFERET dataset includes 3,553 images from 474 subjects.
- Image resolution of 384x256 pixels.

The FERET dataset

The FERET dataset

Face Verification Systems



Face Verification Systems

Face Detection

We experimented face detection techniques on **“The BioID Face Dataset”**

Face Verification Systems

Face Detection

We experiments the performance of four face detection techniques including as follows:

I. **MMOD-CNN**
II. **Haar-Cascade**
III. **Faced**
IV. **HOG+SVM**

Experimental Results

Evaluation Methods

Face detection accuracy which is given by:

$$Accuracy = Acc - Err$$

when

$$Acc = \frac{c*100}{N}$$

$$Err = \frac{e*100}{N}$$

where

c The number of the face images after applying face detection method.

e The number of the error face images.

N The total number of the face images of the face dataset.

Face Verification Systems

Face Detection

- Performance of face detection techniques on The BioID Face Dataset.
- The accuracy obtained from **HOG+SVM was 99.60%**

Methods	Number of face detected	Number of error detected	Accuracy (%)
HOG+SVM	1,507	0	***99.60***
MMOD-CNN	1,513	40	97.36
Haar-Cascade	1,459	40	93.79
Faced	1,449	107	88.70

Experimental Results

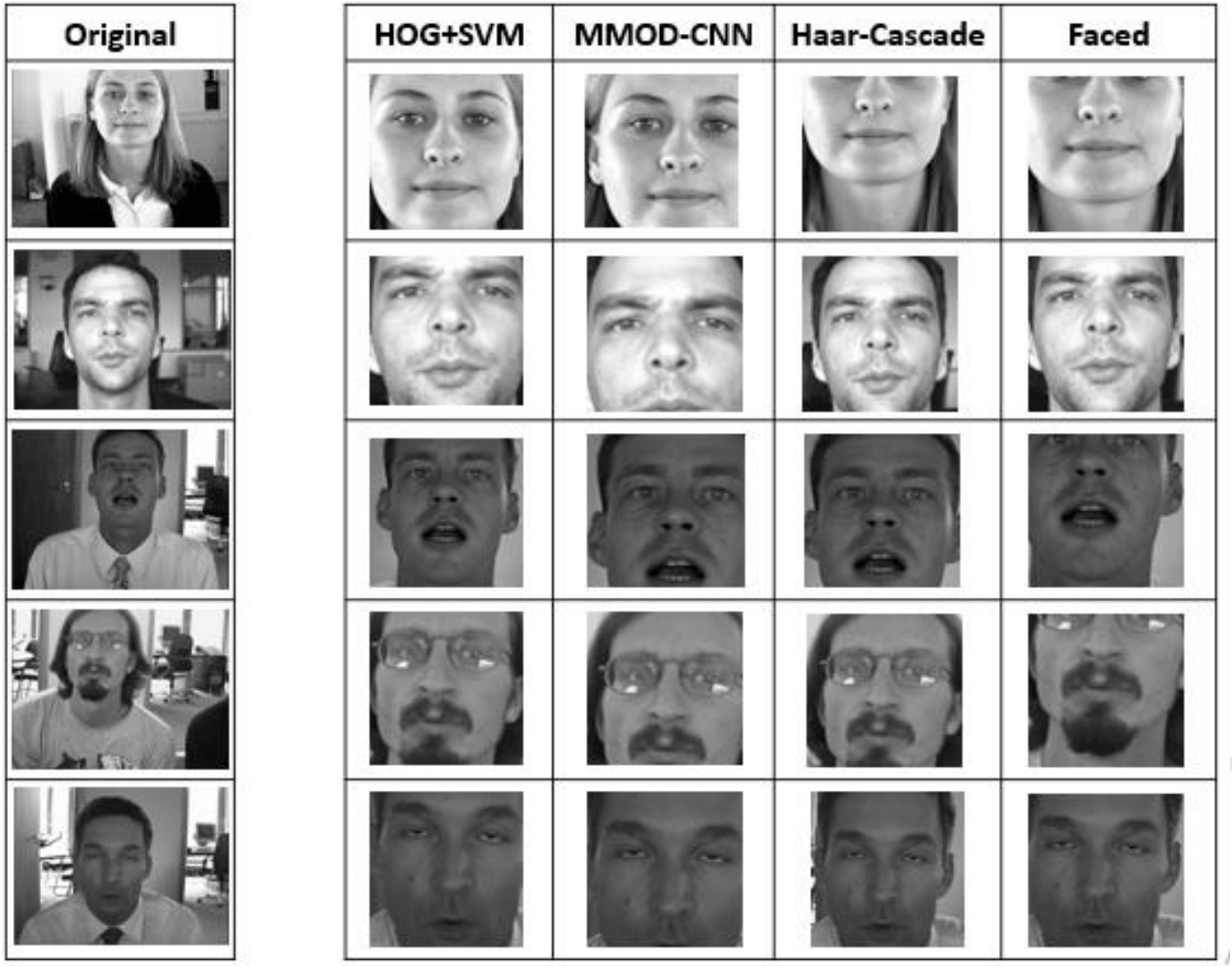
Face Detection Results

Error cropping: Sample results of the face images after applying face detection method.

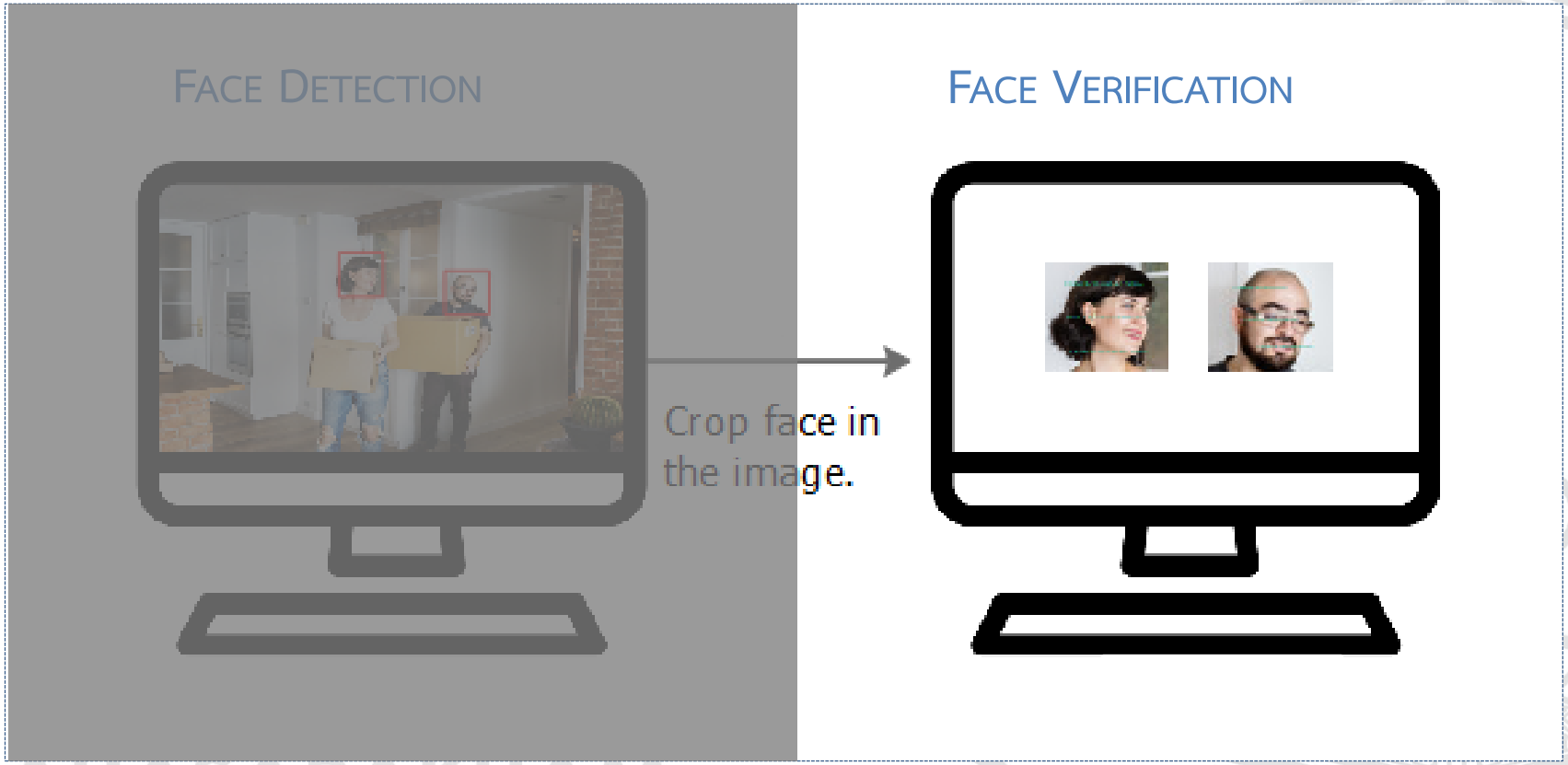
Experimental Results

Face Detection Results

Face detection results after applying face detection techniques.



Face Verification Systems



Face Verification Systems

Face Encoding

For the face encoding techniques, we evaluated the performance of three deep convolution neural networks, including as follows:

I. **VGG16**
II. **ResNet-50**
III. **FaceNet**

Experimental Results

Face Verification Results

- The image resolution and size of the feature vector are shown in Table II.

TABLE II. THE RESOLUTION OF FACE IMAGES REQUIRES FOR CNN METHODS AND THE NUMBER OF FEATURES EXTRACTS FROM THREE CNN FACE ENCODING TECHNIQUES

Parameters	Method		
	VGG16	FaceNet	ResNet-50
Image resolution	224x224	224x224	224x224
Feature vector	25,088	512	2,048

Face Verification Systems

Face Verification Results

- The performance of the different face encoding methods.

TABLE III. FACE VERIFICATION ACCURACIES (%) AND STANDARD DEVIATIONS OF THREE CNN FEATURE EXTRACTION METHODS. THE EXPERIMENTAL RESULTS ARE COMPUTED USING THREE FACE DATASETS

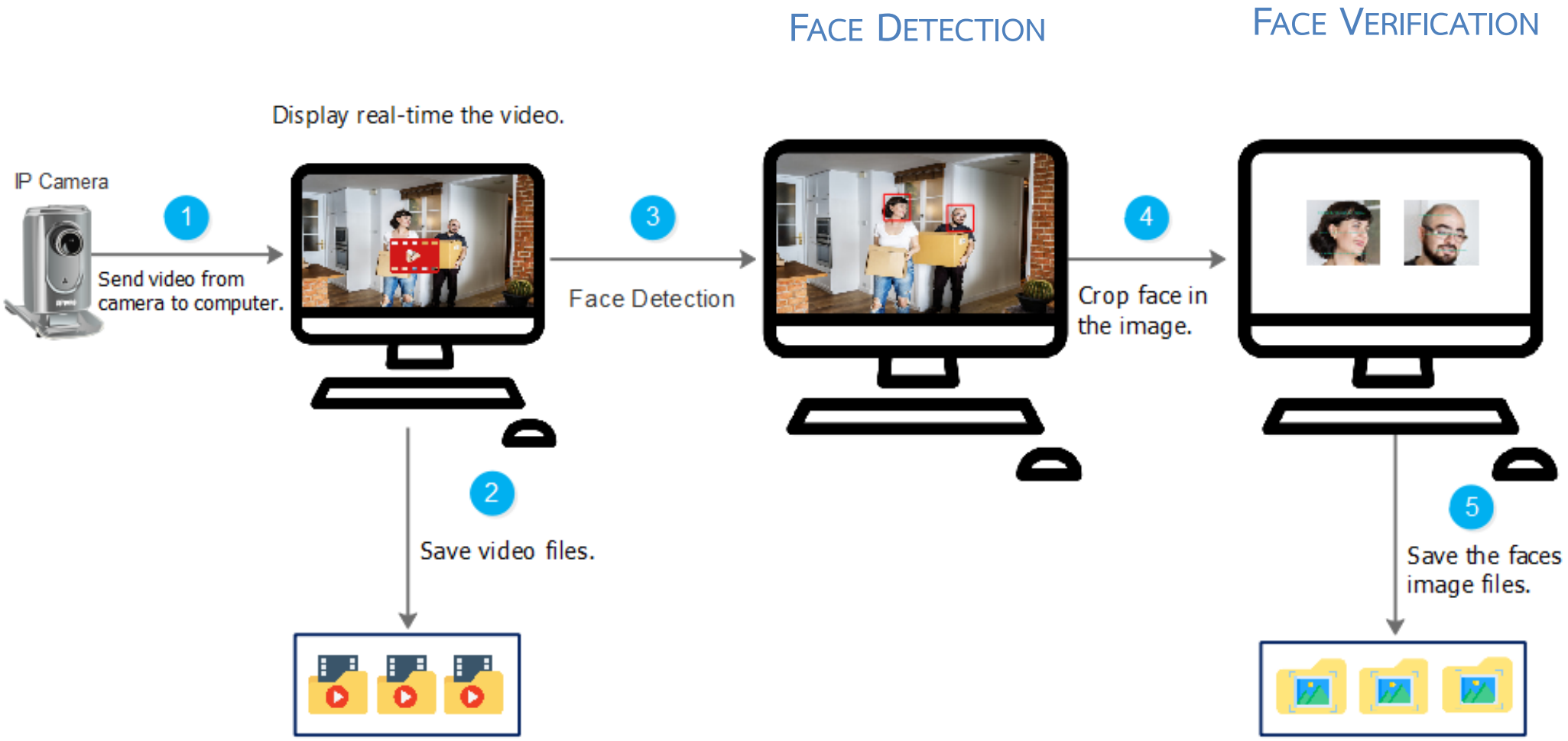
Dataset	Number of image	Number of subjects	Accuracy (%)		
			Vgg16	FaceNet	ResNet-50
BioID	1,507	21	99.74±0.38	100	100
FERET	1,372	196	83.93±0.77	100	100
Color FERET	3,553	474	74.96±1.26	99.32±0.32	99.60±0.46

Conclusion

We have presented an effective face verification systems.

- **First,** the histogram of oriented gradients method combined with the linear support vector machine (***HOG+SVM***) was applied as the face detection process.
- **Second**, the ***FaceNet and the Resnet-50*** architectures, which are the deep convolutional neural network (CNN), are proposed to use as the face encoding methods.
- **Moreover**, The ResNet-50 and FaceNet architectures obtain ***very high verification accuracy on ColorFERET dataset***, with accuracy of 99.60% and 99.32%, respectively.

Future work


FACE DETECTION
FACE VERIFICATION
Display real-time the video.
IP Camera
1
Send video from camera to computer.
2
Save video files.
3
Face Detection
4
Crop face in the image.
5
Save the faces image files.