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

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Present at the 14th International Joint Symposium on Artificial Intelligence and Natural Language Processing – iSAI-NLP2019, 30 October 2019
Outline

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

Face Detection

Face Verification

Crop face in the image.
The BioID Face Dataset

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

Face Detection

Crop face in the image.

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

\[
\text{Accuracy} = \text{Acc} - \text{Err}
\]

when

\[
\text{Acc} = \frac{c \times 100}{N}
\]

\[
\text{Err} = \frac{e \times 100}{N}
\]

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%**

<table>
<thead>
<tr>
<th>Methods</th>
<th>Number of face detected</th>
<th>Number of error detected</th>
<th>Accuracy (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HOG+SVM</td>
<td>1,507</td>
<td>0</td>
<td><strong>99.60</strong></td>
</tr>
<tr>
<td>MMOD-CNN</td>
<td>1,513</td>
<td>40</td>
<td>97.36</td>
</tr>
<tr>
<td>Haar-Cascade</td>
<td>1,459</td>
<td>40</td>
<td>93.79</td>
</tr>
<tr>
<td>Faced</td>
<td>1,449</td>
<td>107</td>
<td>88.70</td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th></th>
<th>Original</th>
<th>HOG+SVM</th>
<th>MMOD-CNN</th>
<th>Haar-Cascade</th>
<th>Faced</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Image" /></td>
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<tr>
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<td><img src="image26" alt="Image" /></td>
<td><img src="image27" alt="Image" /></td>
<td><img src="image28" alt="Image" /></td>
<td><img src="image29" alt="Image" /></td>
<td><img src="image30" alt="Image" /></td>
</tr>
</tbody>
</table>
Face Verification Systems

**FACE DETECTION**

Crop face in the image.

**FACE VERIFICATION**

- Two face images on a computer screen.
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>
<thead>
<tr>
<th>Parameters</th>
<th>Method</th>
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<tbody>
<tr>
<td>VGG16</td>
<td>FaceNet</td>
</tr>
<tr>
<td>Image resolution</td>
<td>224x224</td>
</tr>
<tr>
<td>Feature vector</td>
<td>25,088</td>
</tr>
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</table>
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

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

1. IP Camera
   - Send video from camera to computer.

2. Face Detection
   - Display real-time video.
   - Save video files.

3. Face Detection
   - Crop face in the image.

4. Face Verification
   - Save the faces image files.