Object Based Geometrical and Texture Feature Extraction of Face from Front View

Abstract
Face recognition has been a fast growing, challenging and interesting area in real-time applications. A large number of face recognition algorithms have been developed for decades. For recognition of face, feature extraction plays a crucial role. This paper presents the method for extracting the geometric and texture feature of face automatically from the front view, cumulative histogram approach is used for extracting geometric feature while co-occurrence matrices are used for extracting the texture feature of face. From the input image, face location is detected using the viola-Jones algorithm, from which different object such as left eye, right eye, nose, and mouth area are cropped and is processed.

Keywords
Object, Corner End Point, Linear Search, Cumulative Histogram, Gray Level Co-Occurrence Matrices (GLCM), Corelation (Corr), Angular Second Moment (ASM), Entropy, Maximum Probability, Inverse Difference(ID), Inverse Difference Moment (IDM), contrast.

I. Introduction
The term face recognition refers to identifying, by computational algorithms, an unknown face image. This operation can be done by means of comparisons between the unknown face and faces stored in a database. Face recognition systems have a wide range of applications, especially when dealing with security applications, like computer and physical access control, real-time subject identification and authentication, and criminal screening and surveillance.

In the field of computer vision technology facial feature extraction is the initial stage of face recognition. Although it is influenced by many complications, such as differential expression, the light direction of an image, and variety of posture, size and angle. Facial feature extraction is an important issue in the automatic face recognition of human face.

The most significant geometrical facial feature points are eyes corner, nose width, nose length and mouth corner. Eyes are the most crucial facial feature point of face analysis because of its inter-ocular distance, which is constant among people unaffected by any expression; whereas Texture is one of the most important characteristics of an image as it contains valuable information about the subsurface structure of the area. Therefore, the texture analysis can be used to distinguish different spatial characteristics or patterns that are present in the image. The important texture feature are correlation, angular second moment (ASM), entropy, maximum probability, inverse difference(ID), Inverse Difference Moment (IDM), contrast, although texture feature is very much affected by different lighting condition.

In the resent years several methods for facial feature extraction have been proposed, well known technique are principle component analysis (PCA) [1], Linear Discriminant Analysis (LDA) [2], 2D Gabor wavelet [3], 2D Discrete Cosine Transform (DCT) [4], [5].

The rest of paper is organized as follow. In section 2 Object detection is introduced which describe how different Object such as left eye, right eye, nose, and mouth area are cropped from the face image. In section 3 proposed algorithm is been discussed for extracting the geometrical feature. In section 4 texture feature algorithm is discussed. Section 5 describes the experimental result, conclusions and future work.

II. Object Detection
This portion of paper describe about how different Objects such as left eye, right eye, nose, and mouth area are cropped from the face image. To the input image, viola-Jones algorithm is applied to detect the location of the face, from the face image, different object are cropped, Figure 1 shows the block diagram of face which is obtained by applying the viola-Jones algorithm, from the face image different objects such as left eye, right eye, nose and mouth regions are cropped.

III. Proposed Algorithm for Geometrical Feature Extraction
This section of paper describe about algorithm for extracting the geometric feature of face from front view, fig. 2 show the block diagram of our proposed algorithm.
As shown in Fig. 2, the input image, face location is detected by applying the viola-Jones algorithm [6], and from the face image different objects such as Right eye, Left eye, Nose, Mouth area are cropped, then each Object is converted into a gray scale image then histogram of each gray scale Object is computed and its cumulative histogram [7-8], values are employed by varying different threshold values to create a new filtered binary image, then the linear search technique is applied on binary image of each object to detect the corner end points.

A. Mathematical Formulation of Proposed Algorithm

The mathematic used for generating the binary image of each object is as follow

\[
\Pr ob_{Object}(x, y) = \frac{N_v}{R \times C} \quad \text{where} \quad 0 \leq v \leq 255
\]

\[
Cum_{Object}(x, y) = \sum_{i=0}^{255} \Pr ob_{Object}(x, y) = \sum_{i=0}^{255} \Pr ob_{Object}(x, y) (i)
\]

where \( Object(x, y) \) denotes the Objects which is cropped from the grayscale face image, \( Pr ob_{Object}(x, y) (v) \) is the histogram representing the probability of occurrence of a pixel of gray level \( v \). \( N_v \) is the number of pixel having each pixel value \( v \), \( R \) and \( C \) represent the number of Row and Column of an Object, \( Cum_{Object}(x, y) (v) \) represent the cumulative histogram function up to the gray level \( v \) of an Object, where \( v \) ranges from 0 to 255.

\[
Bin_{Object}(x, y) = \begin{cases} 
1 & \text{when} \ \text{LoTh} \leq Cum_{Object}(x, y) (v) \leq \text{UpTh}
\end{cases}
\]

4. Crop different Object from Gray Scale Image

\[
Left\_eye\_face = \text{crop}(Gray\_face)
\]

\[
Right\_eye\_face = \text{crop}(Gray\_face)
\]

\[
Nose\_face = \text{crop}(Gray\_face)
\]

\[
Mouth\_face = \text{crop}(Gray\_face)
\]

5. Find Probability of Occurrence of Pixel of Gray Level \( v \) of Each Object

\[
Pr ob_{Left\_eye}(v) = \frac{N_v}{(R \times C)}
\]

\[
Pr ob_{Right\_eye}(v) = \frac{N_v}{(R \times C)}
\]

\[
Pr ob_{Nose}(v) = \frac{N_v}{(R \times C)}
\]

\[
Pr ob_{Mouth}(v) = \frac{N_v}{(R \times C)}
\]

Where \( v \) is gray level intensity ranging from 0-255

\( N_v \) is number of pixel of having each pixel value \( v \)

\( R \) is number of ROW in each Object

\( C \) is number of COLOMN in each Object

6. Now compute Cumulative Histogram for each pixel of each Object

\[
Cum_{Hist\_Left\_eye}(x, y) = \sum_{i=0}^{255} \text{cum}\_hist_{Left\_eye}(x, y)
\]

\[
Cum_{Hist\_Right\_eye}(x, y) = \sum_{i=0}^{255} \text{cum}\_hist_{Right\_eye}(x, y)
\]

\[
Cum_{Hist\_Nose}(x, y) = \sum_{i=0}^{255} \text{cum}\_hist_{Nose}(x, y)
\]

\[
Cum_{Hist\_Mouth}(x, y) = \sum_{i=0}^{255} \text{cum}\_hist_{Mouth}(x, y)
\]

7. Obtain the Binary Image of Each Object by Varying Different Threshold Values

// Binary image for Left Eye //

\[
Bin\_Left\_eye = \text{zeros}(x, y)
\]

\[
Bin\_Left\_eye = \text{ones}(x, y)
\]

When \( 0.01 \geq \text{cum}\_hist\_Left\_eye(x, y) \leq 0.14 \)

// Binary image for Right Eye //

\[
Bin\_Right\_eye = \text{zeros}(x, y)
\]

\[
Bin\_Right\_eye = \text{ones}(x, y)
\]

When \( 0.01 \geq \text{cum}\_hist\_Right\_eye(x, y) \leq 0.14 \)

// Binary image of Nose //

\[
Bin\_Nose = \text{zeros}(x, y)
\]

\[
Bin\_Nose = \text{ones}(x, y)
\]

When \( 0.001 \geq \text{cum}\_hist\_Nose(x, y) \leq 0.016 \)

// Binary image of Mouth //

\[
Bin\_Mouth = \text{zeros}(x, y)
\]

\[
Bin\_Mouth = \text{ones}(x, y)
\]

When \( 0.001 \geq \text{cum}\_hist\_Mouth(x, y) \leq 0.075 \)

8. After finding the binary image of Objects linear search technique is applied on each Object to detect the corner end points.

9. When corner end point of each Object is Obtained Euclidean distance is calculated by using the following formula.

\[
\text{Euclidean}\_\text{distance} = \sqrt{(x1-x2)^2+(y1-y2)^2}
\]

10. Store the Euclidean distance of each Object on database which can be used for face recognition.

B. Proposed Algorithm

1. Input Image

\( l(x, y) = \text{front view image} \)

2. Detect Face Region by Applying Viola-Jones Algorithm

\( \text{Face\_Img} = \text{viola\_jones}(I) \)

3. Convert Face Region Into Gray scale

\( \text{Gray\_face} = \text{Grayscale}(\text{Face\_Img}) \)

C. Corner End Point Detection Each Object

The simple linear search technique is applied on binary image of each Object to detect the first white pixel location as candidate points, for eyes, searching start in bottom up fashion and for mouth and nose searching start top down fashion.

- Start searching from bottom left to the right corner.
end point.
• Start searching from bottom right to detect the left corner end point.
• Start searching from top left to detect the right corner end point.
• Start searching from top right to detect the left corner end point.

After detecting the corner end point of each Object, Euclidean distance of each end point is measured and for finding the length of nose mid-point of right corner of left eye and left corner of right eye is computed as a first point and mid-point of nose is computed as second point and Euclidean distance between this two point is determined, and all the parameter is stored in a data base.

After finding the gray level co-occurrence matrices $P(i,j)$ of each Object the following equation can be used to determine the different texture feature.

$$P_x(i) = \sum_{j=1}^{N} P(i,j)$$

$$P_y(j) = \sum_{i=1}^{N} P(i,j)$$

$$\mu_x, \mu_y \text{ mean of } P_x \text{ and } P_y \text{ respectively}$$

$$\sigma_x, \sigma_y \text{ standard deviation of } P_x \text{ and } P_y \text{ respectively}$$

$$\text{Correlation} = \frac{\sum_{i=1}^{N} \sum_{j=1}^{N} P(i,j) - \mu_x \mu_y}{\sigma_x \sigma_y}$$

$$\text{Angular Second Moment (ASM)} = \sum_{i=1}^{N} \sum_{j=1}^{N} P^2(i,j)$$

$$\text{Inverse Difference (ID)} = \sum_{i=1}^{N} \sum_{j=1}^{N} \frac{P(i,j)}{1 + |i-j|}$$

$$\text{Inverse Difference Moment (IDM)} = \sum_{i=1}^{N} \sum_{j=1}^{N} \frac{P(i,j)}{1 + |i-j|^2}$$

$$\text{Entropy (ET)} = - \sum_{i=1}^{N} \sum_{j=1}^{N} P(i,j) \log(P(i,j))$$

$$\text{Contrast} = \sum_{i=1}^{N} \sum_{j=1}^{N} (i-j)^2 P(i,j)$$

$$\text{Max Probability} = \max_{i,j}(P(i,j))$$

**A. Proposed Algorithm**

1. Input Image $I(x,y)$=front view image
2. Detect face region by applying viola-Jones algorithm
   Face_Img = viola_jones(I)
3. Convert face region into Gray scale
   Gray_face=Grayscale(Face_Img )
4. Crop different Object from gray scale image
   Left_eye_face=crop(Gray_face)
   Right_eye_face=crop(Gray_face)
   Nose_face = crop(Gray_face)
   Mouth_face = crop(Gray_face)
5. Compute the gray level co-occurrence Matrices (GLCM) of each Object
   PLeft_eye_glcm=GLCM(Left_eye_face)
PRight_eye_glcm=GLCM(Right_eye_face)
PNose_glcm=GLCM(Nose_face)
Pmouth_glcm=GLCM(Mouth_face)
6. By using the Gray level co-occurrence matrix (GLCM) of each Object, equation from 4-11 is evaluated for calculating the different texture parameter.
7. Store each texture parameter in a database

The face recognition is carried out by first evaluating different texture feature (Correlation, ASM, ID, IDM, ET, Contrast, and Maximum Probability) of images in a database. Based on this parameter the different image of the same person is cross checked if the difference is not very large then it is accepted else rejected, although texture feature is very much affected by lighting and environment.

V. Experimental Results

The work described in this paper is from the front view Position which is checked on 30 different people having different illumination and different background. During evaluation, some images are omitted due to: (1) person with eye glasses and highly dense moustache and (2) failure of viola-Jones algorithm.

The Proposed algorithm is developed and tested on Matlab, for evaluating geometrical feature three different threshold values is used for detecting eyes length, nose width, and mouth width. The different threshold values for eyes $0.01 \leq \text{Cum}_{\text{Object}(x,y)}(p) \leq 0.14$, for nose threshold values are $0.001 \leq \text{Cum}_{\text{Object}(x,y)}(p) \leq 0.016$, for mouth threshold values are $0.001 \leq \text{Cum}_{\text{Object}(x,y)}(p) \leq 0.075$. The detection rate of different Objects is shown in table 1 and fig. 5 show some of the images with True detection and some false detection.

Table 1: Detection Rate of Different Objects

<table>
<thead>
<tr>
<th>Left Eye Length</th>
<th>Right Eye Length</th>
<th>Nose Width</th>
<th>Nose Length</th>
<th>Mouth Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>96.67%</td>
<td>93.33%</td>
<td>96.67%</td>
<td>96.67%</td>
<td>96.67%</td>
</tr>
</tbody>
</table>

The Texture feature of each Object of face is evaluated by finding its corresponding co-occurrence matrix and using this co-occurrence matrix different texture parameter is evaluated using the formula as shown in equation (4-11). Table 2-5 shows the different texture feature evaluated of five images.

For the face recognition purpose ±5% error rate of different parameter of geometric and texture feature can be consider and Combination of geometric feature and texture feature can be used for robust face recognition technique.

Table 2: Different Texture Feature of Left Eye

<table>
<thead>
<tr>
<th>Correlation</th>
<th>ASM</th>
<th>ID</th>
<th>IDM</th>
<th>Entropy</th>
<th>Contrast</th>
<th>MP</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.21</td>
<td>118234</td>
<td>614.3</td>
<td>612</td>
<td>0.9130</td>
<td>188</td>
<td>290</td>
</tr>
<tr>
<td>-0.39</td>
<td>392447</td>
<td>1375.3</td>
<td>1375.5</td>
<td>0.6253</td>
<td>117</td>
<td>455</td>
</tr>
<tr>
<td>-0.022</td>
<td>1288428</td>
<td>1928.5</td>
<td>1928.5</td>
<td>0.4980</td>
<td>103</td>
<td>894</td>
</tr>
<tr>
<td>-0.049</td>
<td>260472</td>
<td>895.58</td>
<td>895.58</td>
<td>0.8351</td>
<td>177</td>
<td>433</td>
</tr>
<tr>
<td>-0.178</td>
<td>2842297</td>
<td>2406</td>
<td>2406</td>
<td>0.4980</td>
<td>146</td>
<td>1430</td>
</tr>
</tbody>
</table>

Table 3: Different Texture of Right Eye

<table>
<thead>
<tr>
<th>Correlation</th>
<th>ASM</th>
<th>ID</th>
<th>IDM</th>
<th>Entropy</th>
<th>Contrast</th>
<th>MP</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.0824</td>
<td>107162</td>
<td>614.3</td>
<td>612.6</td>
<td>0.9284</td>
<td>166</td>
<td>258</td>
</tr>
<tr>
<td>-0.5768</td>
<td>426222</td>
<td>1143</td>
<td>1143</td>
<td>0.6253</td>
<td>106</td>
<td>470</td>
</tr>
<tr>
<td>-0.091</td>
<td>1369006</td>
<td>1934</td>
<td>1934</td>
<td>0.4980</td>
<td>92</td>
<td>968</td>
</tr>
<tr>
<td>-0.760</td>
<td>313826</td>
<td>879.48</td>
<td>876.61</td>
<td>0.9652</td>
<td>267</td>
<td>531</td>
</tr>
<tr>
<td>-0.8018</td>
<td>2416030</td>
<td>2358</td>
<td>2358</td>
<td>0.4980</td>
<td>168</td>
<td>1369</td>
</tr>
</tbody>
</table>

Table 4: Different Texture of Nostril

<table>
<thead>
<tr>
<th>Correlation</th>
<th>ASM</th>
<th>ID</th>
<th>IDM</th>
<th>Entropy</th>
<th>Contrast</th>
<th>MP</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.8809</td>
<td>290088</td>
<td>909.5</td>
<td>909.5</td>
<td>0.7281</td>
<td>197</td>
<td>429</td>
</tr>
<tr>
<td>-0.3455</td>
<td>118304</td>
<td>1713</td>
<td>1713</td>
<td>0.7281</td>
<td>170</td>
<td>1014</td>
</tr>
<tr>
<td>-0.4788</td>
<td>3584901</td>
<td>2980.5</td>
<td>2980.5</td>
<td>0.7281</td>
<td>189</td>
<td>1533</td>
</tr>
<tr>
<td>-0.05293</td>
<td>888605</td>
<td>1391.7</td>
<td>1391.7</td>
<td>0.7281</td>
<td>180</td>
<td>870</td>
</tr>
<tr>
<td>-0.7398</td>
<td>7768234</td>
<td>3740</td>
<td>3740</td>
<td>0.4980</td>
<td>156</td>
<td>2647</td>
</tr>
</tbody>
</table>

Table 5: Different Texture of Mouth

<table>
<thead>
<tr>
<th>Correlation</th>
<th>ASM</th>
<th>ID</th>
<th>IDM</th>
<th>Entropy</th>
<th>Contrast</th>
<th>MP</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.1625</td>
<td>217317</td>
<td>800.5</td>
<td>800.5</td>
<td>0.6253</td>
<td>109</td>
<td>400</td>
</tr>
<tr>
<td>-0.3093</td>
<td>731736</td>
<td>1487</td>
<td>1487</td>
<td>0.4980</td>
<td>106</td>
<td>646</td>
</tr>
<tr>
<td>-0.8821</td>
<td>3183166</td>
<td>2532</td>
<td>2532</td>
<td>0.4980</td>
<td>136</td>
<td>1607</td>
</tr>
<tr>
<td>-0.4854</td>
<td>567964</td>
<td>1172.5</td>
<td>1172.3</td>
<td>0.6253</td>
<td>139</td>
<td>638</td>
</tr>
<tr>
<td>-0.9593</td>
<td>7635123</td>
<td>3176.5</td>
<td>31766</td>
<td>0.4980</td>
<td>86</td>
<td>2741</td>
</tr>
</tbody>
</table>
VI. Conclusion and Future Work

In this paper, we have tried to extract the geometric and texture feature of the face from front view, for this, Cumulative Histogram approach is used for extracting the geometrical feature and gray level co-occurrence matrix is used to extract the texture feature of an image. In future we will concentrate to extract feature of face from different angle so that it will be more useful to recognize the face at different angle, and also try to find out some other feature which will helpful to recognize the person uniquely.

References


