Abstract

The selection of appropriate wavelets is an important target for any application. In this paper Face recognition has been performed using Principal component analysis (PCA), Gaussian based PCA and Gabor based PCA. PCA extracts the relevant information from complex data sets and provides a solution to reduce dimensionality. PCA is based on Euclidean distance calculation which is minimized by applying Gabor filter as compared to Gaussian Filter to enhance the accuracy for Face recognition. The experiments shows that the proposed method (PCA) can effectively reduced the computational complexity. Gabor based PCA shows 99.74% more accurate result as compare to 94.54% Gaussian based PCA for face recognition.

Keywords: PCA, Euclidean distance, Eigen value, Gabor, Face recognition.

I. INTRODUCTION

Face recognition system is a computer application for automatically identifying or verifying an individual by using a digital image. Some face recognition algorithm identifies facial features by extracting exclusive characteristics from an image. An algorithm may analyze the relative position, shape or size of nose, eyes, cheekbones and jaws. These features are then used to identify other images with corresponding matching features. The most popular face recognition algorithm includes Principal component analysis using Eigen faces, Linear Discriminate Analysis using Fisher faces. It is usually employed in high security system which includes Biometrics such as Fingerprints or eyes iris recognition system. Kirby and Sirovich [1] showed that any face image can be efficiently represented along the eigen faces (eigen vectors) coordinate space. Turk and Pentland [2] presented the well known eigen faces method for face recognition based on PCA. Face recognition system can be classified into two broad categories [3]: Firstly, finding a person within a large database of faces [6] e.g. in a police database (Face recognition which is not done in Real time). Secondly, identifying a particular individual in Real time e.g. Location Tracking system. Gabor wavelet transform is a powerful representation of the behavior of respective fields in Human visual system (HVS) for Facial feature construction system. The method is based on selecting High energized points of the Gabors wavelet response as feature points [7]. The feature points are automatically extracted using local characteristics of each individual face in order to decrease the effect of occluded features. The GPCA (Gabor PCA) method is based on gabor transform image matrices which incorporate spatial locality, scale and orientation matrices rather than the original image matrices [8]. Gabor PCA method has superior face representations and recognition performances than the Gaussian PCA method.

II. PRINCIPAL COMPONENT ANALYSIS

PCA is a useful technique for face recognition and image compression. It is highly useful for finding patterns in case of high dimensional data. It includes standard deviation, eigen values and eigen vectors as well as covariance. PCA algorithm is highly robust includes parallelism and is relatively very simple. There are various approaches to face recognition ranging from the principal component analysis approach or eigen faces. Prediction can be done through feature matching. PCA has been called one of the most valuable results from applied linear algebra. It is a dimensionality reduction technique based on extracting the desired number of principal component of the multidimensional data. Face recognition system consist of two phases [4]:

A. Training Phase

Each image in the database is represented as a column in a matrix A. The values in each of these columns represent the pixels of the database image and range from 0 to 255 for an 8-bit grayscale image:

\[
\begin{pmatrix}
    a_1 \\
    a_2 \\
    \vdots \\
    a_m
\end{pmatrix}
\]

Where \(a_i\) = pixel values respectively from an image matrix. The average of matrix A is calculated to normalize the matrix A. The average of matrix A is a column vector in which every element is the average of every DB image pixel values respectively.

\[
\text{avg}(x_1, x_2, \ldots, x_m)
\]

Where \(x_d\) = pixel values from an image matrix. The average of matrix A is calculated to normalize the matrix A. The average of matrix A is a column vector in which every element is the average of every DB image pixel values respectively.
Next, the matrix is normalized by subtracting each column of matrix \( A \) from each column of matrix \( \bar{A} \):

\[
\begin{pmatrix}
a & x & \ldots & a & x \\
11 & 1 & \ldots & 1m & m \\
\end{pmatrix}
\]

We then want to compute the covariance matrix of \( \bar{A} \), which is \( \bar{A} \times \bar{A}^T \) or \( \bar{A}^T \times \bar{A} \). But here we use \( \bar{A} \times \bar{A}^T \), because it reduces the size of the covariance matrix and calculated as:

\[
S = \bar{A} \times \bar{A}^T \tag{2}
\]

Next step is to calculate to obtain the eigen vectors of original matrix thus we need to calculate the eigen vectors of the covariance matrix \( S \), let us say eigen vectors of the covariance matrix are \( C \), with size of \( V \) is same as \( S \).

After that, calculate the eigen vectors of the original matrix after calculation of \( V \) as follows:

\[
C = \bar{A}^T \times V.
\]

Each gesture is then projected to gesture space while calculating the projection of the image as:

\[
\xi = \bar{A} \times C
\]

B. Recognition Phase

We represent the test image as a column vector:

\[
r \begin{pmatrix}
r_1 \\
r_2 \\
r \ldots \\
r_m \\
\end{pmatrix}
\]

The test image is then normalized:

\[
r \begin{pmatrix}
r_1 \\
r_2 \\
r \ldots \\
r_m \\
\end{pmatrix} 
\rightarrow
r \begin{pmatrix}
x_1 \\
x_2 \\
x \ldots \\
x_m \\
\end{pmatrix}
\]

Next, we calculate the projection of test image to project the gesture on gesture space by the equation given below:

\[
\xi = C^T \times X
\]

We then find the Euclidean distance between the test projection and each of the projections in the database:

\[
ED(i) = \sqrt{\sum_{j=1}^{m} (x(j,i) - x(j,j))^2}
\]

Where \( i = 1, 2, \ldots, n \), \( m \) = total number of pixels in a image, \( n \) = number of images in the database.

Finally, we decide which database image is recognized by the test image by selecting minimum Euclidean distance from the Euclidean distance vector “ED”. (Size of the Euclidean Distance vector is \( 1 \times \text{no. of faces} \).

III. GABOR FEATURE EXTRACTION

The Gabor wavelet captures the property of spatial localization, orientation, spatial frequency and face relationship. The wavelet transform could perform multi-resolution Time-Frequency analysis. Among various wavelets, the Gabor function provides the optimal resolution in both time & Frequency domain and Gabor transform seems to be optimal basis to extract local features for several reasons to achieve multi-resolution and multi-orientation.

A. Gabor(Kernels, filters)

The Gabor wavelet can be defined as follows:

\[
K(x,y) = e^{-\frac{x^2+y^2}{2\sigma^2}}cos(2\pi f x)
\]

Where \( k = k_{max}/f \) and \( \sigma = k_{max} \). \( k_{max} \) is the maximum frequency and \( f \) is the spacing factor between kernels in the frequency domain.

The Gabor wavelet kernel in Eq. (5) are all similar as they can be generated from one filter that is the mother wavelet by scaling and rotation through the wave vector \( K_{xy} \). Each kernel is a product of the Gaussian envelope and the complex plain wave whereas the first term in the square brackets in Eq. (5) determines the oscillatory part of the kernel and the second term is used for the DC value. The effect of DC value becomes negligible when the parameter that is determines the ratio of Gaussian window width to that of wavelength must have sufficiently large values. It is useful to use gabor wavelets at five different scales, \( y \epsilon \{0,..,4\} \) and eight orientations \( x \epsilon \{0,..,7\} \) with the following parameter \( =2\pi, K_{max}=\pi/2 \) and \( f = \sqrt{2} \).

B. Gaussian (kernels, filters)

Gaussian RBF kernel is formulated as [5]

\[
K(x,y) = \exp\left(-\frac{x^2+y^2}{\sigma^2}\right)
\]

Where \(|x-y|^2\) may be recognized as the squared Euclidean distance between two feature vectors and \(\sigma\) is a free parameter. The Gaussian outputs a 'weighted average' of each pixel's neighborhood, with the average weighted more towards the value of the central pixels. This is in contrast to the mean filter's uniformly weighted average. Because of this, a Gaussian provides gentler smoothing and preserves edges better than a similarly sized mean filter.

IV. RESULTS AND DISCUSSION

We assess the feasibility and performance of the principal component analysis with the help of Gaussian filter as well as the Gabor wavelet. The analysis steps of PCA algorithm for face recognition can be understood by the following figure 1

A. Matlab results for Face recognition:

We are comparing the face recognition with different methodologies: PCA (principal component analysis), Gaussian PCA and Gabor based PCA given in fig.1 (a), (b) and (c) respectively for database image 2 using MATLAB.

Test Image  
Equivalent Image

(a) Result based on Principal Component analysis

Test Image  
Equivalent Image

(b) Result based on Gaussian PCA

Test Image  
Equivalent Image

(c) Result based on Gabor PCA

Figure: 1 Face Recognition MATLAB results

B. Comparison based on Euclidean distance

Euclidean distance between test image and database image had been calculated by using different methods. However, the method which gives lowest Euclidean distance has highest speed and accuracy for face recognition.

TABLE I: ED CALCULATION FOR FACE RECOGNITION

<table>
<thead>
<tr>
<th>Test image No.</th>
<th>Euclidean Distance(ED)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PCA</td>
</tr>
<tr>
<td>1.</td>
<td>3.0552e-14</td>
</tr>
<tr>
<td>2.</td>
<td>3.6739e-13</td>
</tr>
<tr>
<td>3.</td>
<td>2.5217e-13</td>
</tr>
<tr>
<td>4.</td>
<td>9.8297e-15</td>
</tr>
</tbody>
</table>

So from the above table 1, it is clear that Euclidean distance is minimum in case of PCA algorithm but it is further minimized using Gaussian PCA and is least in case of Gabor PCA. Above discussion can be represented graphically as shown in figure 2.

Figure 2: Comparative analysis of PCA methods.

V. CONCLUSION

In this paper different Face recognition methods like Principal component analysis (PCA), Gaussian PCA and Gabor PCA are used to recognize the test image from the database images. Minimum Euclidean distance has been calculated using PCA algorithm. It is clear that the proposed Gabor based PCA has shown an improvement in accuracy as compared to Gaussian based PCA. The Gabor based PCA is 99.74% more accurate as compared to Gaussian based PCA with 94.54% accuracy in terms of minimum Euclidean distance.
REFERENCES


