Face Recognition using Appearance-Based Statistical Technique on Color Images Database

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Abstract – Face Recognition is one of the most popular problems in the field of image processing. Face recognition is a technology which recognize the human by his/her face image. Identifying a person from an unknown face is usually done by comparing the unknown face with the known faces from a face database. Face Recognition system should be able to automatically detect a face in images or face database. Principal component analysis (PCA) is appearance-based statistical technique used for dimension reduction and recognition, and widely used for facial feature extraction and recognition. In this paper we have attempted a comparative study of appearance based statistical method that is principal component analysis. The experiment is used standard face 96 database, local database and pose variation database. The performance of principal component analysis face 96 database is 100%. The experiment is also tested for locally created poor image quality database and pose variation database and its PCA performance is 100%.

Keywords – Biometrics, Color Image, Eigenfaces, Face Recognition, Image Processing, Pattern Recognition, Principal Component Analysis.

I. INTRODUCTION

After 9/11 tragedy, governments have alert to safety matters. Recent technologies in identification, recognition and tracking of suspects, claimed high portion of national budgets. The demand growth on these applications helped researchers fund their research projects. One of most common biometric recognition techniques is face recognition. Face recognition is not as accurate as the other recognition methods such as fingerprints, it still grabs huge attention of many researchers in the field of computer vision because in efficiencies of the methods used to represent faces have caused many researchers delink their research. The face representation was performed by using two categories. The first category is global approach or appearance-based, which uses holistic texture features and is applied to the face or specific region of it. The second category is feature-based or component-based, which uses the geometric relationship among the facial features like mouth, nose, and eyes [1] implemented feature-based approach by a geometrical model of a face by 2-D elastic graph. Another example of feature-based was done by independently matching templates of three facial regions (eyes, mouth and nose) and the configuration of the features was unconstrained since the system didn’t include geometrical model [2],[14]. In this paper [6] the success of eigen space techniques for object search and recognition in a large image database. This papers [8] Using the original FERET database, a standard PCA classifier did better when using Mahalanobis distance rather than L1, L2 or Angle. This paper [12] an efficient and simple face recognition system can be built for recognition of faces by using PCA and neural network. The system performs very well for standard database and local images. In this paper [13] we have used Test sets i.e. eigenfaces and then Euclidean, Chessboard and City block distance is calculated between the mean adjusted input image and the projection onto face space. The result of detection using different distance measures techniques is 100% but city block distance measure technique is efficient in terms of CPU execution time. Principal components analysis (PCA) method [3],[4] which is also called eigenfaces [5],[6] is appearance-based technique used widely for the dimensionality reduction and recorded a great performance in face recognition.

II. PRINCIPAL COMPONENT ANALYSIS

Principal Component Analysis (PCA) is a dimensionality reduction technique which is used for compression and recognition problems. It is known as Eigenspace Projection or Karhunen-Loeve Transformation [5], [7]. PCA projects images into subspace such that the first orthogonal dimension of this subspace captures the greatest amount of variance among the images and the last dimension of this subspace captures the least amount of variance among the images[8]. The main goal of PCA is the dimensionality reduction, therefore the eigenvectors of the covariance matrix should be found in order to reach the solution. PCA is a useful statistical technique that has found application in fields such as face recognition and image compression, and is a common technique for finding patterns in data of high dimension. It is one of the more successful techniques of face recognition [5].

2.1 The steps in finding the principal component analysis [9] as follows:
1. Get the data: Suppose X1, X2 ……X_M is N x 1

\[ X = \frac{1}{M} \sum_{i=1}^{M} X_i \]

2. Subtract the mean:

\[ \Phi = \bar{X} - X \]

3. Calculating the covariance matrix:

Form of matrix A = [\Phi1, \Phi2…\Phi_M] (N x M matrix) then compute

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4. Calculating the eigenvector and eigenvalue of the covariance matrix: An N x N matrix A is said to have an eigenvector X, and corresponding eigenvalue \( \lambda \) if 

\[
CX = \lambda X \\
\det \{ C - \lambda I \} = 0
\]

Where X is the set of eigenvectors associated with its eigenvalue \( \lambda \).

5. Choosing components and forming a feature vector:
   Once eigenvectors are found from the covariance matrix, the next step is to order them by eigenvalue, highest to lowest. This gives you the components in order of significance. The eigenvector with the highest eigenvalue is the principle component of the data set. Choose the highest eigenvalue and forming a feature vector.

6. Deriving the new datasets: Once chosen the components (eigenvectors) that wish to keep in our data and formed a feature vector, imply take the transpose of the vector and multiply it on the left of the original data set, transposed.

Final Data = Row feature vector * Row Data Adjust

The above formula getting the features of images. The Euclidean distance is calculated between the mean adjusted input image and the projection onto face space. The low values indicate that there is a face and display the face.


**2.2 Euclidean distance**

In Euclidean distance transform, the value at a pixel is linearly proportional to the Euclidean distance between that pixel and the object pixel closest to it. Since the method uses the value at a single object pixel to determine the value at pixel of interest, the process is sensitive to noise. The straight-line distance between two pixels is given by using the formula

\[
D_E = [(i-j)^2 + (k-l)^2]^{1/2} \tag{1}
\]

The (i,j) and (k,l) are the two different point coordinates and \( D_E \) is the distance.

Suppose the point A(6,7) and point B(3,4). The Euclidean distance between the given points is as

\[
D_E = [(6-3)^2 + (7-4)^2]^{1/2} = 4.2426
\]

The Euclidean distance is always greater than or equal to zero. The measurement would be zero for identical points and high for points that show little similarity.

**III. EXPERIMENT AND RESULTS**

The experiments were done using principal component analysis for facial images. The images were obtained from Libor Spacek Collection of facial images [10]. This database includes 7900 colored images of faces of 395 individuals. Each individual has 20 image samples in the database. The database consists of male and female images of various racial origins. The images are mainly of first year undergraduate students, so the majority of individuals are between 18-20 years old but some under individuals are also present. Some of the individuals has glasses and some of the male individuals have beards. The image format is 24-bit color jpeg in other words 200 x 180 array of pixels and each pixel is represented by 24 bits of RGB color values. The image were recorded with an S-VHS camcorder camera and the lighting is artificial, mixture of tungsten and fluorescent overhead.

Experiment were conducted standard face 96 database and local, pose variation database. The face 96 database contains number of individuals 152. The background is complex (glossy poster). Large headscale and some expression variation. The position of face in image is some translation. All images have same size and the extension of these images jpeg. The local and pose variation database is created by digital camera. These databases is available on website http://dsmcsresearch.info.

The 151, 10 and 5 face images in the database were tested using PCA. The threshold value of all database is change.

The first training set 1 include 43 face images figure 4 and is used to compute the face recognition based on eigenfaces with Euclidean distance measures technique. The figure 1 shows the sample images of face 96 database. The figure 2 shows the mean images of sample images. The figure 3 shows the mean face of all images and the figure 5 gives the tested input and output image.

The second training set 2 include 6 face images figure 9 and is used to compute the face recognition based on eigenfaces with Euclidean distance measures technique. The figure 6 shows the sample images of local database. The figure 7 shows the mean images of sample images. The figure 8 shows the mean face of all images and the figure 10 gives the tested input and output image.

The third training set 3 include 3 face images figure 14 and is used to compute the face recognition based on eigenfaces with Euclidean distance measures technique. The figure 11 shows the sample images of pose variation database. The figure 12 shows the mean images of sample images. The figure 13 shows the mean face of all images and the figure 15 gives the tested input and output image. The success rate of recognition using PCA is 100%. The Table 1 shows the PCA performance.

<table>
<thead>
<tr>
<th>Database</th>
<th>Method</th>
<th>Tested Image</th>
<th>Threshold Value</th>
<th>Recognition Accuracy (Percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FACE 96</td>
<td>PCA</td>
<td>151</td>
<td>5.1597e+007</td>
<td>100</td>
</tr>
<tr>
<td>Local Database</td>
<td>PCA</td>
<td>10</td>
<td>2.4198e+007</td>
<td>100</td>
</tr>
<tr>
<td>Pose Variation</td>
<td>PCA</td>
<td>5</td>
<td>3.4307e+007</td>
<td>100</td>
</tr>
</tbody>
</table>
Fig. 1. Sample Images of face 96 database

Fig. 2. Mean Images of face 96 database

Fig. 3. Mean face sample images

Fig. 4. Training set 1

Fig. 5. Input and Output Image face 96

Fig. 6. Sample Images of local database

Fig. 7. Mean images of local database

Fig. 8. Mean face of local database

Fig. 9. Training set 2
IV. CONCLUSION

Face recognition Using Appearance Based Statistical Technique on Color Images Database is implemented in MATLAB. Face Recognition system should be able to detect an automatically face in images or face database. In this paper we have attempted a comparative study of appearance based statistical method that is principal component analysis. The experiment is used standard face 96 database, local database and pose variation database. The performance of principal component analysis face 96 database is 100%. The experiment is also tested for locally created poor image quality database and pose variation database and its PCA performance is 100%.

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