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Face recognition using PCA

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Abstract— Face recognition is one of the most successful applications of image analysis and understanding and has gained much attention in recent years. Various algorithms were proposed by research groups across the world, but we concentrated on PCA (Principal Component Analysis). This paper addresses the problem of face recognition under variation of illumination, variation of expressions and poses with large rotation angles. Standard databases are used for evaluation of results. The Principal components obtained by PCA algorithm are used as feature vectors for classification. The Euclidian distance classifier is used for testing of the images. All the various types of noises are introduced in the database images i.e. multiplicative noise (i.e. speckle), Gaussian noise, salt & pepper noise. For averaging of images median is calculated, which helps to minimise the noises which are introduced. The variation in illumination, variation of expressions and facial poses up to 180 degree rotation angle is used by the proposed method and result shows good recognition rate.

Keywords— Face Recognition, Principal Component Analysis, Variation of pose, Variation of expressions, Variation of illumination, Noise, Median.

I. Introduction

PCA was invented in 1901 by Karl Pearson. Now it is mostly used as a tool in exploratory data analysis and for making predictive models. Principal Components Analysis (PCA) is a way of identifying patterns in data, and expressing the data in such a way as to highlight their similarities and differences. Since patterns in data can be hard to find in data of high dimension, where the luxury of graphical representation is not available, PCA is a powerful tool for analyzing data. The other main advantage of PCA is that once you have found these patterns in the data, and you compress the data, i.e. by reducing the number of dimensions, without much loss of information. This technique used in image compression.

PCA involves the calculation of the eigenvalue decomposition of a data covariance matrix or singular value decomposition of a data matrix, usually after mean or median centering the data for each attribute. Principal component analysis (PCA) involves a mathematical procedure that transforms a number of possibly correlated variables into a smaller number of uncorrelated variables called principal components. Depending on the field of application, it is also named the discrete Karhunen–Loève transform (KLT), the Hotelling transform or proper orthogonal decomposition (POD).

PCA is mathematically defined as an orthogonal linear transformation that transforms the data to a new coordinate system such that the greatest variance by any projection of the data comes to lie on the first coordinate (called the first principal component), the second greatest variance on the second coordinate, and so on. PCA is theoretically the optimum transform for given data in least square terms. For a given set of points in Euclidean space, the first principal component (the eigenvector with the largest eigenvalue corresponds to a line that passes through the mean and minimizes sum squared error with those points. The second principal component corresponds to the same concept after all correlation with the first principal component has been subtracted out from the points. Each eigenvalue indicates the portion of the variance that is correlated with each eigenvector.

II. PCA ALGORITHM

Principal component analysis, or PCA, is a technique that is widely used for applications such as dimensionality reduction, lossy data compression, feature extraction, and data visualization.

A 2-D facial image can be represented as 1-D vector by concatenating each row (or column) into a long thin vector. Let's suppose we have M vectors of size N (= rows of image x columns of image) representing a set of sampled images. Pj's represent the pixel values.

$$Xi = [P1\ldots\ldots Pn], \quad i=1\ldots\ldots M.$$

The images are median centered by subtracting the median image from each image vector. Let m represent the median image.

$$Xmed = [P1, P2, \ldots M, \ldots\ldots Pn-1, Pn]$$

And let U, be defined as median centered image.

$$Ui = (Xi - Xmed)$$

We can get covariance matrix:

$$S = UU^T \text{ Namely,}$$

$$S = 1/m \sum_{i=1}^{m} (Xi - Xmed)(Xi - Xmed)^T$$

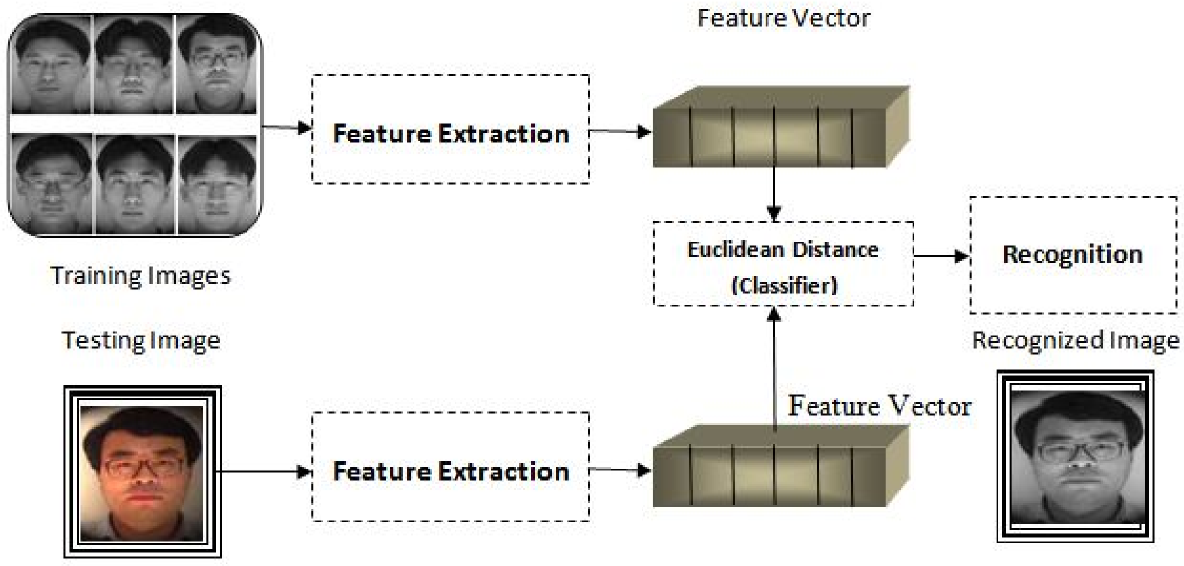

Fig 1: Block Diagram of Proposed system

Our goal is to find the eigenvectors and eigenvalues of the covariance matrix. The size of S is NxN which could be enormous. This eigenvector is known as the first principal component. To summarize, principal component analysis involves evaluating the median Xmed and the covariance matrix S of the data set and then finding the M eigenvectors of S corresponding to the M largest eigenvalues. We introduce various noises in the test images such as Gaussian noise, salt & pepper noise, multiplicative noise such as speckle etc. Calculate the features of test images and calculate the Euclidean distance which recognize the face corresponding to test image from training images

III.EXPERIMENTAL RESULTS

The experimental results presented in this section are divided into two parts. Both parts evaluate the face representations using PCA. In first part the face images are used having the variation of expression changes and pose variation with large rotation angles. In second part the face images are used having variation in illumination conditions.

The algorithm is developed in the MATLAB environment. Standard databases are used for evaluation of these results. The first database is published by IIT Kanpur Widely used for research purpose known as *Indian face database*. In this database images of 60 persons with 10 sample images with different orientations and views are available. The second database known as *Asian face image database* is from Intelligent Multimedia research laboratories having face images of 56 male persons with 10 samples each; which consist of variation in illumination conditions and different views. The Resolution of all images we used in the algorithm is 128 x128 for computational purpose. Few face images are shown in Figure 1 and Figure 2 from both the databases with various views. In this paper, we presented the results for face recognition using PCA method. First 9 Principal Components are shown in fig.3.

Figure1. Various view of face images with different Illumination conditions in Asian face database.

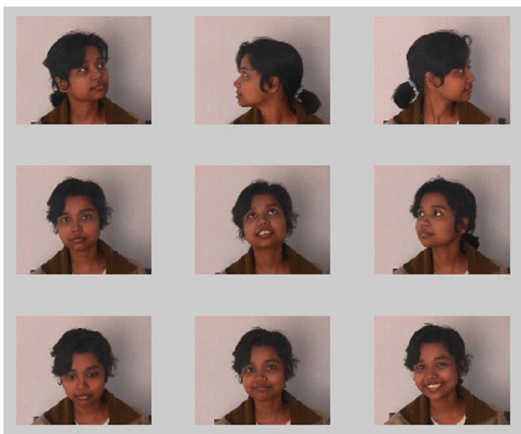

Figure 2. Various view of face images with different face orientations in Indian face database.

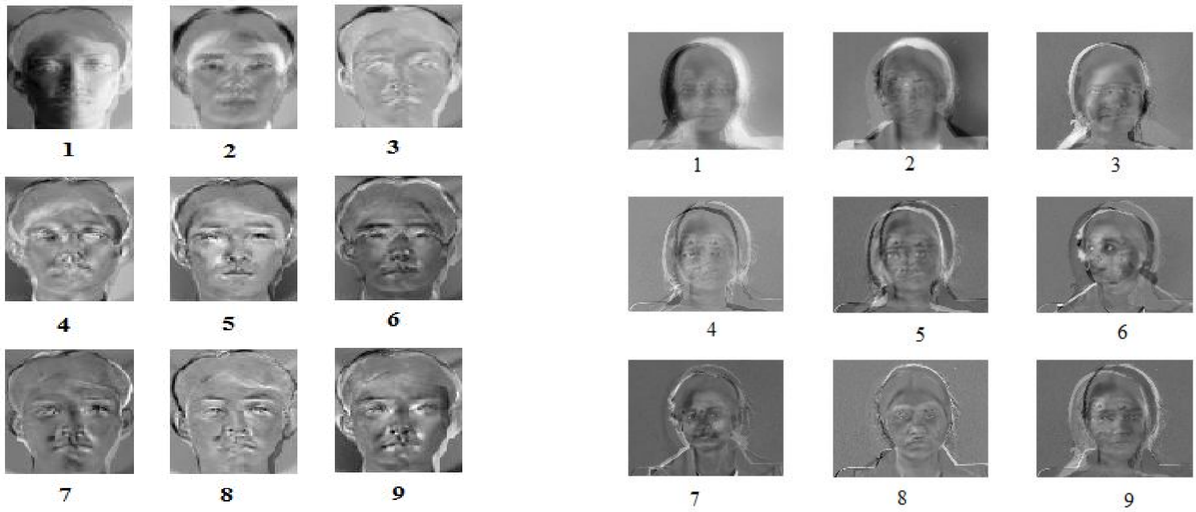

Figure 3 First 9 Eigen images of both databases.
(Principle Components)

Face images used in the second part are from Indian face database with large rotation angles up to 180 degree on this set of images we applied the algorithms PCA. The recognition of individual images using the algorithm is shown in the Figure 4 to 6 respectively. Figure 4 to Figure 6 gives the input (Image to be recognized) and output images (Recognized image) of the algorithm under face orientations. In Figure 5 and Figure 6 the rotation angle is maximum (approximately 180 degree), and with this large rotation angle images are recognized. With this much large facial pose variation the results are encouraging.

Figure 7 to 9 shows recognition of individual images with variation of expression and variation of illumination changes.

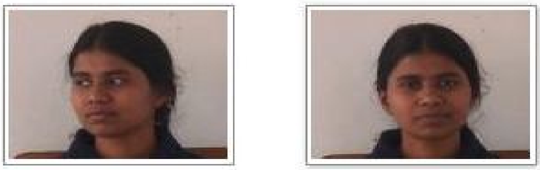

Image to be recognized Recognized Image

Figure 4

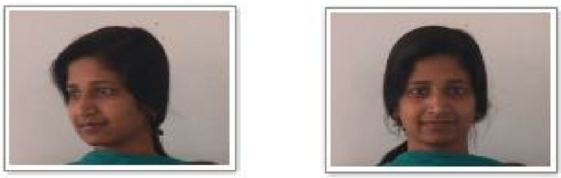

Image to be recognized Recognized Image

Figure 6

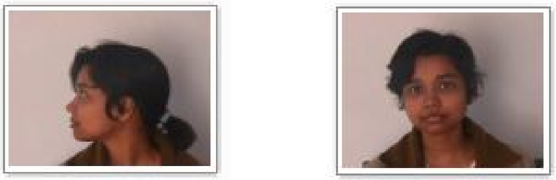

Image to be recognized Recognized Image

Figure 5

The light condition on the face images are from left and right sides as well as from top and down directions.

Images to be recognized Recognized Image

Figure 7

Figure 8

IV. CONCLUSION

In this paper Principal component analysis of face images has been discussed and used for face recognition. Two standard databases are used, which contains the face images with different orientations, expressions and change in illumination. Also observe the results of face recognition using PCA under pose variation with rotation angles up to 180 degree the results are very good.

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