An Efficient Face Recognition System Based On Subspace Linear Discriminant Analysis

Sandeep Mishra[1], Prajyant Pathak[2], Rampal Kushwaha[3]
[1, 2, 3] Department of Electronics & Comm. Engg
[1, 2, 3] LNCT, Jabalpur, Madhyapradesh

Abstract- *In a face recognition system, database has been a great problem for public enterprises. In this work, database problem is being tried to counter. Face database used is ORL face database and also a self made inhouse face database is prepared. ORL Face database consists of facial images of 40 different persons and 10 facial images of each person. Out of these, 8 images are taken for training and remaining are kept for testing purpose. And in self made face database, images of 12 different persons are taken for which 6 are taken for training and 4 are taken for testing purposes. In this work, Image based face recognition system is designed by two different dimension reduction techniques, which are Principal Component Analysis and Subspace Linear Discriminant Analysis. In one dimensional PCA and Subspace LDA, facial test images are compared with training images by City Block Distance, Euclidean Distance and Covariance Methods. Recognition rates achieved by these two dimensional reduction techniques are compared with results of previous techniques and are found better than those techniques. Maximum recognition rate achieved by PCA is 96.35% and achieved by LDA is 98.75% for ORL face database and for self made face database they are 58.33% and 83.33% respectively. As results of these two techniques are compared by varying their dimensions also so after comparison it is found that Subspace LDA outperforms PCA for Large Face Databases.*

Keywords- Biometrics, PCA, SLDA, Nearest Neighbor Classification

I. INTRODUCTION

Traditionally access control was performed by token-based identification systems like driver's license or passport, and knowledge-based manual identification systems, like password or personal identification number. Now a day's behaviometrics authentication is used for individual identification and access control. As biometrics is unique to individuals, their reliability factor is higher than traditional token and knowledge-based methods. Researchers had identified some factors which has to be kept in mind while selection of any one of the aspects. These factors are Universality, Uniqueness, Permanence, Measurability, Performance, Acceptability, and Circumvention.

Face Recognition System- lots of work was done in this field for achieving high recognition rate, but problems had been repeatedly faced while using systems which are not robust enough like automated security platforms, Large database using Banking System which demands very small error, because of huge system investment. Lots of works are still being going on to improve the reliability and strength of such systems [3]. Fig 1.3 is showing block diagram of a face recognition system.

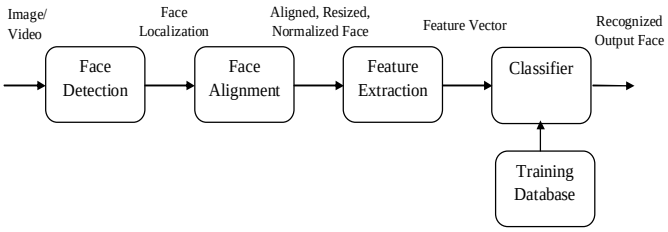

Fig.1: Block Diagram of Face Recognition System

Face detection is the first stage of this system, where human faces are located in an input image. For video inputs, videos are converted into frames and hence faces are tracked in consecutive frames. After detection, faces are centrally aligned to extract facial features like eyes, brows, cheeks, ears, and nose. On these features' basis, face image is preprocessed like rotated, masked, resized and normalized. In the third stage, features are extracted from normalized facial image. The extracted features are sent to a classifier and compared with the stored database.

II. LITERATURE SURVEY

Various techniques had been proposed for extracting facial features from images. PCA and LDA are two of the highly used techniques in feature based face recognition technique.

Slavković implemented eigenfaces approach representing PCA method in which a small set of significant features are used to describe the variation between face images.

Agarwal presented method which is connection of two stages – Feature extraction using principle component

analysis and recognition using the feed forward back propagation Neural Network.

Yong Zhang compared the performances of humans and a principal component analysis (PCA) based algorithm in recognizing face sketches. The experiments were carried out by matching sketches in a probe set to photographs in a gallery set. Both human and PCA fusions showed large performance improvements in comparison with an individual test.

Sahoolizadeh gave a new face recognition method based on PCA (principal Component Analysis), LDA (Linear Discriminant Analysis) and neural networks.

Yanwei Pang introduced an efficient image-as-matrix feature extraction algorithm named B-2DPCA. Principal Component Analysis fails to efficiently work on large-scale and high-resolution image data sets because time complexity is relatively high in the testing procedure. By incorporating merits from both two-dimensional PCA (2DPCA)-based image decomposition and fast numerical calculations based on Haarlike bases, Binary PCA (B-PCA) has been proposed to replace floating-point multiplications with integer additions, so the time complexity of the testing procedure can be significantly reduced.

Meedeniya gave face recognition system which can cope with different lightning conditions and different distorted levels in facial images. Their algorithm extracted the eigen values and eigen vectors from the images followed by minimum distance calculation. Concluded that as compared to traditional PCA, the proposed method gave better recognition accuracy and discriminatory power.

Jian Yang proposed a horizontal and vertical 2DPCA-based discriminant analysis (HVDA) method which applies 2DPCA horizontally and vertically on the image matrices (2D arrays), achieves lower computational complexity than the traditional PCA and Fisher linear discriminant analysis (LDA)-based methods that operate on high dimensional image vectors (1D arrays).

Jian Yang developed a new technique two-dimensional principal component analysis (2DPCA) for image representation. As contrasting to PCA, 2DPCA is based on 2D image matrices rather than 1D vector so the image matrix does not need to be transformed into a vector prior to feature extraction.

Matthew Turk proposed principal component analysis based face recognition system which can locate and track a person's head, and then identify the person by evaluating characteristics of the face to those of known persons. They projected face images onto a feature space that spans the significant variations among known face images.

On the basis of literature studied methodology has been designed for face recognition system.

III. METHODOLOGY

The face recognition algorithms used here are Principal Component Analysis (PCA), and Subspace Linear Discriminant Analysis (SLDA). PCA is the most simple and fast algorithm but can be used only for small database while Subspace LDA is used for comparatively large database. It is obtained by projecting the image onto the eigenface space by PCA and then LDA is applied over previous result.

A. PRINCIPAL COMPONENT ANALYSIS

Turk et. al. used eigen values for principal component analysis, so it is also termed as Eigenface method. In this method, variance due to non-face images are eliminated and variation just coming out of the variation between the face images are collected for analysis. Hence features of images are obtained by finding maximum deviation of each image, in the spatial domain of image, from the mean image.

B. SUBSPACE LINEAR DISCRIMINANT ANALYSIS

Linear discriminant analysis is used to overcome drawback of Principal Component Analysis of its application restricted to small image database. It is achieved by projecting the image onto the eigenface space by PCA and then implementing pure LDA over it, to classify the eigenface space projected data. Linear Discriminant Analysis is also termed as fischerface method. Belhumeour et. al. uses linear discriminant analysis to maximize the scatter between different classes and minimize the scatter between the input data in the same class.

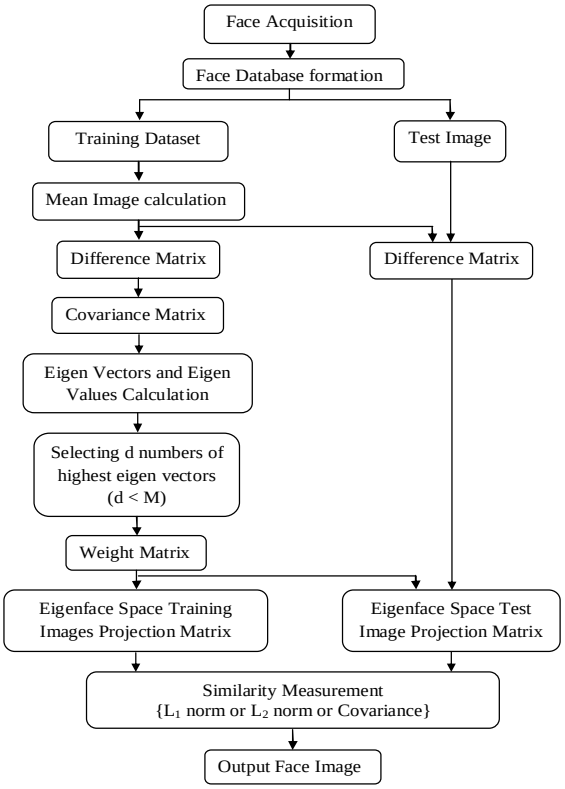

Fig.2: Flowchart of PCA Based Face Recognition System

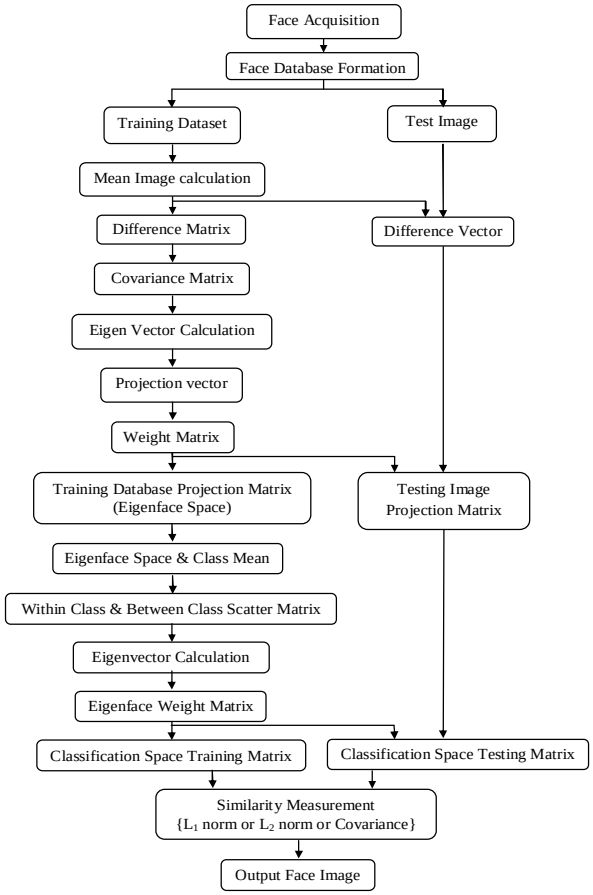

Fig.3: Flowchart of Subspace LDA based Face Recognition System

IV. FACE IMAGE DATABASE

Self Made Inhouse Database- This database is prepared at the institute itself where subjects are staffs and students. Images are taken by camera adjusted at same distance for each one. There are 9 images each of 12 persons. In the first experiment using these images 6 are taken for training and 3 are taken for testing as shown in Fig 4

ORL Face Database- The facial images are collected from the publicly available database called ORL Face Database. The database provided facial images of 40 different persons having 10 images. These images are taken at varying facial expressions and facial details. Out of 10 variant facial images of each person, 8 images are taken for training and 2 images are taken for testing as shown in Fig. 5

Fig. 4: Sample Images of Persons in Self Made Inhouse Database

Fig.5: Sample Images of Persons in ORL Face Database

Specification of Camera Used for preparing Self Made Inhouse Face Database: Cyber-shot HX200V features a new "Exmor R™" CMOS sensors with 18.2 megapixels, with some specification are being listed: -

- 18.2MP "Exmor R™" CMOS Sensor with Extra High Sensitivity technology
- 30x Optical Zoom / 60x Clear Image Zoom
- Photo Creativity
- 9 Picture Effects
- GPS, Compass and GPS Log REC Functions
- 3.0-type "Extra Fine" LCD Screen
- Optical Steady Shot image stabilization with 3-way Active Mode

V. RESULT AND DISCUSSIONS

In this section results of face recognition techniques, implemented by different algorithms, are found out and then their recognition rates are compared at varying PCA features, also termed as dimensions. These face recognition systems are implemented on a 2.67 GHz PC with 3.2 GB RAM and software used is MATLAB version R2010a. The face database has been obtained from ORL Face Database and a self made inhouse face database is prepared.

Face recognition system is applied with feature extraction techniques, Principal Component Analysis and Subspace Linear Discriminant Analysis methods, for checking its performance in two databases. Moreover, testing images are classified from training images by L1 Norm, L2 Norm and Covariance in case of Principal Component Analysis. As City Block Distance is giving good result in PCA so Subspace LDA is being checked by this classification technique only. Results will be compared in both techniques by varying number of testing images and by varying number of principal components.

By taking a test image as input to the face recognition system, it calculates image based features on eigen face space and hence the system compares this feature with features of all other images which were used for training of the system. Fig. 6 is showing one such output.

Fig.6: Output of Face Recognition System

A. Results of Principal Component Analysis based system for ORL Face Database

Fig. 7 shows, Comparison of recognition rate of Principal Component Analysis based system with varying principal components. Experiment is performed under three conditions where numbers of testing images are varied.

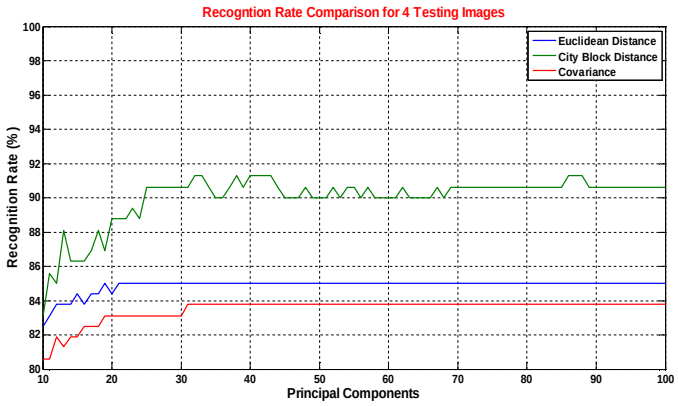

Fig 7: Recognition Rate comparison for 4 testing Images per Person

It can be observed that recognition rate has always been good for City Block Distance Calculation Classification Technique. Also it is observed that more numbers of training images give good recognition rate and hence improves efficiency of the system.

B. Results of Subspace Linear Discriminant Analysis based System for ORL Face Database

For Subspace Linear Discriminant Analysis Method separate classes has been prepared for different person. As it is observed that high training images give good result so here also for each person, 8 images are kept in training classes and 2 images are kept for testing purpose.

From fig.8, it can be observed that recognition rate is increasing with increasing LDA features; also it is good for less numbers of PCA features.

As PCA is dimension based technique, so here it can be observed that LDA is capable of reducing dimension and giving better result.

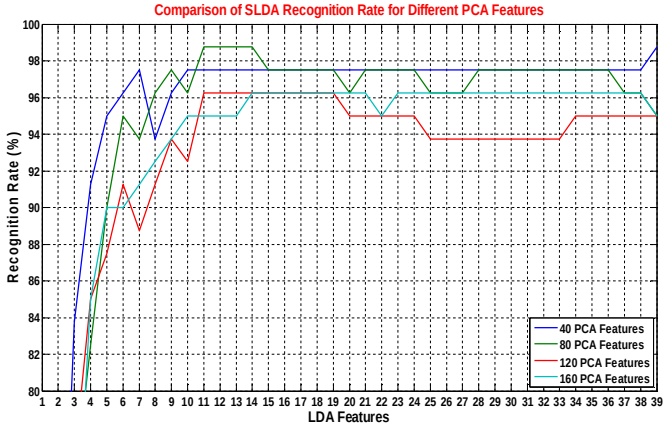

Fig 8: Recognition Rate Comparison in different Principal Components with variable LDA features for ORL Database

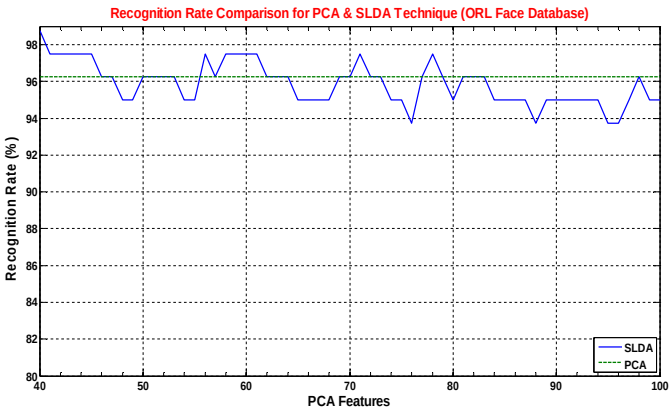

Fig.9: Recognition Rate Comparison of PCA & SLDA feature extraction technique with variable PCA features and fixed LDA features for ORL Database

From above figure 9, it can be found that Subspace LDA is giving good result than PCA technique. But as number of PCA features of dimension of eigenspace is increased SLDA recognition rate get reduced.

C. Results of Subspace Linear Discriminant Analysis based System for Selfmade Inhouse Face Database

A Selfmade Inhouse database has also been prepared for testing of this system. This database is having 9 images for 12 different persons taken under different gesture and occlusions.

Out of these 9 images person, 6 images are kept for training and 3 images are kept for testing purpose. Figure 10 shows, Comparison of recognition rate of Subspace Linear Discriminant Analysis based system with varying LDA features for different PCA features. It can be observed that with increase in LDA features recognition rate increases but in this case recognition rate is not best for least PCA feature.

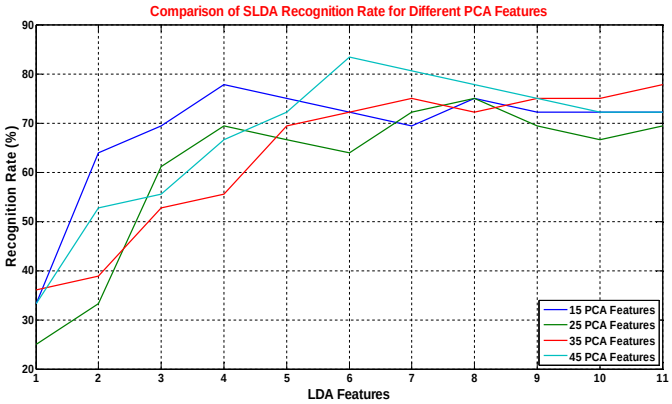

Fig.10: Recognition Rate Comparison in different Principal Components with variable LDA features for Selfmade Inhouse Face Database

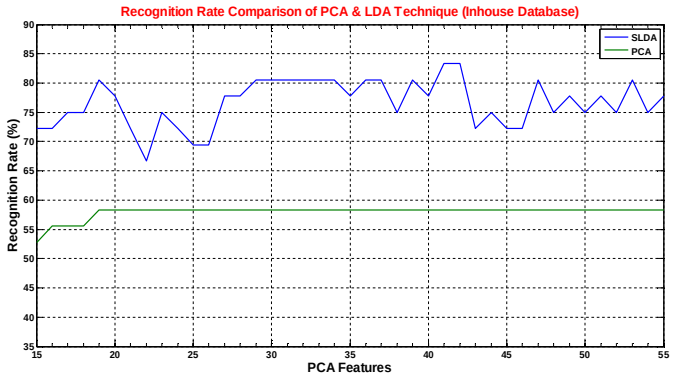

Fig.11: Recognition Rate Comparison of PCA & SLDA feature extraction technique with variable PCA features and fixed LDA features for Inhouse Database

Figure 11 is comparison of recognition rate for PCA and SLDA technique for inhouse database and it is found that SLDA has always been performing better that PCA. However here also with increase in PCA features, recognition rate of SLDA technique is reducing.

VI. CONCLUSION

On the basis of methodology designed for face recognition system, experiments are performed under different conditions and their results are analyzed graphically. In table 5.2 best recognition rates for PCA and SLDA techniques for both ORL and Selfmade Inhouse face database are being shown.

TABLE I: RESULTS OF FACE RECOGNITION TECHNIQUES

S. No.	Techniques	Recognition Rate (%)	
		ORL Face Database	Self Made Inhouse Face Database
1	PCA with L_2 Norm [15]	84.00%	---
2	DCT Based Face Recognition [23]	84.50%	---
3	K-means [24]	86.75%	---
4	PCA & LDA with L_2 Norm [9]	94.80%	---
5	Fuzzy Ant with fuzzy C-means [24]	94.82%	---
6	Principal Component Analysis (Designed)	96.35	58.33
7	Subspace Linear Discriminant Analysis (Designed)	98.75	83.33

Proposed image based feature extraction technique cannot be used in facial feature based system, where facial features like eyes, nose, ears are needed to be located. Some more databases are available which is much bigger and where images are taken in very complex conditions. They should

also be used to check efficiency of the designed system. Also live video database can be used, where face tracking and detection is performed before identification.

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