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An Automated Classroom Attendance System Using Video Based Face Recognition

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Abstract— **This paper proposes and compares the methodologies for an automated attendance system using video-based face recognition. Here input to the system is a video and output is an excel sheet with attendance of the students in the video. Automated attendance system can be implemented using various techniques of biometrics. Face recognition is one of them which does not involve human intervention. In this paper, attendance is registered from a video of students of a class by first performing Face Detection which separates faces from non- faces, and then Face Recognition is carried out which finds the match of the detected face from the face database (collection of student's name and images). If it is a valid match then attendance is registered to an excel sheet. Face recognition is performed and compared on the basis of the accuracy of recognition using Principle Component Analysis (PCA) and Linear Discriminant Analysis (LDA) algorithms.**

Key Words: Video-based Face detection, Face recognition, PCA, LDA.

I . INTRODUCTION

In recent years, video-based face recognition has received extensive attention and is one of the most important topics of research in the field of image processing for people's identification. There are so many other methods of identification which can be more accurate than face recognition, still, it is gradually evolving in the biometrics because of its noninvasive nature and because it is the primary method for person's identification [1]. We can utilize it in the field of education for managing the attendance of students. There are number of organizations where the attendance of students or employees has to be registered. We all know about the traditional approach of registering attendance in a register which is very tedious and time-consuming and also can be easily manipulated, destroyed or misplaced. To avoid such problems different biometric techniques like fingerprints, iris recognition, smart card etc. have evolved and successfully used in all sized organizations. These forms of biometrics are dependent on individuals so to avoid human intervention, face recognition is the main focus of researchers, especially video-based face recognition, because it can be implemented for many applications such as video surveillance, attendance monitoring in different organizations, and similar security purposes.

This paper demonstrates how face recognition technique can be utilized in the field of education for an effective attendance system to automatically record the presence of an enrolled individual within the respective venue. The process of this face recognition system is divided into various steps, but the important steps are detection and recognition of the face. Firstly, to mark the attendance of students, the image of student's faces will be required. We can get this image either by recording a video or by capturing an image from a camera device, which will be placed in the classroom at a suitable location from where the whole classroom can be covered. The camera will record the video of class for few seconds then the system reads the frames from the video and detects the faces therein. After acquiring the frames, system performs face detection, which distinguishes face and non-face objects. For face detection, we use Viola- Jones algorithm which consists of an Adaboost algorithm and Haar feature classifiers. Viola-Jones is the most efficient and widely used algorithm for face detection.

The detected cropped faces are processed further for face recognition using the suitable algorithm. Here, Principle Component Analysis (PCA) and Linear Discriminant Analysis (LDA) are applied and both the algorithms are compared on the basis of the accuracy of recognition. The Eigenfaces are used along with PCA. Eigenfaces are the extracted features of the image which contain the relevant information about the image. The input image is recognized by comparing them with the face database which is our training set. After finding the valid match attendance is registered in an excel sheet.

In this paper, the training set consists of 5 images per person with a different pose. We get the different experimental results by varying the size of the training set.

II. LITERATURE REVIEW

In literature survey of video and image-based face recognition, we get to know about the various face recognition techniques and also realized that it is mainly two steps methodology which involves face detection and face recognition. To get high recognition rate, detection plays a major role. In recent years researchers have developed numbers of face detection and face recognition algorithm.

Huge amount of work is being carried out to implement classroom attendance system [1-6]. In [1] we came to know about the two stage methodology of automated attendance system. [4] Suggests the improvised recognition rate by enhancing the quality of the image.

In [7] & [8] there are different approaches to face detection. [7] gives the study of Local Binary Pattern (LBP), Adaboost

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algorithm, SMQT Features and SNOW Classifier Method and Neural Network-Based Face Detection.

To get an efficient system for image /video-based face recognition, researchers proposed various algorithms like [9] [10] [11] [12] [13] & [14] using Eigenfaces in Principle Component Analysis (PCA), Linear Discriminant Analysis (LDA). [15] [16] compared LDA and other methods of face recognition.

[17] [18] [19] used hidden Markov model, probabilistic appearance manifold, and ARMA model respectively. [20] presented deep review of various proposed methods for overcoming the difficulties.

III PROPOSED METHODOLOGY

A. Structural design

The architecture of our automated attendance system is as shown in the Fig. 1. As far as hardware and software are concerned, we need a high definition camera which will be installed such that it covers the whole class. Then we must have a PC installed with a very helpful and multi-functional machine language "MATLAB" and MS Excel. To acquire the image or video, connect the camera to the PC and make sure that the camera driver is properly installed and compatible with MATLAB. The working of our smart attendance system is pretty simple and easy to comprehend.

To begin with, there should be a face database which contains the images of the students. The images will be focused only on the face region. Now as soon as we start the camera it records the video, continues for few seconds and then stops. The system reads the frames of video and after reading, it sends the frame for detection where the face of each student sitting in the class has to be detected and cropped. After detection, the cropped faces are used for recognition. These cropped faces are compared with the face database using the proposed algorithm and then after acceptable recognition, the system marks the attendance in an excel sheet.

B Methodology

In this paper, the system has to follow some particular methodologies which need to be processed in following steps:

- Creating face database
- Video recording
- Face detection
- Face recognition
- Registering attendance

1. *Creating face database*

The database is the training set of our system and is created in such a way that it contains images of enrolled students. These images are cropped to get the region of interest which is the face of the student. In this paper, to test the working of the system it is trained with the training set which consists of 5 images per student and here, the number of students is 10. So, overall the system is trained with 50 images.

2. *Video recording*

As we discussed, we must have a very good quality camera to get the efficient detection and recognition. It should be connected to the PC and its drivers have to be properly installed and should be compatible with MATLAB. As we start the camera, the video will be recorded for few seconds and then will be processed further for face detection.

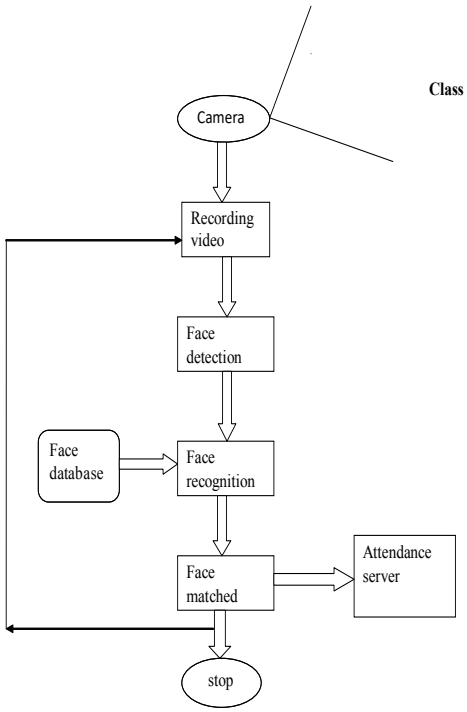


Figure 1. Block diagram of an Automated Attendance System

3. *Face detection*

After getting the video, the system reads the frames. Once the reading stops, it gets the frame and sends it for face detection. In this paper, to detect the faces, "vision.CascadeObjectDetector" command is used which is an inbuilt function in MATLAB for face detection based on the Viola-Jones algorithm.

Viola Jones Object Detection Framework

The Viola–Jones object detection framework is the first object detection framework to provide competitive object detection rates in real-time proposed in 2001 by Paul Viola and Michael Jones. The Viola -Jones method is a machine learning based approach where a cascade function is trained from a lot of positive and negative images. The basic principle of this algorithm is to scan a sub-window capable of detecting faces

across the given input image. The method is to rescale the input image to different sizes and then run the fixed size detector through this image. Each sub-window is processed by a series of detectors, called cascade. The processing of a sub-window starts then, from a simple classifier, which is trained to reject most of negative (non-face) frames, while keeping almost all positive (face) frames. If the classifier rejects a frame, it is thrown away and systems proceed to the next sub-window. If a sub-window is classified as positive by all the classifiers in the cascade, it is declared as containing a face.

Figure.2 Detected Faces

After detection, the cropped faces are extracted from the frame and are saved in suitable image format using IMWRITE command. These images are test images which will be compared with the training set to get the correct match for them. We can also perform image enhancement like gray scaling, histogram equalization, and median filtering to get improved quality of images.

4 *Face Recognition*

This is the most important module of our system which is used to perform the comparison between the test images and the training images. To execute the recognition operation, there are various algorithms but here, the algorithms used are [9-14] PCA and [15-16] LDA.

a) PCA and its Mathematical Model

PCA is a statistical approach used for reducing the number of variables in face recognition. In PCA, every image in the training set is represented as a linear combination of weighted eigenvectors called Eigenfaces. These eigenvectors are obtained from the covariance matrix of a training image set. The weights are found out after selecting a set of most relevant Eigenfaces. Recognition is done by projecting a new image in the Eigenface subspace, after which the person is classified by comparing its position in Eigenface space with the position of known individuals.

Mathematical model:

Let I be an image of size (Px, Qy) then the training operation of PCA can be explained in mathematical form with following steps:

1. Convert the training image matrix I of pixel (N, M) in the vector form as X as $(N, 1)$

   Where

   $$N = P \times Q$$

2. Create a training set of training image vectors by concatenating each column vector X_i such that its size is (N, M) and $X = [X_1, X_2 \ldots . X_M]$ where, X_i represent the i^{th} image vector.

   $$M = number\ of\ training\ images$$
   $$N = size\ training\ images.$$

3. Compute the mean of training set and given by A:

   $$A_{(N\times 1)} = \frac{1}{M} \sum_{i=1}^{m} x_i \quad (1)$$

4. Obtain mean subtracted vector (B) by subtracting mean from each training image and is given by:

   $$B_i = X_i - A \quad (2)$$

5. Create the difference matrix B by concatenating $B_{N\times 1}$ mean subtracted vectors such that difference matrix is given by:

   $$B_{N\times M} = [B_1\ B_2 \ldots \ldots B_M]$$

6. Compute the covariance matrix (C) such that it reduces the computation. The covariance matrix is given by

   $$C_{M\times M} = B^T \times B \quad (3)$$

7. Compute the eigen vectors and eigen values of the covariance matrix C

   $$C \times V = \lambda \times V \quad (4)$$
   $$W = B \times V \quad (5)$$

W is the Eigen vector matrix. Here we have taken 15 Eigen vectors which represent Eigen face space of our face database is shown in Fig.2.

8. Order the eigenvectors descending by their Eigenvalue. The k principal components are the eigenvectors corresponding to the k largest Eigenvalues. Projecting the sample images to this Eigenface space.
   k< less than total samples M

   $$Y_{k\times N} = W^T \times (X - A) \quad (6)$$

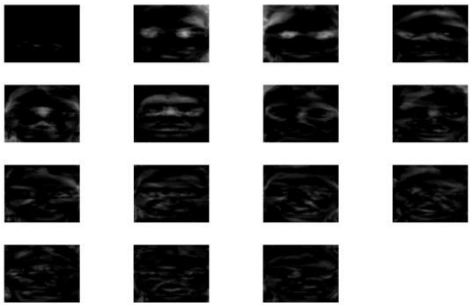


Figure 3. Eigen Face Images of Normal Face Images

9. For recognition of unknown face or test image, normalize it by subtracting from mean vector of all images in the training set. Then using equation (5) project the normalized test image as shown in the following equation:

$$T = W^T \times D \quad (7)$$

Where D is the normalized test image.

10. After the feature vector (weight vector) for the test image have been found out, next step is to classify it. For the classification task we could simply use Euclidean distance classifier

$$e = min||T - Y|| \quad (8)$$

if distance is small then we can say the images are similar and we can decide which is the most similar image in the database.

b) Linear Discriminant Analysis (LDA)

LDA is another holistic approach based face recognition method proposed by Etemad and Chellapa. However, unlike Eigenfaces which attempt to maximize the scatter of the training images in face space, it attempts to maximize the between class scatter, while minimizing the within class scatter. In other words, moves images of the same face closer together, while moving images of different faces further apart. Overall it tries to increase the ratio of the between-class scatter to within class scatter. Here, the class is the collection of images of the same person.

Algorithmic Description

Let X be a random vector with samples drawn from c classes:

$$X = \{X_1, X_2, \ldots\ldots, X_c\}$$
$$X_i = \{x_1, x_2, \ldots\ldots, x_n\}$$

The scatter matrices SB and SW are calculated as:

$$S_B = \sum_{i=1}^{c} N_i (U_i - U)(U_i - U)^T \quad (9)$$

$$S_W = \sum_{i=1}^{c} \sum_{x_j \in X_i} (X_i - U)(X_i - U)^T \quad (10)$$

Where U is total mean;

$$U = \frac{1}{N} \sum_{i=1}^{N} X_i \quad (11)$$

And U_i is the mean of class $i \in (1,.,c)$:

$$U_i = \frac{1}{|X_i|} \sum_{x_j \in x_i} X_j \quad (12)$$

Fisher's classic algorithm now looks for a projection W that maximizes the class seperability criterion:

$$W_{opt} = arg\ max_w \frac{(|W^T S_B W|)}{(|W^T S_W W|)} \quad (13)$$

The rank of S_W is at most (N - c), with N samples and c classes. In pattern recognition problems the number of samples N is almost always smaller than the dimension of the input data (the number of pixels), so the scatter matrix S_W becomes singular. This was solved by performing a Principal Component Analysis on the data and projecting the samples into the (N- c) dimensional space. A Linear Discriminant Analysis was then performed on the reduced data, because SW isn't singular anymore.

$$W_{pca} = arg\ max_w |W^T S_B W| \quad (14)$$

$$W_{fld} = arg\ max_w \frac{|W^T W_{pca}^T S_B W_{pca} W|}{|W^T W_{pca}^T S_W W_{pca} W|} \quad (15)$$

The transformation matrix W projects the sample images into the (c-1) dimensional space, also known as fisher face (shown in Fig.3) that is then given by:

$$W = W_{fld}^T W_{pca}^T \quad (16)$$

The expression for projection of image samples is given by:

$$Y_{(C-1)\times N} = W^T \times (X - A) \quad (17)$$

Rest of the procedure for face recognition is similar to that of PCA.

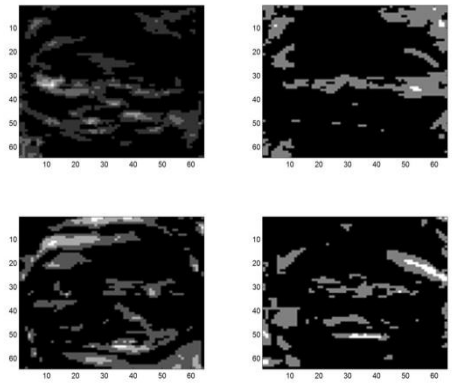


Figure 4. Fisher Faces

4 Registering Attendance

After completion of the face recognition module, next comes the module to register the attendance. If the detected face has been recognized, then it marks the attendance in the excel sheet. To export data to excel workbook it is required to link MATLAB with MS EXCEL. Once these are linked we can easily export or import data to either of them using 'xlwrite' and 'xlread' commands.

IV RESULTS AND DISCUSSION

Results of our experiments are shown in the figures below:

Fig.5 shows that how the system gives the output when the query image is matched with the image there in the database.

Figure 5. Matched Image 2

In this paper, we performed experiment on ORL database which contains 400 images of 40 people, 10 images for each and in our class database there are 25 images of 5 individuals, 5 images for each. Here, ROC (Receiver Operative characteristic) and CMC (Cumulative Match Characteristic) curve are generated for PCA and LDA techniques on both the database as shown in Fig.6 and Fig.7.

To perform the experiment we divided the datasets into training set and test set as shown in table 1. Experiments and their result show that LDA gives more recognition rate than that of PCA as can be seen in the graphs (Fig.6 and Fig.7).

Table 1. Description of Datasets

Datasets	Total images	Individuals	Training images	Test images
ORL Database	400	40	120	280
Class Database	25	5	10	15

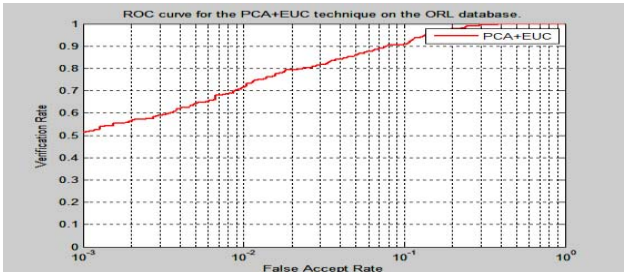
Table II. Comparison between PCA and LDA based on speed and principle.

Algorithm			**PCA**	**LDA**
Comparing Parameters	**Time elapsed**		0.009531 seconds	0.052781 seconds
	Subspace projection		Eigen faces $N \times k$ dimensional	Fisher faces $N \times (C-1)$ dimensional
	accuracy	**Orl database**	66.07%	83.57%
		class database	53.33%	60%

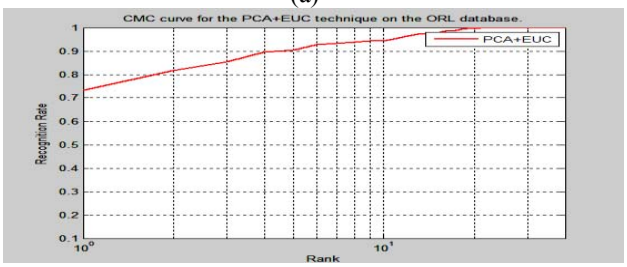
ROC and CMC plots are generared to analyse and compare the performace of both the databases.

ROC is a plot of the **verification rate** against the **FAR** (False Acceptance Rate) for the different possible cut points of a diagnostic test. The closer the curve follows the left-hand border and then the top border of the ROC space, the more accurate the test. **FAR is percentage of invalid inputs which are incorrectly accepted.**

CMC is a plot of **recognition rate** against the corresponding **rank**. The rank 1 point of the modeled CMC curve is used as our measure of recognition performance. The rank 1 point (i.e.; nearest-neighbor) represents the probability of correctly identifying an individual from a gallery of a particular size.



(a)



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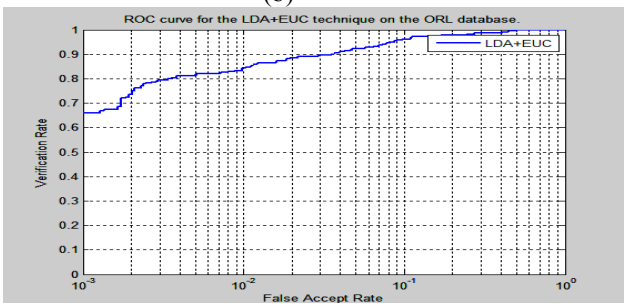

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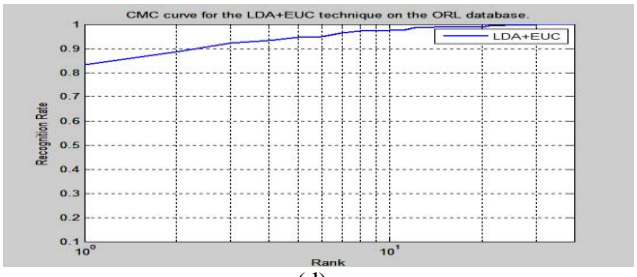
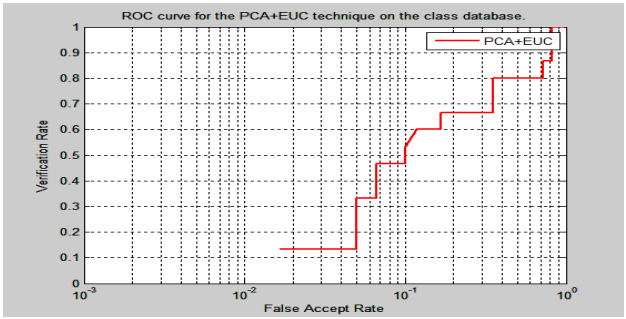
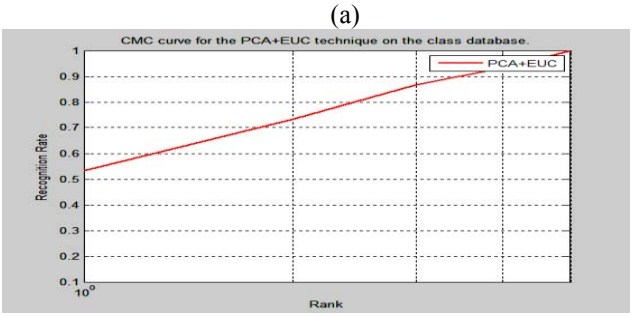


(d)

Figure 6. ROCand CMC curve for PCA and LDA on the ORL database



(a)



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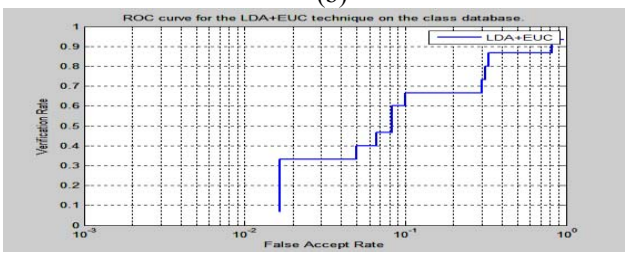

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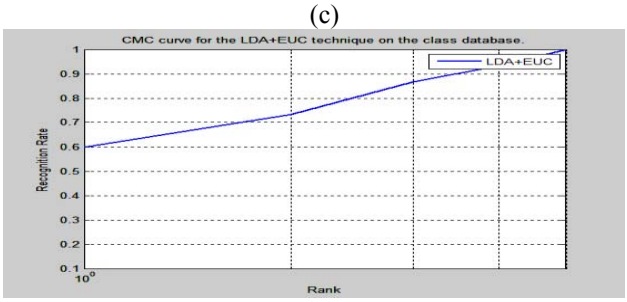

(d)

Figure 7. ROC and CMC curve for PCA and LDA on our Class database

CONCLUSION

This project on Face recognition had given us an opportunity to study about various methods used in the field of face recognition. The literary survey provided us with the pros and cons of many recognition systems.

In this project we developed a PCA and LDA based face recognition system for feature extraction using Eigenfaces and Fisherfaces subspace projection and matching with Euclidean distance classifier. The observation says, PCA and LDA both perform well under the suitable conditions like: Normal light condition, no pose variation, distance from camera should be 1-3 feet for best results. Since both work on pixel to pixel calculation, higher resolution is required. Although there is not much difference in performance of PCA and LDA but as far as time is concerned PCA takes lesser time in recognition phase than LDA. But LDA is preferable for its higher recognition rate.

For recognition of large number of people, some more innovative methods have to be used which overcome the issues occurred in PCA and LDA methods.

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