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Comparative Study of Feature-based Algorithms and Classifiers in Face Recognition for Automated Attendance System

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Abstract— **Attendance plays an indispensable role in any educational system. In this research work, an automated attendance recording systems has been proposed to update the attendance records of the students by recognizing their physical presence in the classroom with the help of face detection and recognition techniques. Face recognition mimics the operations of object recognition in computer vision and image processing domain. PCA and LDA are the two widely used models for feature extraction in face recognition algorithms to extract the low dimensional and more discriminating features from face. The purpose of this paper is to present an autonomous, relative study of three state-of-the-art appearance-based feature extraction methods (PCA, LDA and Hybrid approach) in completely even conditions regarding processing and algorithms execution. The experiments were performed on face databases known as SDB (Student Data Base), where the images were collected by using Truevision HP laptop camera with different illumination conditions at different angles with different facial expressions and poses etc. The hybrid approach improves the face recognition rate when compared with PCA and LDA using SVM as a classifier.**

Keywords— PCA, LDA, Hybrid Approach, SVM, FAR, FRR, Eigen faces, Fisher faces, Scatter Matrices.

I. INTRODUCTION

Attendance of the students play a very important role in the field of education. The problem in traditional manual process occurs when the students presence in the attendance is marked by labelling their name or roll number. This task is more time consuming and it takes more appropriate knowledge on the present students. The manual attendance process fails, when the strength remains very high in a classroom.

Now-a-days for automated attendance of the students we can use their biometric identity such as figure print, iris using IFRD cards or attendance can be marked using bluetooth in mobile phone but all these methods have their own limitations such as time consuming, proxy attendance marking or should have mobile device present with student respectively [1].

When face recognition is considered in terms of machine, many researches have been done from last three decades and it still continues. It mainly concentrates on physical appearance of a person, where the facial features such as eyes, ears, and nose plays the most important role in identification [4]. In the proposed system, face is mainly used for identification. This system includes five modules namely, face detection, pre-processing, training, recognition and attendance update in an excel sheet. The face database contains the faces of students, who belong to different age groups has been collected by the system. This collective data is known as student database (SDB).

This paper contains the following sections; Section 2 includes an overview of proposed system. 3, 4 sections gives a brief overview about face recognition techniques and basic feature extraction techniques. Fifth section describes face classifier used in this paper whereas six sections include experimental details with result analysis, seven section ends with conclusion.

II. METHODOLOGY

The proposed system is divided into five modules namely face detection, pre-processing, training phase, face recognition (testing phase), and attendance marking in database. The first step in proposed system is face detection, for which theViola Jones algorithm is used [1]. This method is generally a modified Haar cascade method for face detection. This type of face detection systems are quite reliable, robust and more useful in real-time applications.

Preprocessing involve conversion of RGB colored image into grayscale image, remove noise, histogram equalization and segmentation, which improves the quality of cropped image suddenly to decrease the error rate that helps to extract the features from faces.

The most complicated and important step is the third step i.e. feature extraction; this involves the identification of local features such as nose, eyes, mouth etc that are common in all the faces. The extracted face is also called as normalize face. In the proposed system, we successfully implement the most widely used feature extraction techniques i.e. PCA; extract lower dimensional and calculates the eigen faces using eigen values [3]. LDA; extracts more discriminating features from faces know as fisher faces [4]. The eigen faces and fisher faces are used for classification [5]. Here we use euclidean distance and SVM as the most accurate classifier [6].

The fourth step involve recognition, means we have to classify the face as per the features match with face database and identify the pupils belongs to which class. The fifth step involve attendance marking, as the face will be recognized using classifier, where his or her attendance is marked in the excel sheet. Figure 1 displays the block diagram.

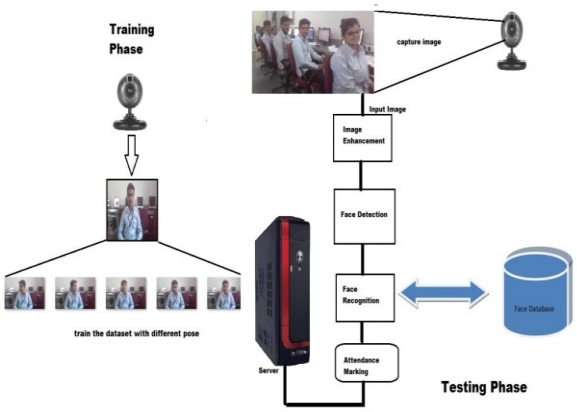

Fig.1. Overview of Automated Attendance System Using Face Recognition.

III. An Overview of Methods

Face recognition is an easy task for human beings since childhood. In term of machine, it remains as the most complicated and complex task due to its huge size.

Face recognition contains an identification of the face present in training dataset. In this process the given input image is compared against a face database and reports a match, the face dataset is known as training dataset done in training phase in which for each person different samples stored in to the training dataset; testing phase contains the unknown image or face to be identified from training dataset. The recognition is done by matching the extracted features from training dataset with testing dataset.

As many research has been done from last three decades shows that face recognition broadly classify into two groups i.e. Template based method, focused mainly on feature such as nose, eyes, mouth, chin and Geometric feature based Methods, focused mainly on shape, facial expressions etc. So proposed system we focus on feature based methods as it does not affected by illumination condition also it gives better results though there are variations in poses[1 2 3 4].

A. Template Based Approach

The appearance based methods used for face detection are Eigen faces, Linear Discriminate Analysis, Neural Networks, and Support Vector Machine etc. In this methods feature are extracted from face used as template for matching.

B. Geometry Based Approach

Research in Neurophysiology studies manifest that the triangular shape of face mainly contains eyes, nose and mouth, are amongst the most important part as features for face recognition.

C. Hybrid Method

Hybrid approach is combination of geometry based and template based approach as discussed in above section. In hybrid approach, we combine PCA (low dimensionality reduction) and LDA (Fisher feature) to obtain the best features, further can be used for better classification [13].

IV. Facial Feature Based techniques

A. Eigen Faces

PCA is also known as K-L transform method used successfully in order to perform dimensionality reduction. In 1987, Sirovich and Kirby developed a method which uses Eigen faces for identification of faces. Matthew Turk and Alex Pentland implement a method i.e. principal component analysis (PCA) for face detection and recognition [6]. An image is M*N dimensional matrix. In this method, Eigen-vectors calculated by the linear combination of weights of Eigen faces i.e. the M*N matrix converted into one dimension (M`=M*N) known as image vector. Find image vector for each image in training dataset, calculate average-face vector (ψ) by sum of all face-image-vector divided by total number of images in training dataset. Subtract all the image-vector from average-face-vector. Stack all (image-vectors – average-face-vector) in matrix forming A, where A is a one dimensional matrix as ([M*N]*I, where I is the total no. of images). Calculate covariance matrix of A i.e. cov(A)= A* A`.

Find eigenvectors and eigenvalues of covariance matrix. As the size of the covariance matrix is very huge, eigenvectors are calculated by transpose (A)*A, in this way the lower dimensionality reduction is achieved. So, the eigen faces are considered as the linear combination of weights. Eigen faces are also referred as ghostly images as shown in the figure2 below.

Fig.2. Eigen faces for SDB training dataset.

B. Fisher Faces

Based on Linear Discriminator Analysis (LDA) technique fisher faces derives also known as Fisher`s linear discriminate technique. In this, data is supposed to be uniformly distributed in each class. The aim of Fisher face is to maximize the ratio of the between-class scatter matrix and minimises with-in class scatter matrix. Figure shows fisher faces.

Fig.3. Fisher faces for SDB dataset.

C. Hybrid Approach

The hybrid approach is the concatenation of two best methods to overcome the drawbacks of each method and the derived method results will be encouraging and improved the recognition rate. Face recognition algorithm based on Hybrid approach (PCA+LDA) is the union of PCA and LDA, two different kinds of algorithms. The combination of two methods in such a way that, PCA reduces the dimension of the data and also data redundancy is minimized as orthogonal components and LDA is used to preserve the class discriminatory information as much as possible. . PCA, achieved, ***low dimensionality reduction***, whereas the goal of LDA is to maximize the distance between ***class scatter matrix*** while minimizing the distance ***within class scatter matrix***.

V. CLASSIFICATION

Euclidean distance is the measure of distance between two points supposes P and Q. It is the length of the distance between the length of the line segment connecting them [PQ]. The Euclidean distance between landmarks is used by most authors as a morph-metric measure. Once facial feature points are obtained from a facial image or a two-dimensional face, they select some significant distances between them and compute the corresponding Euclidean distances. Then, these distances are used to compare faces for face recognition system.

Support Vector Machine (SVM) was originally designed for binary classification. Face recognition is still remaining as the multi-class classification problem. There are two basic methods for face recognition with SVMs: one-against-one and one-against-all. The one- against-all is classification between each class and all the rest classes. The one-against-one method is classification between each pair classes. We implement one-against-all method for face classification [15].

The above discussed feature-based techniques such as PCA, LDA used with classifiers are compared in different real-time situations such as different lighting conditions, Unexpected facial feature changes (Occluded faces), vary in face Expressions. System Performance is also assessed in terms of recognition rate, distance, false positive rate, time taken for training. Distance plays as benchmark in this system model as the image frames are captured when pupils seats in the classroom and face region is resized. So the face region captured at about 1.2 meter and 2.1 meter may results better performance.

VI. EXPERIMENT AND RESULT

The experiment is performed using Matlab 2013a GUI for PCA, LDA and hybrid approach. Training datasets are created by considering different lighting conditions, pose and facial expression in real time using HP Truevision HD laptop camera.

Training Data Base: The experiment performed using *SDB* database, created by us for the proposed system as it is based on real-time. We capture the faces of pupils using HP True Vision HD camera with different angles, facial expression also with different illumination conditions. The SDB also contains the images for different age groups as we broadly define it in to five categories as Primary Age Group *(PAG)*, Secondary Age Group *(SAG)*, Higher-Secondary Age Group *(HAG)*, Graduate and above Age Group *(GAG)*. The training datasets also trained to recognized the osculated faces as we capture the images such as face covered by scarf, faces wear the cap, sun glasses, having moustache and beard to male pupils. Following Figures shows the SDB.

Fig.4. Training samples of SDB contains Primary Age Group (PAG).

Fig.5. Training Samples from Secondary Age Group (SAG) of SDB.

Fig.6. Training Samples from Higher-Secondary Age Group (HAG) of SDB.

Fig.7. Training Samples from Graduate and Above Age Group (GAG) of SDB.

Experiment performed on SDB, Table 1 represent the result for two pupils with centre light condition and 8 samples per pupil. Table one shows the light illumination condition affect on recognition rate, as in this experiment we just change only the light condition with frontal face images. We observed that the success rate going to be decreased as the numbers of pupils are increased, as it depends on how many faces are cropped by face detection technique. The maximum success rate is *90.1%, 92.3% and 95.6 %* for PCA, LDA and Hybrid approach respectively using Euclidean Distance as classifier. As there are huge number of pupils within class the success rate goes down up to 35-25% for all the algorithms as we failed to recognized the pupils seated on last, since their faces are *not* captured; however we also unable to recognize the pupils whose capture faces are not enough for feature extraction example. Partially recognized images. The *False Rejection Ratio (FRR)* is the calculation of the probability that the face recognition system will wrongly *reject* an correct attempt by an approved image. A FRR generally stated as the *ratio* of the number of *false* rejections divided by the number of recognition shots; however we overcome this problem by increase the samples per pupil in the training dataset. We success to identify 18-20 pupils seating in a class at a time.

Method	Pose	Light condition	Euclidean Distance	Success Rate	FRR (False rejection Ratio)
PCA	Centre	Dark (day time) & centre	6.1245e-12	96.90	0.32
LDA	Centre			97.01	0.29
Hybrid Approach	Centre			98.50	0.20
PCA	Centre	Light (Night time) & centre	1.4870e-11	25.00	75.50
LDA	Centre			55.50	45.60
Hybrid Approach	Centre			75.23	25.36

Table 1. Comparison of PCA, LDA and Hybrid approach using Euclidean distance as classifier.

A. Experiment

This experiment was performed on different number of students with different number of sample per student i.e. 3-5 images per pupil. As the number of samples per pupils decreases the training time required by system decrease, system perform @ speed 5 seconds / image means it takes lots of time when we increase the samples/ pupil. Experiment performed on all feature based techniques here require the performance time as 6 Seconds / image, 9 / image, 4.5 /image for PCA, LDA and Hybrid resp. SVM is used as a classifier instead of Euclidean distance with same database.

No. sample per pupil	No. of pupils	No. of pupils recog-nized by PCA	No. of pupils recog-nized by LDA	No. of pupils recognized by Hybrid Approach	FRR in % for PCA	FRR in % for LDA	FRR in % for Hybrid Approach
4	10	6	7	8	96.90	97.89	98.50
6	20	15	17	18	75	87.5	90.53
5	30	22	24	26	66.67	83.33	91.67
4	50	29	41	42	75	91.67	92.33
3	60	50	52	55	83.33	91.67	95.23

Table 2. Comparisons of feature based algorithms and Hybrid approach using SVM.

B. Result Analysis

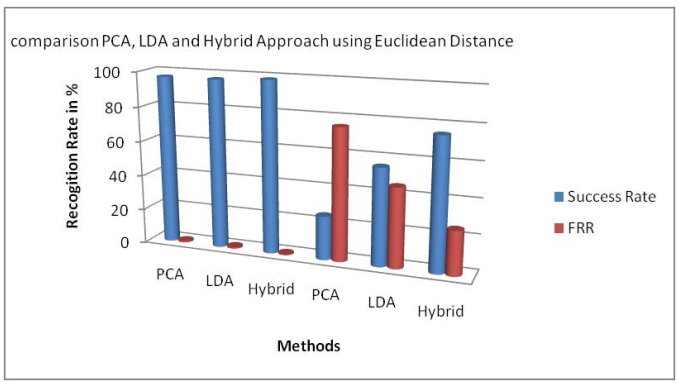

Fig.8. Comparative study of LDA, PCA and Hybrid Approach in two illumination conditions i.e. having high intensity light (day time); having low intensity light (night / evening time),

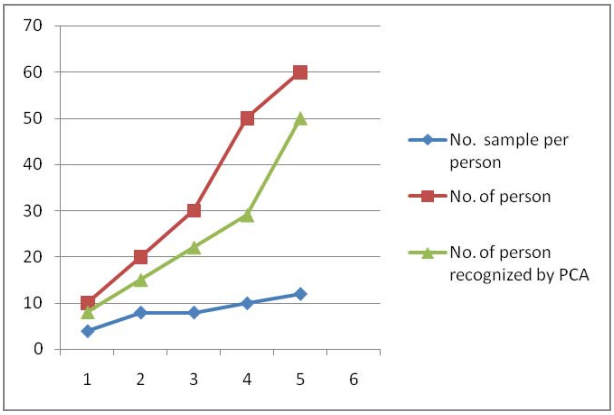

Fig.9. Curve shows PCA with SVM as classifier.

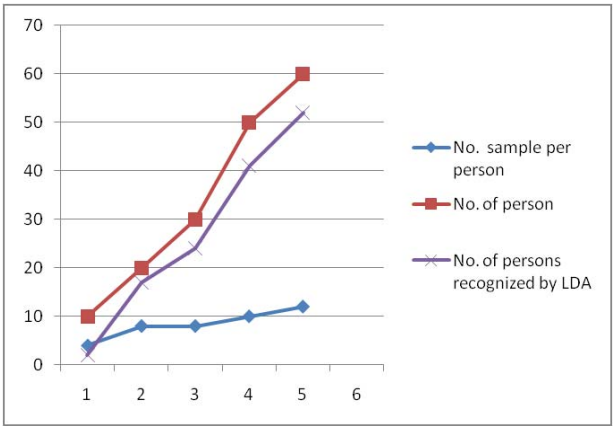

Fig.10. Curve shows LDA with SVM as classifier.

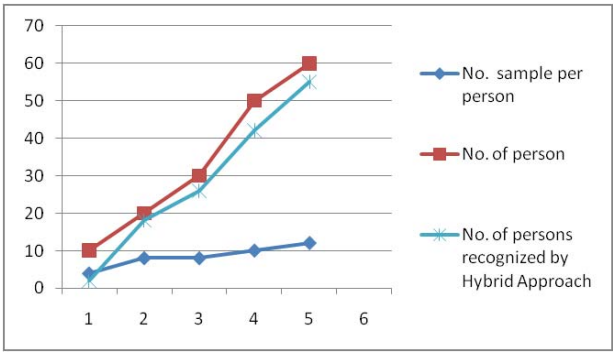

Fig.11. Curve shows Hybrid approach (PCA+LDA) with SVM as classifier.

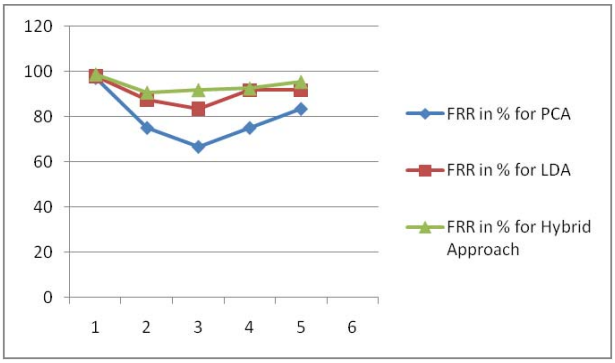

Fig.12. Comparison between PCA, LDA and Hybrid approach.

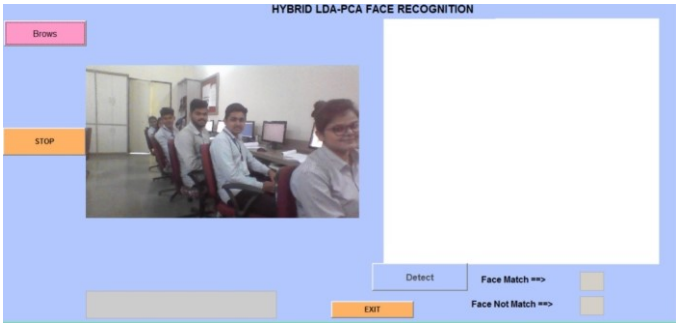

Fig.13.Input data-screen.

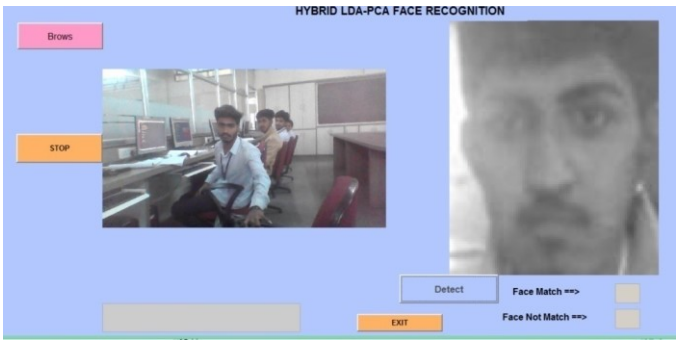

Fig.14. Output shows the matches found to given input images.

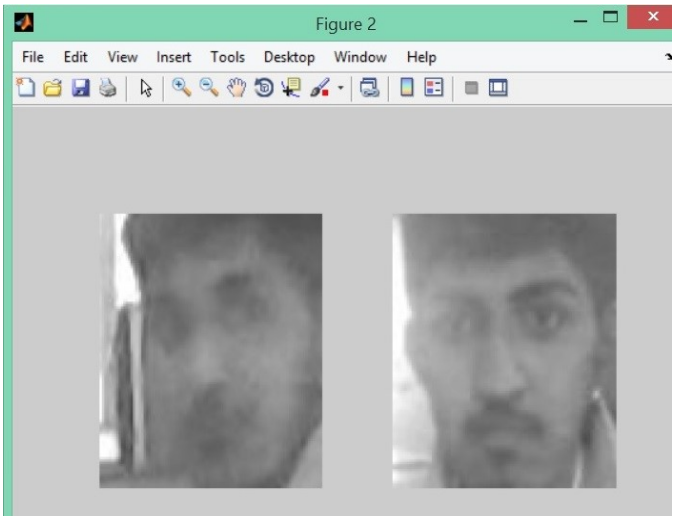

Fig.15. Input image match with training data.

Roll No.	Name	Present or Absent	
1	Anil D. Patil	P	
2	Sunita S. Kale	A	
3	Tom D.	P	
4	Samidha S.	P	
5	Sarika K.	A	
6	Ashok M.	P	
7	Mohini D.	A	
8	Dadasaheb P	A	
9	Balaji Jagtap	A	
10	Krishna Murthy	P	

Fig.16. An updated Excel Sheets attendance record.

VII. CONCLUSION

From above discussion we can conclude that

- Frontal face images with good lighting condition the recognition rate increases for all algorithms is in an average 95% as training dataset contains 10 images for each person as sample. The recognition rate goes down as the number of recognizing persons in an image are more than 10-20.
- Face angle with left-side or right-side face image with good lighting condition the recognition rate for PCA, LDA and Hybrid Approach is 68%, 75%, 86% respectively.
- If lighting condition is bad i.e. dark or cloudy in which faces are not visible in such cases the recognition rate goes down up to 10%.
- Hybrid approach (combination of PCA, LDA) results in good feature extraction which increases the RR up to 97.23 % with respect to good lighting condition with frontal face.

Future Scope: We want to improve the recognition rate for huge cloudy face image i.e. more than 50 or 100 in an input image for face detection and identification.

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