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Face Recognition Using Principal Component Analysis in MATLAB

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***Abstract*—** The paper present an semi-automated program for human face recognition. A self prepared database of different faces is used. Task of removing background from the image is a challenge but on the other hand by implementing Viola-Jones face detection algorithm and by Principal Component analysis it is possible. An application of system can be real time implementation of face recognition system. A robust and reliable form of recognition can be done by using Principal Component analysis. In the process Eigen faces or Eigen values are selected by PCA calculating the nearest face or value and then displaying result. This biometric system has real time application as used in attendance systems.

Keywords- *Eigenface, Eigenvalues, Detection, PCA, Recognition*

I. INTRODUCTION

Face Detection and Face Recognition is the biometric on which lots of work has been performed. Over the time lots of methods are introduced for detection and recognition which are considered because as it's a best way for person identification [1] and doesn't require human cooperation [2] for identifying or verifying. Viola-Jones detection [3] is a milestone for detection of facial parts. It is a effective and fast way of detection than any present.

In current paper we developed a system for the said method's valuation. The overview of the system is shown in figure 1. In this process face is detected and then recognized by using PCA algorithm for Eigen Faces made of images in the database and the one captured or one in the database. Selection of face for displaying is dependent on the selection of the nearest value which is generated as a result of the Algorithm performed. Figure 1 show the processes involved on the face detection and recognition process.

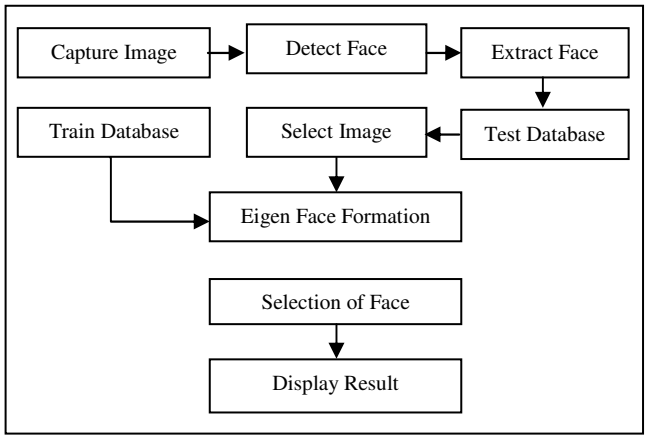

Fig. 1 System Overview

Face recognition can be performed by two basic methods: the first method is extraction of some basic parts of a face such as eyes, nose, mouth, and chin, with the one stored in the database.

Second method is based on Principal component analysis method. In this method the information which defines the dace more is derived from the face image. Face can be represented in terms of a best coordinate system termed as 'Eigen faces'. In this paper a recognition system is implemented based on Eigen face- PCA. The technique involved in this paper is regardless of the expression or features of the human face (face expression, eyes open/closed, with or without glasses). PCA is an information theory approach in which the extraction of relevant information regarding face is extracted efficiently. The following paper discuss about Face Detection method in section II, section III discuss about Face Recognition method, section IV defines PCA algorithm followed by eigen face approach and at the end summarized result and conclusion.

II. FACE DETECTION

Face Detection is useful tool in biometrics, often as a part of a facial recognition system [4]. Viola-Jones [3] Face Detection Technique is used for the purpose of detection of face in the image captured. Benefits of using this technique are: Firstly it is the fastest technique present for the detection of face process. Secondly contribution a simple and efficient classifier built from computationally efficient features using AdaBoost for feature selection [3]. In this step or process the location and size of the face in an input image is determined. Face detection can be regarded as specific case of object-class detection. Under face recognition it can be considered as a general case of face localization. In face localization, the central task is to find the face location and sizes of a well-known number of faces (usually one) [4]. Whereas in face detection purposed by viola-Jones emphasis on detection of

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the frontal face from the given input. Figure below show face detected by Viola-Jones algorithm.

Fig. 2 Face detected using Viola-Jones Algorithm

III. FACE RECOGNITION

Before Biometrics face recognition system is a computer application which automatically verifies and identifies a person from an image or video feed. One of the ways to do this is by comparing selected facial appearance from the image or by facial database. The accuracy of face recognition depends heavily on the quality of the input image or the pose of the image or by expression of person in image. The variations of facial appearances caused by illumination, the appearances are classified into four main components: diffuse reflection, specular reflection, attached shadow and cast shadow [4],[5].

The image captured has background along with it which is called illumination changes. This lighting is cause of which the recognition process can be affected. There are some algorithms which can be used for extraction of features from image and comparing or matching features in recognition process, although complete removal of illumination is not achieved. In PCA based face recognition we have database with two subfolders; Train Database and Test Database.

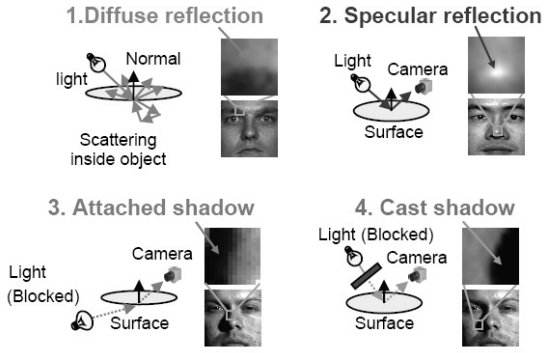

Fig. 3 Variation of facial appearances in case of Face Recognition

IV. PCA ALGORITHM

PCA method is a useful arithmetical technique that is used in face recognition and image compression. Both of these applications are based on pattern finding in data of high dimensions. In arithmetical terms first the transformation matrix is formed of the image, next, the training images in the database are projected onto the formed matrix columns. Finally the image is selected and shown. PCA covers standard deviation covariance, eigenvectors and eigen values. There are many applications which can be used for solving the problem of recognition, but out of those the appearance-based approach is best. Principal Component Analysis also has some limitations like it is time consuming and some important features are missing in this method. The benefit of using it is can be directly used for two-dimensional patterns.PCA can perform prediction, redundancy removal, feature extraction, data compression, etc [6]. PCA can not only decrease computational complexity with a linear transform, but also make the distribution of face image data more compact for classification, it have become popular feature extraction methods for face recognition[9]. On the other hand, PCA method can not only effectively reduce the dimension of human face images, but also retain its key identifying information [8]. Process followed in PCA Algorithm is illustrated by the following Flow Chart [7]:

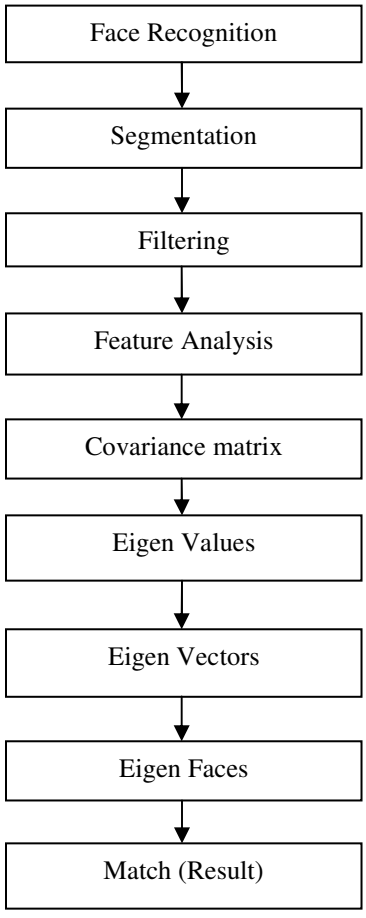

Fig. 4 Flow Chart of PCA Algorithm

I. Let a face image X(x_1, x_2) be a 2- dimensional M x N array of intensity values of face image(s). Image can also be considering by the vectors of dimension of image mn. Let the training set of images {X1, X2, X3,……, XN}. The average face of the images in the set is defined by

$$\bar{X} = \frac{1}{N}\sum_{i=1}^{N} X_i \quad (1)$$

II. Calculate the Covariance matrix to represent the scatter degree of all characteristic vectors related to the average vector.

The Covariance matrix C is defined by

$$C = \frac{1}{N}\sum_{i=1}^{N}(X_i - \bar{X})(X_i - \bar{X})^T \quad (2)$$

III. The Eigenvectors and corresponding eigenvalues are computed by using

$$CV = \lambda V \quad (3)$$

Where V is the set of eigenvectors associated with its eigenvalue λ.

IV. Sort the eigenvector according to their corresponding eigenvalues from high to low.

V. Each of the mean centred image project into eigenspace using the below equation:

$$W_i = V_i^T (X_i - \bar{X}) \quad (4)$$

VI. In the initial phase each test image should be mean centered, now by projecting the test image into the same eigenspace as defined during the training phase.

This projected image is now compared with project training image in eigenspace. Images are compared with similarity measures. The training image that is closest to the image will be matched as used to identify [6].

V. EIGEN FACE APPROACH

In information theory, we want to extract the appropriate information in a face image, encode it as efficiently as possible, and compare one face encoding with a image in database of model encoded similarly [6], [10], [11]. When we consider pattern detection Human Face Detection is a difficult and has practical problems. In the process we need to find the principal component of the faces or eigenvectors of the set of images in mathematical terms. This is done by considering image as a point (vector) in a very high dimensional space. Eigen vector can be considered as a set of facial appearance that together characterizes the deviation between face images. Each image is used for defining the eigenvector, so an eigenface i.e. arrangement of various eigenvecters. Every face can be represented in terms of a linear combination of eigenfaces accurately and we can approximate the face using only the best eigenfaces (Those that have the largest eigenvalues, and which therefore account for the most variance within the set of face images.).[7] The best M eigenfaces span an M-dimensional subspace “face space” of all possible images. [10], [11]
In order to calculate the eigenfaces and eigenvalues in MATLAB we have to use the command eig. The syntax of the command is

d = eig(A)
V,D = eig(A)
V,D = eig(A,'nobalance')
d = eig(A,B)
V,D = eig(A,B)

d = eig(A) returns a vector of the eigenvalues of matrix A.

V,D = eig(A) produces matrices of eigenvalues (D) and eigenvectors (V) of[13] matrix A, so that A*V = V*D. Matrix D is the canonical form of A, a diagonal matrix with A's eigenvalues on the main diagonal. The matrix ‘V’ is the *modal matrix*, and its columns are the eigenvectors of A. The eigenvectors are scaled so that the norm of each is 1.0. Then we use W,D = eig(A'); W = W' in order to compute the left eigenvectors, which satisfy W*A = D*W.

V,D = eig(A,'nobalance') finds eigenvalues and eigenvectors without a preliminary balancing step. Ordinarily, balancing improves the conditioning of the input matrix, enabling more accurate computation of the eigenvectors and eigenvalues.

d = eig(A,B) returns a vector containing the generalised eigenvalues, if A and B are square matrices. V,D = eig(A,B) produces a diagonal matrix D of general eigenvalues and a full matrix V whose columns are the corresponding eigenvectors so that A*V = B*V*D. [10]

VI. SOFTWARE USED

Under software section is completely based on MATLAB. In our case we have used MATLAB for face recognition. We are able to use it in a way that it is able to match the face from predefined database or input from camera and generate an output. MATLAB 2012a is utilized and its Image Acquisition and Image Processing toolbox are used.

VII. IMAGE ACQUISITION

Image Acquisition Toolbox enables user to capture images or video from camera and get it directly to MATLAB. This tool can directly detect hardware automatically and configure its properties. This Toolbox provides graphical tools and a programmatic interface to work with image grabbing through hardware in MATLAB. This Toolbox helps in converting the live feed to RGB or to grayscale as per requirements.

VIII. IMAGE PROCESSING

The acquisition process only captures the image but further processing of image is required as it need to be resized or cropped in accordance to make the face available for database storage. In this process the Viola-Jones approach for face detection is used. The IP toolbox care to process the image according to the user need for desired output.

IX. RESULT AND DISCUSSION

In PCA based face recognition, by increasing the number of images of faces in the database increases the recognition rate of system. But the recognition rate starts saturating after a definite sum of increase in eigen value. This is because increasing the images in the database increases the recognition rate but however this increase is compensated by noisy images which decrease the recognition accuracy. Figure below shows the implementation of the system. Firstly the image is given as input to system from train database folder, and then it is matched with the mean eigen face formed of the images in the database. The one which has the value or eigen value nearest to the eigen face value of the images in database it is shown as the result at output. The image on the left side is the input to the system and image at the right side is the output which is shown after matching. These images are stored in the train and test database.

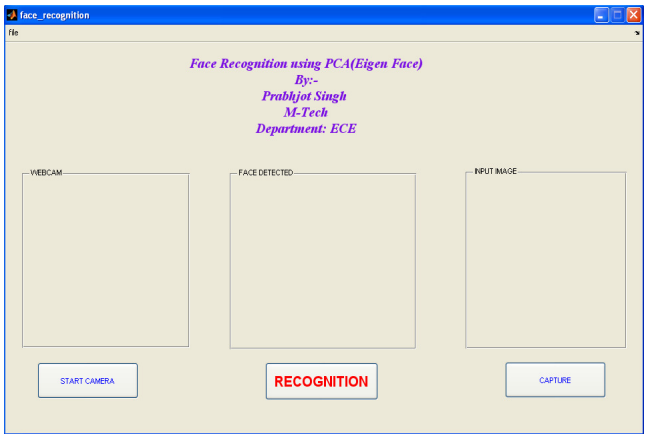

Fig. 5 GUI interface for Face Recognition

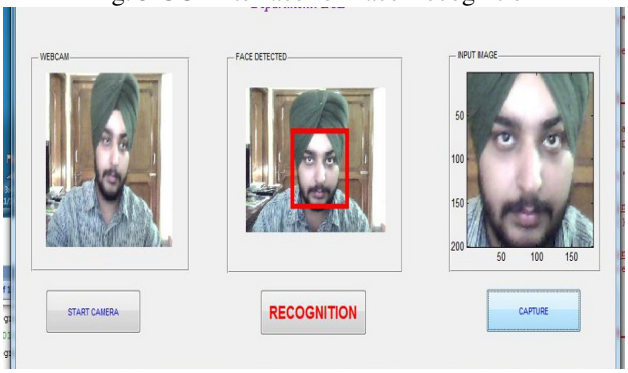

Fig. 6 Detection of Face Region

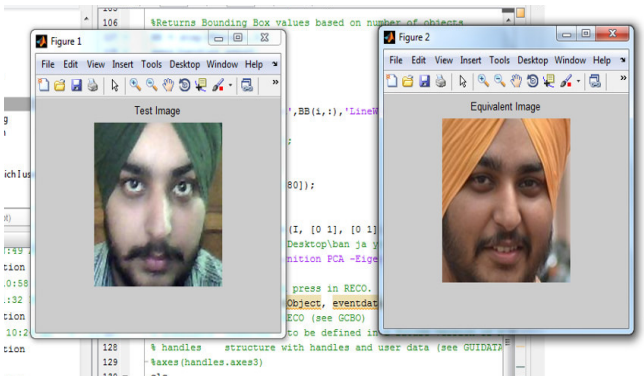

Fig. 7 Result shown at the output

X. CONCLUSION

In the work performed we are able to develop a system to evaluate the face detection and face recognition. To speed up the process of face detection we used Viola-Jones detection algorithm. The database created is used as a source for the eigenfaces and the input image is matched over the mean image in eigenspace. As in PCA based face recognition, increasing the number of faces increases the recognition rate.

But the recognition rate saturate after a definite sum of increase in eigen value. Increasing the images in the database increases the recognition rate however noisy images decrease the recognition accuracy. Resolution of image is not important in case of PCA approach but expressions and pose have effect on the system. As such, continuous works have been carried out in order to achieve satisfactory results of face recognition system. All the above discussion provides adequate data and optimal design to implement and test of human face recognition system. Future work can consider working on removing the issue of quality of image as always regarding issues of friendly environment for image capturing.

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Prabhjot Singh is pursuing his M.Tech in Electronics & Communication Engineering from CGC-COE, Landran, Mohali and will complete his degree in 2015. He graduated in B.Tech in Electronics & Communication Engineering from DIET, Kharar and also did diploma from Govt. Polytechnic Khunnimajra in Electronics & Communication Engineering. His areas of interest are Image Processing, Wireless Communication.

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