

# Image Analysis for Face Recognition Using PCA

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## Abstract

Face is a compound multidimensional construction and requires superior computing techniques for identification in image analysis. In this paper, the appearance-based statistical approach called Principal Component Analysis (PCA) is proposed for decreasing the number of variables in face recognition. PCA is very prominent method as it can reduce the larger dimensionality of data to the lesser one of feature space which can project data accurately. PCA is efficient when the database is of smaller size. In this each image in the trained set is represented as weighted sum of Eigen vectors called Eigen faces. These Eigen vectors are obtained from covariance matrix of a training set. Mathematical approach for formulating the calculation of eigenface has been discussed and the results are also presented. The coding is performed using MATLAB software and GUI (Graphic User Interface)..

**Index Terms;** *Eigen face, Covariance, Euclidean distance, GUI, MATLAB*

## I. INTRODUCTION

Face recognition is a popular computer vision application for automatically recognizing the faces or to verify an individual from a digital image to perform image analysis. Facial recognition may be a very challenging problem but there are many techniques available to acknowledge face [1]. There are various applications of face recognition in our daily life such as identifying people using debit cards, pan card checks and aadhar verification etc. Several works have been performed from several years in order to develop suitable face recognition techniques. These techniques generally involve an appearance-based method, in which a vector indicating a particular size in a dimensional space of size analogous to the image is considered. To encounter over large dimensional spaces problem some other efficient methods were developed. These techniques generally involve the Principal Component Analysis (PCA) and the Linear Discriminant Analysis (LDA) [2]. PCA algorithm is an eigenvector based approach used to represent

large-dimensional data efficiently. PCA is the most reputed appearance-based statistical method that is mainly used to decrease the dimensionality of an image [3]. This method is employed to scale back the size of face space data by means of knowledge compression [4]. This reduction in dimension filters the data that is not important and also acknowledges the face. Then it also splits the face structure into uncorrelated components called Eigen face [5-6]. Each face image can be represented as a feature vector or a weighted sum of the eigen faces and are stored in a one-dimensional array. The PCA method requires a full front face image to perform analysis in order to offer good performance results [6]. PCA technique has an advantage that it requires small amount of data needed to recognize an individual to perform image analysis [7].

## II. MATHEMATICAL FORMULATION OF PCA

A two-dimensional face image is generally represented as a one-dimensional vector. In this section main scheme for

Eigen face using PCA is presented. Initially from M number of a face images a training set S is obtained. In this case M=10 (9 images of face database plus one face image to offer new entry within the database. M is variable as it depends on face database). It can be represented as,

$$S = \{\Gamma_1, \Gamma_2, \Gamma_3, \dots, \Gamma_M\} \quad (1)$$

Next step is to calculate average matrix  $\Psi$ ,

$$\Psi = \quad (2)$$

Then average matrix  $\Psi$  is subtracted from the original faces and the result is stored in the variable ,

$$\Phi_i = \Gamma_i - \Psi \quad (3)$$

Then a set of M orthonormal vectors are determined that specifies the allocation of the face space data. The Kth vector , is to be selected such that,

$$(4)$$

is highest, subject to,

$$(5)$$

Here the vectors are eigenvectors and scalars are covariance matrix.

Covariance matrix C is specified as,

$$(6)$$

With the matrix

$$A = \{\Phi_1, \Phi_2, \Phi_3, \dots, \Phi_n\} \quad (7)$$

The matrix C is of  $N^2 \times N^2$  hence we need computationally feasible method so we create the matrix with M x M that is

$$(8)$$

Where,

$$(9)$$

Then M number of eigen vectors of L are determined.

These eigenvectors are used to establish

combination of M training set face images to structure Eigen faces.

$$(10)$$

So these are the Eigen faces of training set of original face images.

### III. RECOGNITION PROCEDURE

In face recognition, initially input face representation is converted into its Eigen face and it is compared with the mean image. Then the difference of these two images is multiplied with each eigenvector of 'L' matrix. Each individual value is saved as a vector called  $\Omega^T$  and each would be represented as a weight.

$$) \quad (11)$$

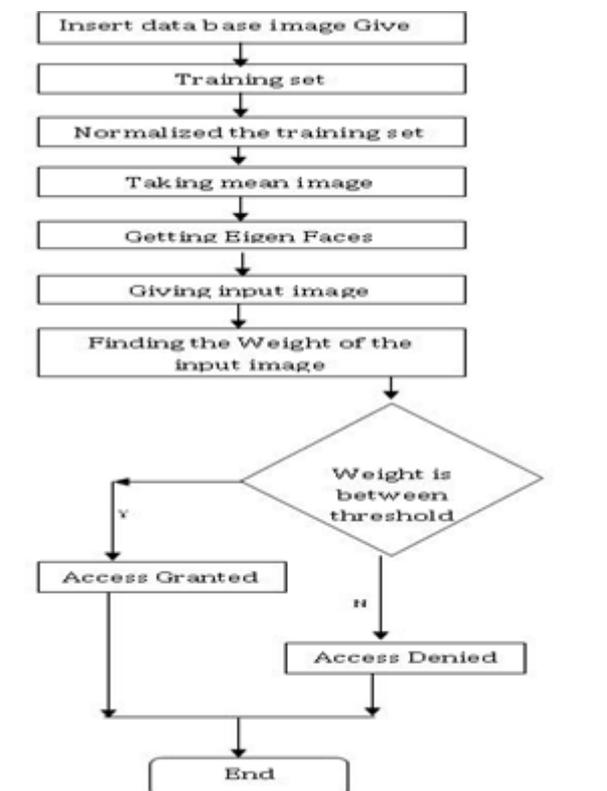
$$\Omega^T = [\omega_1, \omega_2, \dots, ] \quad (12)$$

Then the face class is calculated and it provides good similarity for the input face image. This is performed by minimizing the Euclidean distance which is,

$$(13)$$

is a vector that describes face section of face space. The input face image is classified as a face section k if is less than some defined threshold , then the face image can be considered as a "known face" class. If the difference is greater than the chosen threshold, the image can be treated as an "unknown face" class. In case the image is greater than these two chosen thresholds, then the image cannot be considered as a facial image. For each new face image which is to be identified or recognized by algorithm, its pattern vector called  $\Omega$  is to be calculated from Eq. (12), the distance to each known class, and a distance to face space. If the minimum distance is less than and distance less than , then the input face image is classified as "known". If the minimum distance greater than but distance less than , then the input face image is classified as "unknown". If the original face is joined to original set of familiar face images then

the eigenvectors must be calculated again by repeating the steps of calculation that are described above. Following flow chart describes the operational steps of proposed algorithm.



#### IV. EXPERIMENTAL RESULTS

The algorithm is implemented in MATLAB software by using the Image Processing Toolbox. Preprocessing on face image like converting the image into black & white and resizing is completed by using standard MATLAB function `imresize`. The images are resized into 157x128 dimensions. The training set now contains images with the same dimensions. Fig.1 shows the training set of face space. The normalized training set is generated by changing the mean and standard deviation of all images and transposing all images matrix which is shown in Fig. 2. The mean image is described in Fig.3. Then eigenvectors and their corresponding eigen values are calculated from the covariance matrix and are normalized to obtain eigenface as shown in Fig.4. Input image is shown in Fig.5. This is the primary representation of the training set. Reconstructed image of Fig.5 is shown in Fig.6. The

Euclidian distance and weight of the input face image are shown in Fig.7. The code is also implemented in MATLAB GUI to enable the user to perform some user-friendly tasks. The user does not have to create any type of scripts or type commands at the command line of MATLAB main screen to accomplish these tasks. GUIDE or GUI of MATLAB is a tool that uses graphics, text inputs and the user of a GUI need not understand the details of how the tasks are performed as code is running in the background. Fig.8 shows the main screen of the user interface. Fig.9 and 10 shows the “Select Image” and “Recognition” response of the system respectively. In case there may be a chance that the thresholds do not match with computational one when the image is not taken from database then that image will not be recognized and access will be denied. This is shown in Fig.11. When we want to make new entry authorized at that time “Register” button is used. By using this button we are providing one new entry each time when the system starts. If any entry will get access denied then after registering those images we can grant access a new face to system. This is shown in Fig.12. So by performing simple preprocessing techniques on the image, we can add a new face image. It is also possible to increase the size of database (increasing the value of  $M$ ) to make some changes in the algorithm.

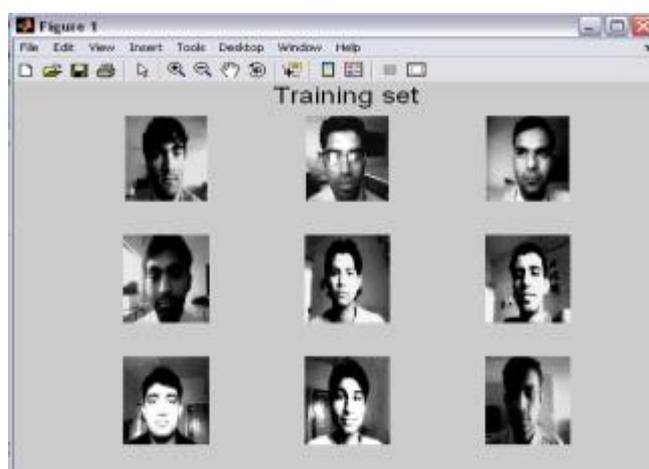


Fig.1: Training Set of Face-Space



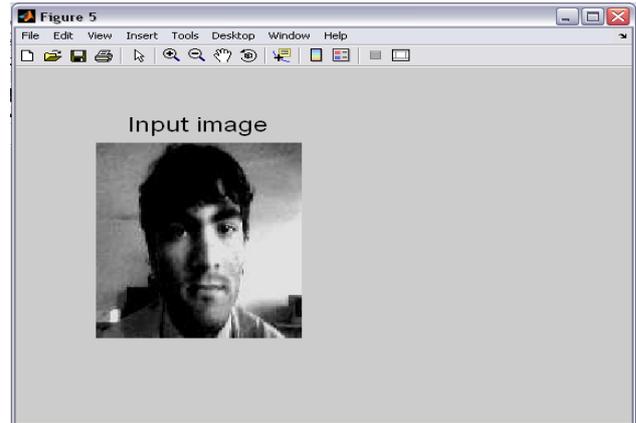
**Fig.2: Normalized training set of Face-space**



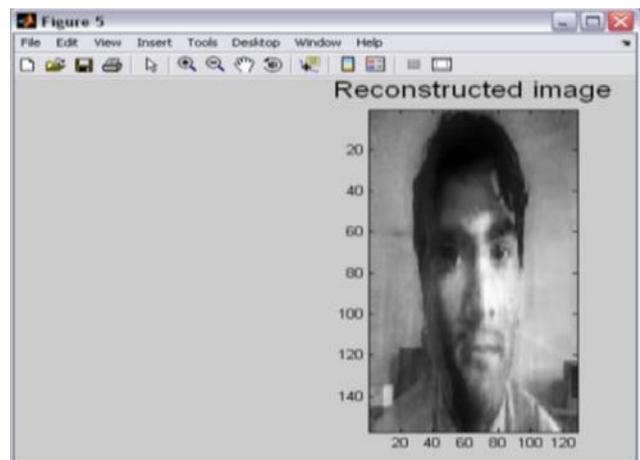
**Fig.3: Mean image of Face-space**



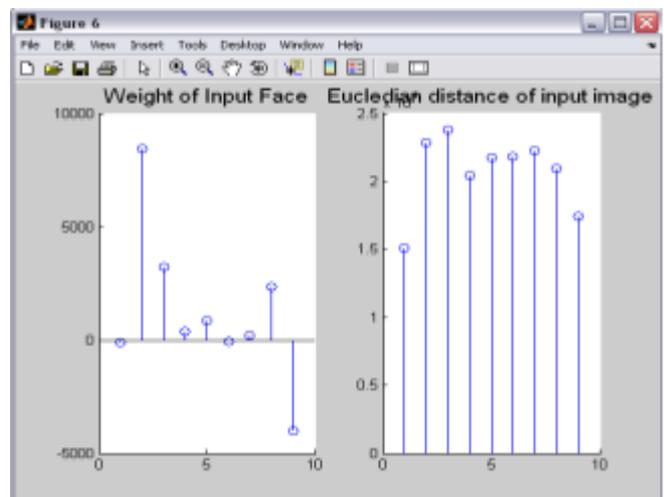
**Fig.4: Eigenfaces of training set**



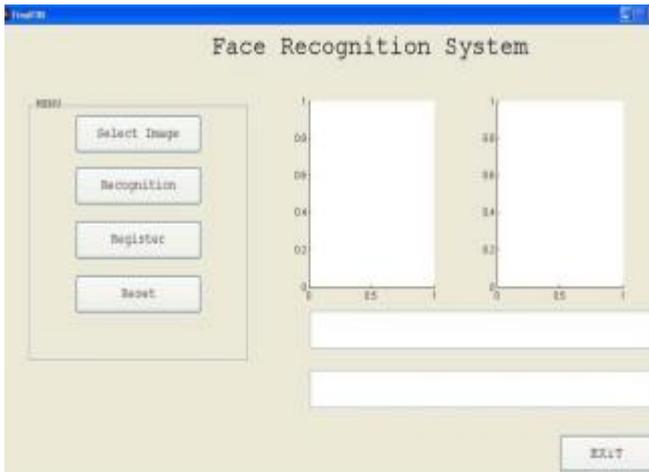
**Fig.5: Sample input image**



**Fig.6: Reconstructed image of sample input**



**Fig.7: Weight of the input face and Euclidean distance of input face**



**Fig.8: Main screen of face recognition GUI**



**Fig.9: Select button press**



**Fig 10: Recognition button (Recognized image)**



**Fig 11: Recognition button (Access Denied)**



**Fig 12: Register Button (After recognition of image)**

## V. CONCLUSION

Eigen face based face recognition using the PCA algorithm is presented in this paper. In this method, only a small amount of preprocessing of an image is required. A new-fangled face is matched to the recognized face class and evaluates the distance between their projections. This technique is verified on a number of face images and obtained impartial outcomes. Future work shall be focused on increasing the face space size and to study the effects of facial expressions.

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