PCA AND EIGEN FACE BASED FACE RECOGNITION METHOD

[1]Sanju, [2]Kirti Bhatia, [3]Rohini Sharma*
[1]Student, [2]Assistant Professor, [3]Assistant Professor
[1]Sat Kabir Institute of Technology and Management, Bahadurgarh, India
[2]Sat Kabir Institute of Technology and Management, Bahadurgarh, India
[3]A.I.J.H.M. College, Rohtak, India
*Corresponding Author: Rohini Sharma

Abstract: The face recognition is the identification process of a person by the special characteristics of his face. With growing security requirements and with improvement in technology of obtaining information has become less complex. This paper presents principal component analysis (PCA) and Eigen face base feature extraction and face recognition methodology. This method can identify faces with different pose and facial expressions. This method allows user to select an input image and match it against a given database of images. The database stores a set of image. The proposed method gives 99 % accurate results.

IndexTerms **– Principal Component Analysis, Eigen Face, Face expression.**

I. INTRODUCTION

There are various image analysis methodologies like face recognition system [1] and Bio-metric systems [2]. It is gaining popularity because of the widespread range of low cost applications, and the availability of affordable cost technologies present in the market. Yet some issues exist in face recognition system; recognition of facial image taken in an outdoor environment may pose complications because of variations in illumination of lights. Computer based face recognition systems are still not analogous to the human observation system. The biometric systems such as fingerprint, voice, iris, fuzzy extractor, Keystroke dynamics and Hand geometry have been the problem of data acquisition. In case of fingerprint biometric, the related person should keep her finger in appropriate position and direction and in case of speaker recognition the microphone should be kept in correct position and distance from the speaker. However, the face recognition method is non-intruding and therefore the face can be matched secretly where user is not aware of being identified.

II. RELATED WORK

Face recognition is a challenging and growing area in real time applications [3-4]. Various types of algorithms have been developed in recent times for the face recognition. These include PCA [5], genetic algorithm [6], Eigen faces [7], Self-Organizing Map [8], wireless sensor network based [9-19] techniques, wireless body area based techniques [20-21], energy based techniques [22-23], LDA based techniques [24] and DCT based technique [25]. The face recognition technique is essential in security fields like [26-28], location tracking field [29] and testing [30-31].

III. FACE RECOGNITION PROCESS

The process of recognizing a face in an image has two phases:

- **Face detection**: detecting the pixels in the image which represent the face. There are several algorithms for performing this task.
- **Face recognition:** the actual task of recognizing the face by analyzing the part of the imaged identified during the face detection phase.

It can also be classified in three categories.

Face recognition brings in several problems which are completely unique to this domain and which make it one of the most challenging in the group of machine learning problems.

- **Illumination problem:** due to the reflexivity of human skin, even a slight change in the illumination of the image can widely affect the results.
- **Pose changes:** any rotation of the head of a person will affect the performance.
- **Time delay:** of course that due to the aging of the human individuals, the database has to be regularly updated.

IV. DISTANCE BETWEEN TWO IMAGES

Each picture influences the same to the comparison of an input image, but not each pixel holds beneficial information. E.g. background and hair pixels would randomly make the distance larger or smaller. For a direct comparison we would need the faces to be perfectly aligned in all pictures and we would hope that the rotation of the head was always the same. To overcome this issue the PCA algorithm creates a set of principal components, which are called Eigen faces. Eigen faces are images that represent the main differences between all the images in the database. The recognizer first finds an average face by computing the average for

each pixel in the image. Each Eigen face represents the differences from the average face. First Eigen face will represent the most significant differences between all images and the average image and the last one the least significant differences. Here is the average image created by analyzing the faces of 10 consultants working at OCTO Technology, having 5 image of each consultant. **Figure 1** shows the Eigen faces of an image.

Figure 1: Image and its Eigen faces

Each image in the database can be represented as components of these.

Image1 = Average Image + 10% Eigenface 1 + 4% Eigenface 2 + … + 1% Eigenface 5 (1)

This ultimately means that we are able to precise each image as a vector of percentages. The preceding image becomes to our recognizer just a vector [0.10, 0.4, …, 0.1]. The previous equation is a slight simplification of the subject. When we have articulated the image as a simple vector, we are able to say what the distance between two images is. Getting the distance of two vectors is not complicated. If in 2D space we have the vectors **[x1,y1]** and **[x2,y2]** we now that the distance between these two can be visualized and computed as shown in the figure 2.

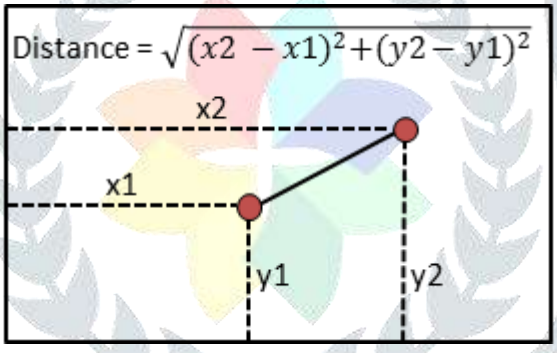

Figure 2: Distance between two images

V. REDUCING THE NUMBER OF DIMENSIONS

The main idea in the PCA is the lessening of dimensional space. We would basically compare each pixel of one image to another image. An image with a resolution of 50 x 50 pixels, that would give us 2500 pixels, and we would have space of 2500 dimensions. While comparing through the eigenvalues we got a reduced dimensional space – the number of Eigen faces is the number of dimensions in our new space.

In the equation of the distance between two points, every pixel would provide the distance between images. But all pixels don't hold some significant information. The background behind the face, the cheeks, the forehead, hairs; these are the pixels which do not provide significant information about the face. Instead the eyes, nose, ears are important. In the terms of Image processing lot of pixels just bring noise to the computation of the distance. One of the main ideas of PCA is the reduction of the noise by reducing the number of the dimensions.

In two-dimensional space, every point is described by its two coordinates. Though if several points are laid on the same line, we could identify the position of each point only by recognizing it's position along the line. To get the x and y coordinate of the point we would need to know the slope of the line and the position of the point on the line. We have reduced the dimension by one. In this example the slope of the line becomes the principal component, the same way our Eigen faces are principal components during the face recognition algorithm. Note that we can even assess the position for the points which are not on the line, by using the projection of the point on the line (the case of the last point). Eigen faces are graphical representation of eigenvectors (sometimes called characteristic vectors) of co-variance matrix representing all the images.

Standard deviation and variance work only for one dimensional data. However, we need a measurement which can compare between two or more than two dimensions. Covariance is such a tool which measure how much a dimension varies from the mean. If a 3 Dimensional data set (x, y, z) is available, then covariance can be evaluated between {(x,y), (x,z)}and {(y,z)}. For a 2D data

we need two covariance calculations and for 3D, we need three covariance calculations. Covariance between dimension x and y can be calculated as

$$Cov(x,y) = \frac{\sum_{i=1}^{i=n}(X_i-\bar{X})(Y_i-\bar{Y})}{n-1} \quad (2)$$

VI. PCA COMPUTATION

It is done as follows:

- Accumulate the database of images
- Create a dataset having mean zero and subtract the mean from each dimension of the data.
- Compute Covariance Matrix for a 2D data and for an n Dimensional data, the matrix will be 2 x 2 and n X n respectively.
- Calculate Eigen vectors and values for the matrix which give statistics about the pattern of the data.
- Pick up components and form feature vector: Principal Component is the Eigen vector with highest Eigen value. If we leave an Eigen vector with low value, there is no harm, only a small amount of information will be lost. It also reduces dimensions of the data. Feature vector is a matrix of Eigen vectors.

$$Feature\ vector = [Eig_1 \ldots\ldots Eig_n] \quad (3)$$

VII. FACE RECOGNITION WITH EIGEN FACE AND PCA

We have used PCA and Eigen face methodology to detect a face. There are 18 data sets. An image is selected and math with these data set. If there is a match answer is found. As shown in Figure 3, 4, 5, and 6.

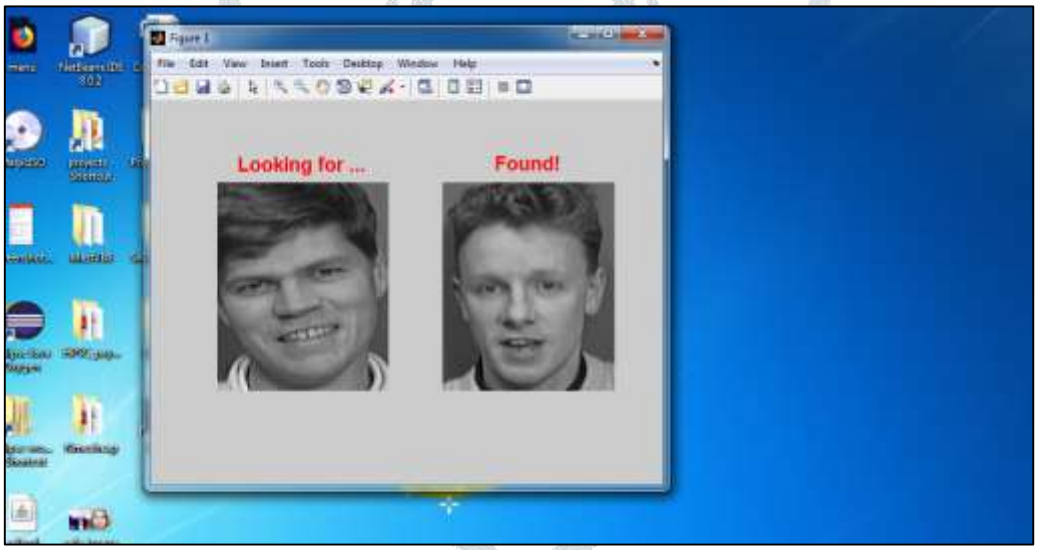

Figure 3: Image Found

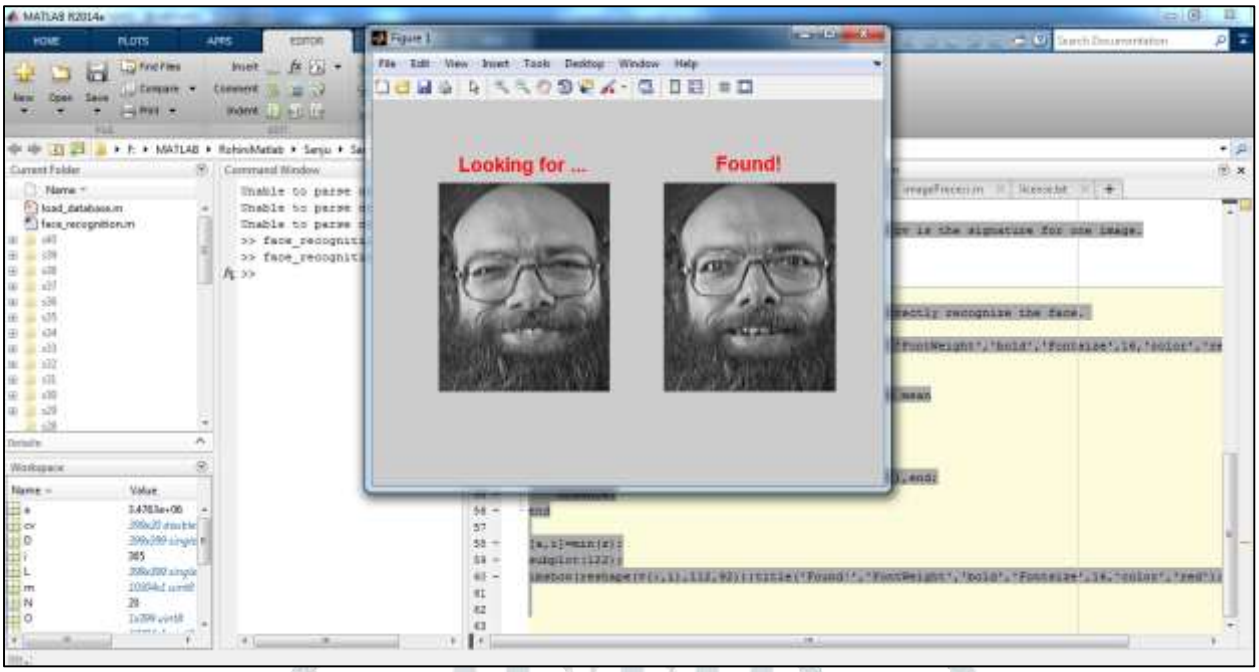

Figure 4: Same image found

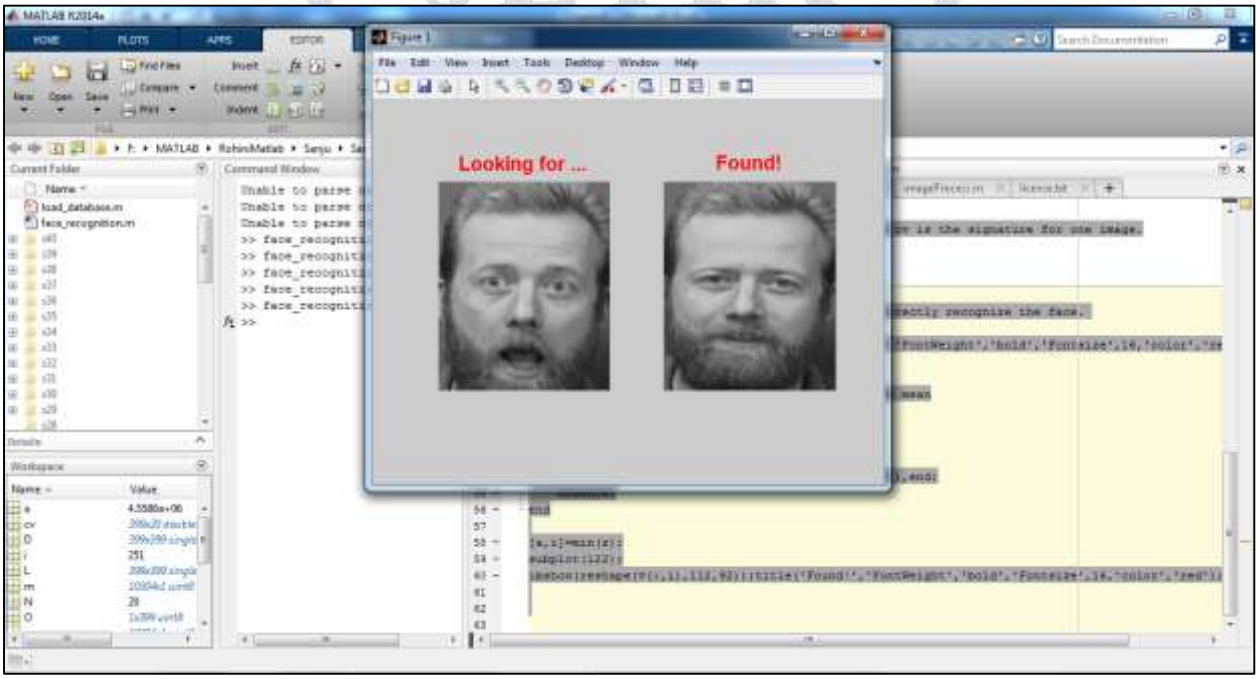

Figure 4: Image found with different expression

VIII. RESULT OF EMOTION DIFFERENCE BETWEEN TWO IMAGES.

IMAGE001.JPG,2001,NEUTRAL,IMAGE046.JPG
IMAGE002.JPG,3099,HAPPY,IMAGE008.JPG
IMAGE003.JPG,4674,DISGUST,IMAGE014.JPG
IMAGE004.JPG,4642,ANGER,IMAGE029.JPG
IMAGE005.JPG,3393,ANGER,IMAGE025.JPG
IMAGE006.JPG,4475,HAPPY,IMAGE003.JPG
IMAGE007.JPG,5938,SAD,IMAGE041.JPG
IMAGE008.JPG,5581,HAPPY,IMAGE010.JPG
IMAGE009.JPG,2053,NEUTRAL,IMAGE046.JPG
IMAGE010.JPG,4813,HAPPY,IMAGE008.JPG
IMAGE011.JPG,5315,SAD,IMAGE040.JPG
IMAGE012.JPG,6139,ANGER,IMAGE031.JPG
IMAGE013.JPG,5922,HAPPY,IMAGE006.JPG

IMAGE014.JPG,6027,HAPPY,IMAGE012.JPG
IMAGE015.JPG,5989,HAPPY,IMAGE006.JPG
IMAGE016.JPG,4613,SAD,IMAGE040.JPG
IMAGE017.JPG,4102,NEUTRAL,IMAGE046.JPG
IMAGE018.JPG,6908,DISGUST,IMAGE022.JPG
IMAGE019.JPG,4381,DISGUST,IMAGE022.JPG
IMAGE020.JPG,5724,ANGER,IMAGE026.JPG
IMAGE021.JPG,5202,ANGER,IMAGE029.JPG
IMAGE022.JPG,5335,DISGUST,IMAGE021.JPG
IMAGE023.JPG,4374,DISGUST,IMAGE018.JPG
IMAGE024.JPG,4870,DISGUST,IMAGE022.JPG
IMAGE025.JPG,4981,DISGUST,IMAGE023.JPG
IMAGE026.JPG,3987,NEUTRAL,IMAGE049.JPG

IX. CONCLUSION

The proposed face recognition methodology primarily consists of fallowing stages: pre-processing, feature extraction, dimensional reduction and classification using principal component analysis and Eigen face methods. This work can identify a given image against a set of images stored in a database. It can match an image with different face expression and poses. It gives an exact match of the facial expression and distance from it. This work can be further enhanced by introduction of face recognition in different light illumination and inside a video recording. This work gives 99% accurate results.

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