Face Recognition System by using Eigen Value Decomposition

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Summary
The biometric-based projects are mostly used for testing human body parts. Especially face identification is one of the interesting problems in the field of image analysis. Early Face recognition algorithms used geometric-based methods but nowadays image processing is used for biometric projects especially for both face verification and recognition purpose. In this paper, MATLAB programming based software is developed and used for face recognition propose. The proposed system is based on the password for authentication proposes. The database contained a group of students that contain 50 facial images. The proposed system uses Eigenvalue approach along with PCA component analysis with hardware implementation for identification. The hardware contained green LED for access grant and red LED for access denial.

Key words:
face recognition; eigen values.

1. Introduction

There are many image analysis techniques used for various security systems. The successful operation of such biometric systems is based on the reliability and accurate interface of hardware and software. The authentication is the main requirement of the biometric system. A biometric-based system such as the face, fingerprint, retina, and access is the main requirements[1]. Face recognition has many advantages than other biometric methods. All the biometric-based systems require some user action, for example, user needs his/her hands on hand scan for his fingers scanning and stand in proper position in front of the camera for retina detection[2]. But there is not any such requirement for face recognition because face images can be captured from a distance by the camera without any interpretation of user[3]. This is main advantage for security and surveillance purpose. Data collection is the main task for testing and validation of the biometric system. A biometric system is based on the fingers scan having a problem if the skin tissue is injured while in iris and retina identification need costly devices, and these devices are much sensitive [4]. Recognition of voice contained issue of noise in its background while in signature recognition, the signature can be modified. But face images can be easily captured by expensive/good resolution cameras[5]. However, face recognition is one of the cheapest biometric systems and do not carry any health risks too. Face recognition required two tasks[6]

1. Reliable authentication for faces of individuals.
2. Recognition of correct system among the database.

Face recognition is used in many applications for above two defined purposes. These applications are [7]

3. Security such as in airports, ATM.
4. Surveillance such as a large number of hidden cameras and many other applications.

In this paper, the face identification system is proposed based on the Eigenvalue decomposition through Principal Component Analysis (PCA). The database contained 50 images of a group of students. The novelty of this biometric system is the verification based on the individual user password to access the system[8].

2. Related Work

There are many techniques for detection of face recognition, but we adopted the PCA technique due to proper detection of Eigen intensities of pixels and give the accurate result. There are some background techniques for implementation of the Eigen based PCA techniques. The face geometry was one of the first recognition of face method. It is based on pixels selection according to the geometrical features of data. The features are mostly included the nose, eye and lips and other features on the face. Another face recognition technique is elastic graph matching (EMG) face recognition technique, it is based on the selection of depth area of facial features to detect the face. These two techniques give the false detection of face analysis, so robust technique is required to detect the face with linear properties of the features, PCA is suggested to work for face recognition. In this work, we implemented PCA through eigenvector normalization to detect a proper

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face. The proposed method is elaborated in following sections.

3. Proposed Method

The proposed approach is elaborated below.

Eigen space-based approaches approximate the Eigenvectors known as face vector with lower dimensional extract features[9]. The core purpose of using Eigen's faces (we use image faces as Eigenvalues, so it is called as Eigen Faces) used to reduce the dimensionality of images. It is the reason that we utilize Principal Component Analysis[10] for selection of correct Eigenface images[11]. This approach is used for training face database, and projection matrix of images is calculated. The projection matrix is used for the contribution of the particular image towards the face space[12]. The proposed model as shown in Figure 1. The Eigenvalues and Eigenvectors of a used database of image, it created image vectors or eigenvector of each image in the database. There are many eigenvalues and eigenvectors of the image according to image representation, but we only consider those eigenvalues and eigenvectors which are projecting towards the formation of an average image. Average face is obtained through Eigenvalue decomposition[13] [14].

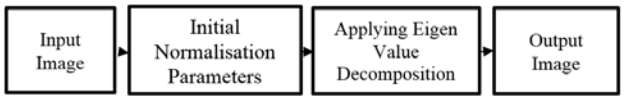

Fig. 1 Proposed Model of Eigen Value Approach

The subsequent steps of the proposed method are described as.

1. Initially, train the image data sets into classes.
2. Apply the Eigenvalue Decomposition to calculate Eigenvalue decomposition.
3. Reduce the dimensionality to achieve average image by applying PCA and achieve the resultant image.

Intensity values denote images. Let the image contained a dimension of m by n rows and columns. Let I is the image give a representation of its intensity values of x and y[15]. The image can be presented in some space in order to achieve the low dimensional space and it is necessary to train the image data set[16]. Consider M images of data set in M number of classes. Each of image represented into vector form $I_1, I_2, I_3 ..... I_M$ and the sum of images is given in Equation 1.

$$\omega = \frac{1}{M} \sum_{I}^{M} I_i \tag{1}$$

It's necessary to make the uniform distribution of the image so it can be achieved by normalized image as Equation 2.

$$\Phi_i = I_i - \omega \tag{2}$$

Where i=1……M.

After normalization of image subset, a new matrix B is formed with image subset of M Φ_i along with dimension of N x M with respect to Φ_i and represented as Equation 3 and 4.

$$B = \left[\Phi_1, \Phi_2, \Phi_3 ..... \Phi_M \right] \tag{3}$$

$$C = BB^T \tag{4}$$

Since the covariance matrix is Symmetric, which implies that the relating Eigen faces will also be zero so we can't use them in as the coordinate of our Face space. To determine the average image, consider the Equation 5.

$$Y = B^T x \tag{5}$$

For further simplification, the Eigenvalue decomposition theorem is applied

$$U = BV \quad \text{or}$$

$$U_{Eigen\ \text{Faces}} = B_{Adjusted\ \text{images}} * \mathrm{V}_{Eigen\ Vector}$$

V is the matrix with a dimension of M x M is projected with M Eigenvectors of Y, U is the matrix with a dimension of N x M is projected with C, and generalized representation of Eigenvalue decomposition is defined in Equation 6.

$$\Omega_i = U^T (\mathrm{I}_i - \omega) \tag{6}$$

Where $I_i = I_1, I_2, I_3 ..... I_M$ would reveal the secret of Ω_K In Equation 7 before it creates more confusions. Ω_K Is actually the average pattern vector of each class so instead of having a separate pattern vector for each image of every class we have taken an average pattern vector for each class which may be called class pattern vector. The distance between two images of the face can be calculated to achieve average image as shown in Equation 7 and 8.

$$e^2 K = \| \Omega - \Omega_K \|^2 \quad (7)$$

where

$$\Omega_K = \frac{Database}{Numbers\ of\ samples\ \text{in}\ each\ class}$$

$$\Phi_i = I_i - \omega$$

Where I_i is the input image, ω is the mean image and $\Phi_f = \sum_{I=1}^{i=m} \omega_i \mu_i$ is the eigen vector of the matrix:

$$e^2 K = \| \Omega - \Omega_K \|^2 \quad (8)$$

There are four outcomes as elaborated below.

5. The image is recognized within the classes; it means: recognized and verified.
6. The image is recognized, but it is not verified in the class.
7. The image is not recognized, and it is not verified in the class.
8. The image is not recognized, but it is verified the class.

In all above choice, the system will be accessed only in first choice and the system will not work in all other choices.

This system is connected to a camera and access grant and access denied electronic system. Two LEDs are used which are green and red. Green LED indicates the access granted and red LED indicates the access denied. The overall system diagram is shown in below Figure 2.

Initially, the user is required to give an image using the camera as an input to the system, and then the system adds the user it to a database or performs recognition according to the requirement of the user. The password is also taken from the user and stored along with the image in the case of 'Add to database', and compared with the one stored in the database in case of 'Perform Recognition.' If both the image and the password match to a single class in the database, access is granted, else denied.

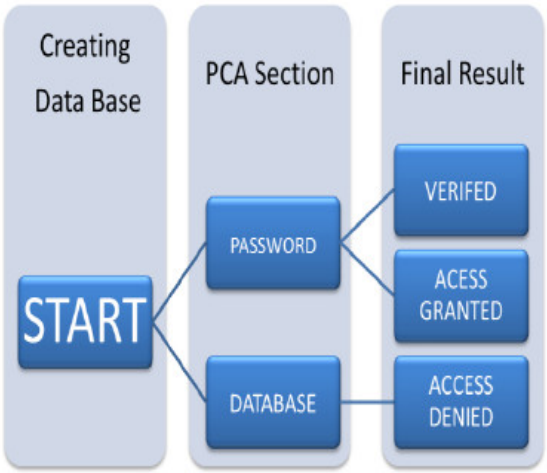

Fig.2 System Flow Chart

The Results are based on the training database, and the database contained a group of students that embodies 50 facial images. The system works per system flow in Figure 2 and if the password and recognition of user are matched then access is granted otherwise denied.

The accuracy of the system is measured by observing false acceptance and false rejection ratios. The images unrecognized images by the system without any class is known as false rejection ratio. The images recognized by the system as well as classified in the training dataset is known as true acceptance ratio. The table shows the accuracy of the system as we achieved the 90% false acceptance ratio of 10 classes of 200 images.

Table 1: Accuracy of the System

Total images	Total Classes	No. of Attempts	False Rejection	Error	Success
200	10	190	10	10%	90%

4. Conclusion

The proposed system is very modest software-based system and may be used in offices and universities for security purpose. Matlab is used as programming tool because of its easier availability. However, Matlab doesn't have sufficient efficiency to handle large database (It may contain no more than 100 classes, and each class may contain 05 images). To overcome this problematic issue and fast processing of large database; C++ may be a better platform to perform such operation. In future research, this facial recognition approach may be used for video surveillance for monitoring proposes.

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