Face Recognition Based Automated Attendance Management System using Principal Component Analysis

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Abstract: ***Security and verification of a person is a crucial part of any industry. One of the commonly used technique for this purpose is face recognition. Face recognition is an effective means of authenticating a person. The advantage of this approach is that, it enables us to detect changes in the face pattern of an individual to an appreciable extent. There are several approaches to face recognition of which Principal Component Analysis (PCA) has been used extensively in literature. In this paper, Face Recognition based Automatic Attendance Management System using Principle Component Analysis is proposed. The system consists of a database of a set of facial patterns for each individual. The characteristic features called 'eigenfaces' are extracted from the stored images using which the system is trained for subsequent recognition of new images.***

Keywords: Biometrics, Face Recognition, Principal Component Analysis, Eigen Values, Eigen Vector.

1. Introduction

Face recognition has been active research area in the pattern recognition and computer vision domains. It has many potential applications, such as, surveillance, credit cards, passport, security, etc. A number of methods have been proposed in the last decades [1]. In the field of face recognition, the dimension of the facial images is very high and require considerable amount of computing time for classification. The classification and subsequent recognition time can be reduced by reducing dimensions of the image data. Principal Component Analysis (PCA) [2]. Is one of the popular methods used for feature extraction and data representation. It not only reduces the dimensionality of the image, but also retains some of the variations in the image data and provides a compact representation of a face image. The key idea of the PCA method is to transform the face images into a small set of characteristics feature images, called eigenfaces, which are the Principal Components of the initial training set of face images. PCA yields projection directions that maximize the total scatter all classes, i.e. across all face images [3].

A number of works related to Radio frequency Identification (RFID) based Attendance Systems exist in the literature. In [4] the authors have proposed RFID based system in which students carry a RFID tag type ID card and they need to place that on the card reader to record their attendance. RS232 is used to connect the system to the computer and save the recorded attendance from the database. This system may give rise to the problem of fraudulent access. An unauthorized person may make use of authorized ID card and enter into the organization. Iris is another biometric that can be used for attendance systems. In [5] the authors have proposed Daughman's algorithm based Iris recognition system. This system uses iris recognition management system that does capturing the image of iris recognition, extraction, storing and matching. But the difficulty occurs to lay the transmission lines in the places where the topography is bad. In [6] authors have proposed a system based on real time face recognition which is reliable, secure and fast which needs improvements in different lighting conditions.

The remaining part of the paper is organized as follows. Section II provides the procedure of extracting face features using the PCA method. Section III presents the design methodologies and training procedure of the system . the experimental results and discussion on the yale face database are presented in Section IV. Finally, Section V draws the conclusion remarks. Face recognition can be used in multiple applications that utilize this effective technology. Common uses for facial recognition technology are given below in Table 1.

Table 1: Typical Applications Of Face Recognition

Areas	**Specific Applications**
Entertainment	Video game, Virtual reality, Human-Computer-Interaction
Smart Cards	Driver's license, National ID, Passports, Voter Registration, Welfare fraud
Information Security	TV Parental control, Personal Device logon, Desktop logon, Application security, Database security, Internet access
Law Enforcement and Surveillance	Advanced video surveillance, CCTV control, Portal control, Post event analysis, Shoplifting, Suspect tracking and investigation
Access Management	Secure access authentication, permission based systems, access log or audit trails

2. Face recognition using PCA

A typical Face Recognition system has mainly six functional blocks which explains the main working strategy of the Face Recognition system [7]. This outline carries the main characteristics of a typical pattern recognition system and description of main block of system is followed by the following diagram is given below:

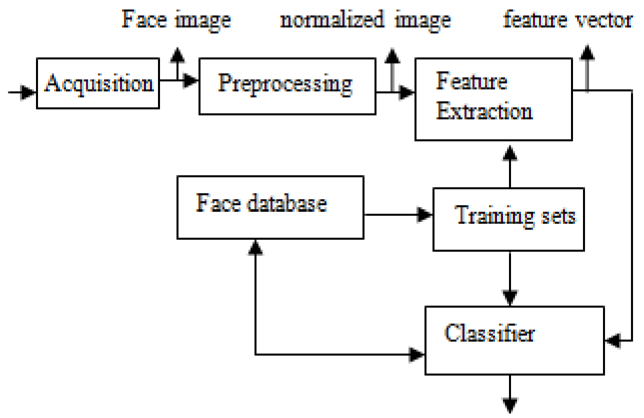

Figure 1: Outline of typical Face Recognition system

- Acquisition Module: It is the module where the face under consideration is presented to the system. The user prepares to present a face image to face recognition module. It can request a face image from several different environments: the face can be image file from files or captured by video or scanned from paper.
- Pre-Processing Module: It is face normalized and desires, they are enhanced to improve the performance of recognition system.
- Feature Extraction Module: After performing some pre-processing (if-necessary), the normalized face image is presented to the feature extraction module in order to find the key features that are going to be used for classification. In other words, this module is responsible for composing a feature vector that is well enough to represent the face image.
- Classification Module: In this module, with the help of pattern classifier, extracted features of the face image is compared with the ones stored in a face library or face database. After doing this comparison, face image is classified as either known or unknown.
- Training Set: Training sets are used during the "learning phase" of the face recognition process in supervised face classifiers. The feature extraction and the classification modules makes direct use of the face library.

1) Database Used

The Yale face database that is an open database reported by Kuang-Chih Lee, Jeffrey Ho, and David Kriegman. The Yale face database (size 6.4 Mb) contains 165 grayscale images in GIF format of 15 individuals. Database for different set of conditions is maintained. From this database, 6 images of 5 individuals is selected which is under normal condition. These 6 images are taken as a reference image in the face verification and as a query images in face identification.

Figure 2: Some of the Datasets from the Database

PCA is a statistical method under the broad title of factor analysis. The purpose of PCA is to reduce the large dimensionality of the image space (observed variables) to the smaller intrinsic dimensionality of feature space (independent variables), which are needed to describe the image data economically [9]. In this case, the observed variables in image space are strongly correlated and variables in smaller feature space are uncorrelated [10]. It is well known that there exist significant statistical redundancies in natural images. The purpose is to reduce the dimensionality of a data set (sample) by finding a new set of variables, smaller than the original set of variables that nonetheless retains most of the sample's information i.e. variations present in the sample, given by the correlations between the original variables. The new variables, called Principal Components (PCs), are uncorrelated, and are ordered by the fraction of the total information each retains[11].

3. Steps of PCA

Let us consider a set of N sample images $(X_1, X_2, \dots X_N)$ taking values in n-dimensional image space, and assume that each image belongs to one of c classes $(C_1, C_2, \dots C_c)$. Let N_i be the number of samples in class C_i(i= 1,2,……c), $\mu_i - \frac{1}{N_i}\sum x\epsilon\, c_i\, \mathcal{X}$ be the mean of the samples in class C_i, $\mu = \frac{1}{N}\sum_{i=1}^{N} x_i$ be the mean of all samples[12]. A linear transformation maps the original n-dimensional image space into an m-dimensional feature space, where m<n. The new feature vectors $y_k \in \mathbb{R}^m$ are defined by the following linear transformation:

$$Y_k = W^T x_k \quad (1.1)$$

Where k = 1,2,…..,N and $W \in \mathbb{R}^{n\times m}$ is a matrix with orthonormal columns.

Total scatter matrix S_T(or covariance matrix) is defined as [13]:

$$S_T = \frac{1}{N}\sum_{k=1}^{N}(x_k - \mu)(x_k - \mu)^T = \frac{1}{N}AA^T \quad (1.2)$$

After applying the linear transformation W^T, the scatter of the transformed feature vectors $\{y_1, y_2 \dots, y_N\}$ is $W^T S_T W$. In PCA, the projection W_{opt} is chosen to maximize the determinant of the total scatter matrix of the projected sample, i.e.

$$W_{opt} = argmax_w[W^T S_T W] = [w_1, w_2 \dots, w_m] \quad (1.3)$$

Where $\{w_i | i = 1,2, \dots m\}$ is set of n-dimensional eigenvectors of S_T corresponding to the m largest eigenvalues $\{\lambda_i | i = 1,2, \dots, m\}$,i.e.

$$S_T w_i = \lambda_i w_i \qquad i=1,2,\dots,m \qquad (1.4)$$

The steps involved in implementing the algorithm are [13-16]:

Project training database images to feature space: A set of images which is made up of classes of images of images of subjects that should be recognized by the system is used as training set. Represents the 2D images $\{x_1, x_2, \dots, x_N\}$ in the database in terms of 1D column vector X as given below:

$$X = \{x_1, x_2, \dots, x_N\} \qquad (1.5)$$

The average training set image (μ) is defined by:

$$\mu = \frac{1}{N} \sum_{I=1}^{N} x_i \qquad (1.6)$$

Each trainee image differs from the average image by vector (Φ)

$$\phi_i = x_i - \mu \qquad (1.7)$$

Total scatter matrix or covariance matrix is calculated from ϕ as follows :

$$C = \frac{1}{N} \sum_{i=1}^{N} \phi_i \, \phi_i^T = AA^T \qquad (1.8)$$

$$AA^T, \text{ where } \quad A = [\Phi_1, \Phi_2, \Phi_3, \dots, \Phi_N] \qquad (1.9)$$

Calculate the eigenvalues λ_k and eigenvectors w_k of the covariance matrix C.

4. Results and Discussion

Images taken in the database are gray scale. A colored face image if given as input test image is to be first converted to gray scale image as gray scale images are easier for applying computational techniques in image processing. Matlab 2013a is used for coding. A gray scale face image is scaled for a particular pixel size as 243×320 because many input images can be of different size whenever we take an input face for recognition. All the images in our database are of same size i.e. 243×320. Steps Involved in Algorithm for Automatic Attendance System:

1. On starting the simulation, the system displays a message "reading database.." and reads the images given in the directory by user.
2. On counting the number of images, the system reads the images one by one, resize them into a vector of 1×M. All the images are then stored in a matrix of size N×M where N is the total number of images in directory and M is total size of image.
3. The average face is computed called the mean face and is subtracted from each image vector.
4. Calculation of Eigen faces is done in step 4 using EVD on the images.
5. This step includes finding the projection of each image vector on the facespace (where the eigenfaces are the coordinates or dimensions).
6. In the next part of recognition, we compare two faces by projecting the test image into facespace and measuring the Euclidean distance between them.
7. The test image is read and option is given to user to apply a preprocessing to the image displaying a message "press 1 to apply preprocessing on test image….. 2 to skip".
8. 1×M image vector is created from the 2D image, subtracted by mean image and projection of test image onto the facespace is calculated.
9. Calculating and comparing the Euclidean distance of all projected trained images from the projected test image. A threshold is decided to check if the given face is present in database or not. If the minimum Euclidean distance among all projected image with test image is greater than the threshold value, it is assumed that the test image is not present in database.
10. If the user press the key "1" from the keyboard, the system automatically updates the database with the new face and gives a message as "database has been successfully updated" else on getting "2" as input, the system ends the recognition module.
11. In case of perfect recognition, a message saying "recognized_person_is" followed by the detected person's roll number is displayed.
12. An excel sheet is updated with the present roll number and message is displayed on command window saying "attendance sheet updated" and "0's represent the absent and 1 represent the detected present face".

A test image for recognition is tested by comparing to the stored data set. Threshold value of the test face image to eigenface space which is Euclidean distance is taken as 1 which classifies the face as known or unknown. Six different images for different mentioned condition were taken to test for different people. We can observe that normal expressions are recognized as face space efficiently because facial features are not changed much in that case and in other cases where facial features are changed efficiency is reduced in recognition. After reading the database and the test image, the first step in automatic attendance system is to ask user if he wants to apply any preprocessing to the test image. The figures shows the snapshots of Matlab window for the same. Preprocessing is required if the test image is noised. Noise may affect the image due to improper lighting conditions other factors. In this dissertation we consider it to be salt and pepper noise. If the user chooses to apply preprocessing and presses 1, noise is first added to test image, then removed by using median filtering. The noised image and the preprocessed image are shown in figure 4 and 5 respectively. On the other hand, if the user presses 2 and opts not to apply preprocessing on test image, the system bypass the filtering module and straight away moves to the recognition module.

Test Image 1:

Figure 3: Test Image

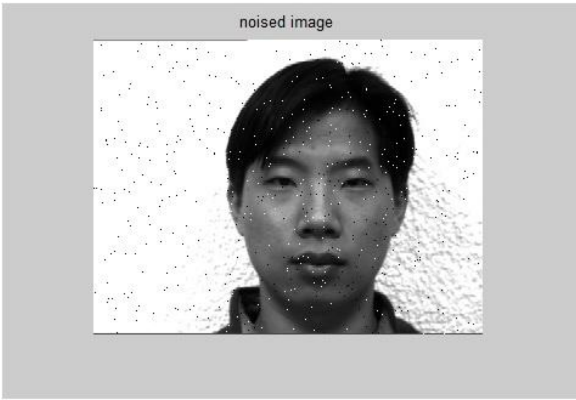

Figure 4: Noised Image

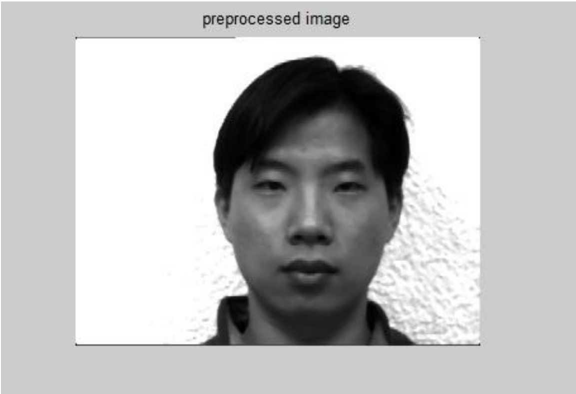

Figure 5: Preprocessed Image

Figure 6: Recognized Image

In the recognition module, the test image is compared with the images present in database. If a positive match is found, the recognized face with respect to the test image in fig. 6. After recognizing the image, the roll number of recognized person is displayed on the command window. The attendance sheet for the current iteration is updated in an excel sheet. Snapshot of this process is shown in fig. 7. Excel sheet of recognized person is shown is shown in fig. 8.

Figure 7: Roll number of Recognized Person

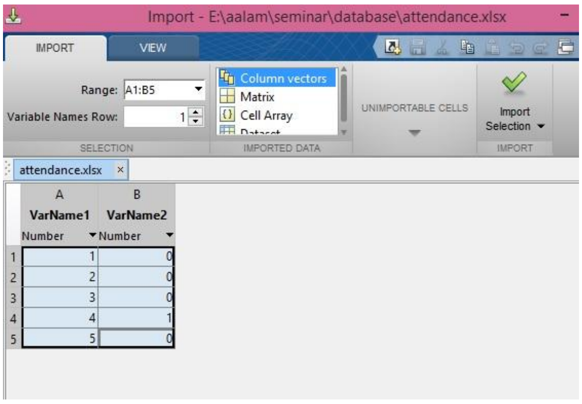

Figure 8: Attendance of Recognized Person

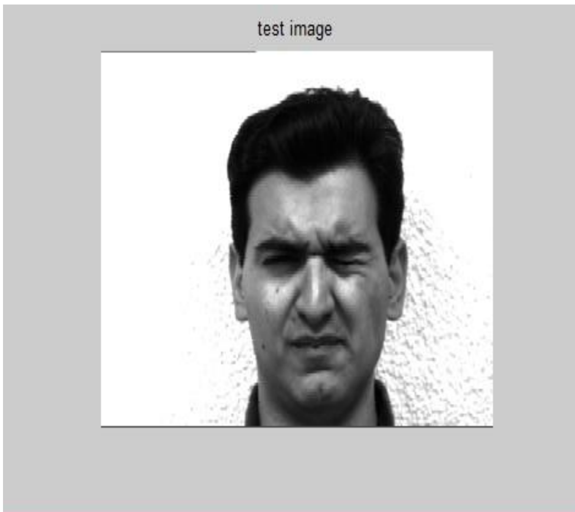

Figure 9: Test Image 2 (not recognized)

In this case, a test image is chosen which is not present in database. In this case the Euclidean distance between the test face and eigenfaces will be greater than the threshold value. Hence the face will be considered as unrecognized face. In this case, a message will be displayed on the command window starting that the face is unrecognized and asks the user if he wants to update the database or not. The choice is given to a user either to update the database (1) or to discard the current test image (2). But if a face is not present in database, we have an option to ask from the user either to add unrecognized test image to database or to just exit the program without updating the database as shown in fig. 10.

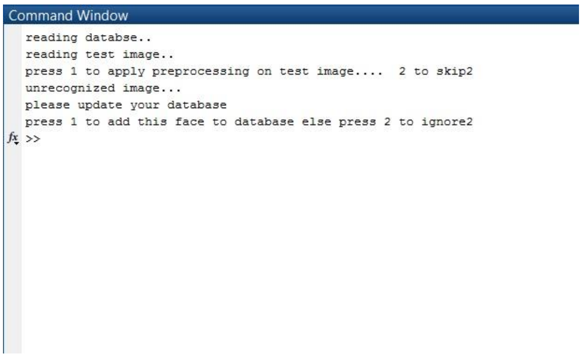

Figure 10: Unrecognized Person

5. Conclusion

In this paper, we implemented the face recognition system using Principal Component Analysis and Eigen face approach. The system successfully recognized the human faces and worked well with different facial expressions and addition of salt and pepper noise. The face recognition system was used to create an automatic attendance updating system based on face recognition. This attendance system can be used to take attendance of different individuals on the basis of their face images. The system automatically updates the attendance of the individuals and mark present/absent for them in an excel sheet.

The excel sheet used to update attendance is overwritten every time the program is executed. Hence the user has to save the current attendance in the memory in order to use it for future reference. From the results performed on the database, it is evident that the attendance system based on face recognition performs satisfactorily. Hence it can be concluded that the present algorithm demonstrates better performance with respect to speed, low false positive rate and high accuracy.

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