



Review of Face Recognition Techniques

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Abstract—Use of Biometrics and widespread acceptability for person authentication has instigated several techniques. Now a day's security is very important. Biometrics has received a great attention. Face biometrics, is useful person's authentication that recognizes face. In this paper first we represent an overview of face recognition and discuss the methodology and functioning. Thereafter we represent face recognition techniques which are recently used including their advantages and disadvantages. A large number of face recognition algorithms have been developed. In this paper an attempt is made to review a wide range of methods including PCA, Eigen face, LDA for recognition and hybrid combination if this techniques. Under the various illumination and expression condition of face images some techniques specified here also improves the efficiency of face recognition.

Keywords— Face Recognition, Principal Component Analysis, Eigen Face, Linear Discriminant Analysis

I. INTRODUCTION

From the past few years face recognition becomes a most important biometrics authentication technique. Face recognition is a biometric approach to verify or recognize the identity of a living person based on his/her physiological characteristics. Biometrics can measure both behavioural and physiological characteristics. In physiological biometric, data derived from direct measurement. In behavioural biometric, data derived from an action. Both these biometrics based on measurements. Face Recognition is integral part of biometrics. Face recognition is a successful application of image analysis and pattern recognition. The main aim of face recognition is to recognize person from video or pictures using databases of face images. Biometric is the technology is motivated by traditional methods. Traditional methods can be categorized as possession-based methods and knowledge-based methods. In possession-based method, items such as keys, badges, or cards are utilized. This method requires low cost. However, these items can be shared, duplicated and easily lost. In knowledge-based method, there are also drawbacks for those who used password or PIN. Some passwords are easily guessed. Besides, they can be forgotten or shared.

There are two main tasks used in face recognition are Verification and Identification. Verification means one to one (1:1) matching and Identification means one to many (1: N) matching. Face verification is commonly applied in access control applications. Identification system determines identity of input image and compares query face image against all image templates stored in database. Face identification is typically used for surveillances. There are various applications areas in which face recognition can be exploited for these two purposes such as; security, smart card applications, criminal justice system etc.

Basically there are three steps in face recognition system; face detection, feature extraction, and classification [1]. First step in face recognition system is face detection. Face detection is a technology that determines the locations and sizes of human faces in digital images. It detects only face and ignores anything else. The main aim of face detection is to find whether there are any faces in the image or not. Face detection is the process to detect location and presence of features such as eyes, nose, lips, mouth, ears etc. Face detection and feature extraction are carried out simultaneously. In face recognition, the input image is compared with database. Then it gives a match report and classification is carried out to identify the new observation.

Additionally face recognition methods categorize as,

- 1) Feature – based Approach
- 2) Holistic Approach

1.1 Feature – based Approach

In feature-based approaches, geometric features such as position and width of nose, eyes, and mouth eyebrow's thickness, are first extracted to represent a face. Like facial features other fiducial marks are also extracted. Then compute geometric relationship among those facial points. Using these measurements, standard statistical recognition techniques are then employed to match faces. Appearance based method give good results than feature based method [11]. Benefits of using feature based schemes include high speed matching.

1.2 Holistic Approach

To perform face recognition holistic face recognition utilises global information from faces. The Global information from faces is represented by a small number of features which are directly derived from the pixel

information of face images. This small number of features distinctly captures the variance among different individual faces and therefore is used to uniquely identify individuals [3]. In Holistic Approach, whole face is taken as an input to perform face recognition in face detection system. The main advantage offered by Holistic approach is that they concentrate on only limited regions or points of interest without destroying any of the information in images. Hybrid approach is combination of feature based approach and holistic approach. In this, both local and whole face is used as input to face detection system. All face recognition algorithms consist of two major parts: (1) face detection and (2) face identification. Algorithms that consist of both parts are referred to as fully automatic algorithms and the algorithm which consist of only the second part are called partially automatic algorithms. Partially automatic algorithms are given coordinates of the centre of the eyes and a facial image. Whereas fully automatic algorithms are only given facial images.

Face recognition is a challenging problem in the field of pattern recognition and image processing. Today security is very important. There are numerous application areas such as, access control, credit card verification, surveillance etc. in which face recognition plays very important role. Face recognition has received great attention because of lots of applications in different fields. Face recognition is challenging task in terms of hardware that is creating physical implementation and software that is developing algorithmic solutions [13].

We have done survey on current face recognition methods, covering both earlier and recent literature related to face recognition algorithms and techniques. The various face recognition techniques are: 1) PCA 2) Eigen face 3) LDA. In this paper, we have done classification of each recognition technique and briefly summarize papers under that particular class.

II. LITERATURE REVIEW

This section gives an overview on the major human face recognition techniques. Every method has its advantages and disadvantages. There are different methods used in face recognition. Some methods are according to feature based and on similarity based. Here a brief review of some of the previously proposed methods for the face recognition is summarizing. The methods considered are Eigen faces, PCA, LDA. The approaches are analysed in terms of the facial representations they used.

A. Principal Component Analysis (PCA)

Now a day need of security is important. Many methods are using for maintaining the security like as pin numbers, credit cards, smart cards etc. But sometimes it fails. Here we present face recognition using Principal Component Analysis. The PCA has been extensively used for face recognition algorithms. It is one of the most popular representation methods for face image. PCA not only reduces the dimensionality of the image, but also retains some of the variations. PCA also known as Karhunen-Loève method. It is one of the popular methods for feature selection and dimension reduction. PCA is a variable reduction procedure. It is useful when obtained data have some redundancy and this will result into reduction of variables into small number of variables which are called principal components. PCA is a mathematical procedure that performs a dimensionality reduction by extracting the principal component. This belongs from multi-dimensional data [12]. PCA uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components. It is the linear combination of original dimensions that has highest variability. PCA normally the use of Eigen faces. PCA is used in application fields like image compression and face recognition. PCA applies on both database image and input image. Using PCA the system finds the Eigen values, Eigen vector and Euclidian distance. After comparing with database it declares the matches. PCA is sensitive to the relative scaling of the original variables.

Rala M. Ebied describe a method of feature Extraction using PCA and Kernel-PCA for Face Recognition in which they investigate the nonlinear kernel function to improvement the principal component analysis (PCA) for feature extraction. The experiments carried out to investigate the performance of Kernel-PCA by comparing it with the performance of the PCA [4]. Two kernel functions are used with the kernel-PCA, polynomial and Gaussian functions, to check which one achieved a better performance. Neelam Mahale and Dr. M.S. Nagmode [4] use principal Component Analysis method to improve the security of an Automated Teller Machine. Mohammed Alwakeel et al. presented a Face Recognition Based on Haar Wavelet Transform and Principal Component Analysis. Smt.M.P.Satone et.al compared Euclidian distance measure and city block distance measure using PCA on four leveldecomposition of Daubechies wavelet transforms for facerecognition.

To perform PCA several steps are undertaken:

1) Pre-processing:

Pre-processing prior to be face detection and classification is essential. Input image is in RGB format is then converted in Gray image.

2) Mean Image:

For PCA work properly we need to calculate the mean image.

3) Covariance Matrix:

Calculate covariance matrix.

4) Eigen value and Eigen vector:

Calculate the Eigen value and Eigen vector from covariance matrix.

5) Euclidian Distance:

The Euclidian distance measure between two values. The Euclidian distance calculates between Eigen values of input image and database image.

After the calculation of Euclidian distance we compare from database and declare the match weather the person present in data base or not. After calculating the Euclidian distance the system recognizes the face and name of the person. If the Euclidian distance of input image matches then the person is authorized otherwise it is not authorized. If the match is found the message comes that person is authorized and if the match is not found it display person is not authorized. PCA has some drawbacks, like Poor discriminatory power, and High computational load.

B. Eigen face

Eigenface is one of the most generally investigated approaches to face recognition. It is also known as Karhunen-Loève expansion, Eigen picture, eigenvector, and principal component. One of the generally used algorithms for face recognition is Eigen face method. Karhunen-Loève is based on the Eigen faces technique in which the Principal Component Analysis (PCA) is used [6]. PCA is successfully used to perform dimensionality reduction. Principal Component Analysis is used by face recognition and detection. Mathematically, Eigenfaces are the principal components that divide the face into feature vectors. The feature vector information can be obtained from covariance matrix. These Eigenvectors are used to measure the variation between multiple faces. The faces are characterized by the linear combination of highest Eigenvalues. Each face can be considered as a linear combination of the Eigenfaces. The face can be approximated by using the eigenvectors having the largest eigenvalues. The best M Eigenfaces construct an M dimensional space, i.e., the “face space”. The authors reported 96 percent, 85 percent, and 64 percent correct classifications averaged over size variations, lighting, and orientation respectively. Their database contained 2,500 images of 16 individuals.

Eigen face is a practical approach for face recognition. Implementation of an Eigen face recognition system becomes easy because of the simplicity of its algorithms. The accuracy of Eigen face depends on many things. The Eigen face technique finds a way to create ghost-like faces that represent the majority of variance in an image database. This technique is based on an information theory approach that decomposes face images into a small set of characteristics feature images called “Eigen faces”, which are actually the principal components of initial training set [5]. The drawback of Eigen face is, it is sensitive for lightening conditions and position of the Head. Disadvantage is finding the eigenvectors and eigenvalues are time consuming.

C. Linear Discriminant Analysis

Lih-Heng Chan [7] proposed a framework of facial biometric was designed based on two subspace methods i.e., Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA). First, PCA is used for dimension reduction, where original face images are projected into lower-dimensional face representations. Second, LDA was proposed to provide a solution of better discriminant. Both PCA and LDA features were presented to Euclidean distance measurement which is conveniently used as a benchmark. LDA-based methods outperform PCA for both face identification and verification.

Fisher faces are one the most successfully widely used method for face recognition. It is based on appearance method. In 1930 Fisher developed linear/fisher discriminant analysis for face recognition which shows successful result in face recognition process [8]. The disadvantage of LDA is that within the class the scatter matrix is always single, since the number of pixels in images is larger than the number of images so it can increase detection of error rate if there is a variation in pose and lighting condition within same images. So to overcome this problem many algorithms has been proposed. Because the fisherface technique uses the advantage of within-class information so it minimizes the variation within class, so the problem with variations in the same images such as lighting variations can be overcome [9].

The fisherface method for face recognition described by Belhumeur et al [10] uses both linear discriminant analysis and principal component analysis which produce a subspace projection matrix, similar as used in the Eigenface method. However, the fisher face method is able to take advantage of within-class information, minimising variation within each class, yet still maximising class separation. Like the Eigenface construction process, the first step of the fisherface technique is take each (NM) image array and reshape into a ((N*M) x1) vector. Fisherface is similar to Eigenface but with enhancement of better classification of different classes image. With FLD, one can classify the training set to deal with different people and different facial expression [1]. PCA method suffers the disadvantage in terms of discriminant ability. Thus, LDA have been proposed to improve discriminant ability of PCA. The combination of PCA and LDA has been proven of achieving relevant good results (Belhumeur et al., 1997; Zhao et al., 1998). For face biometrics LDA is able to provide better discriminant ability in feature extraction. PCA is standard technique with lower dimensionality to represent original data. On the other hand, LDA finds an optimal linear discriminant function to map the input into the classification space. The disadvantage of fisher face method is it is more complex than Eigen face to finding the projection of free space.

III. DISCUSSION

Face identification using LDA and PCA were implemented. For more reliable evaluations, different combinations of training set and testing set were used.

Table I Identification performances of algorithms using 6 different ways for AT and T face database

Set	Training set	Testing set	Recognition rate (%)	
			PCA	LDA

1	1,2,3,4,5	6,7,8,9,10	88.50	91.00
2	2,3,4,5,6	1,7,8,9,10	94.00	94.50
3	3,4,5,6,7	1,2,8,9,10	95.00	97.00
4	4,5,6,7,8	1,2,3,9,10	92.50	96.00
5	5,6,7,8,9	1,2,3,4,10	92.50	94.00
6	6,7,8,9,10	1,2,3,4,5	89.50	92.50
Average			91.90	94.20

Table I shows the identification performance of algorithms in six different ways of partitions in the AT and T face database

Table II Identification performances of algorithms using 6 different ways for the CBE face database

Set	Training set	Testing set	Recognition rate (%)	
			PCA	LDA
1	1,2,3,4,5	6,7,8	73.3	77.5
2	2,3,4,5,6	1,7,8	70.0	78.3
3	3,4,5,6,7	1,2,8	76.7	85.0
4	4,5,6,7,8	1,2,3	86.7	91.7
Average			76.7	83.1

For CBE Face Database, identification performances of algorithms using 4 different combinations of training and testing sets are shown in Table II. Improvement of LDA over PCA is 2.3% (AT and T) and 6.4% (CBE).

Table III Verification performances of algorithms

Database	EER (PROTO1)		EER (PROTO2) (%)	
	PCA	LDA	PCA	LDA
AT and T	1.15	0.78	5.05	4.20
CBE	7.30	5.81	5.57	3.53

Verification performances of algorithms based on two protocols were conducted using AT and T and CBE face database. Results are shown in Table III. Compared with PCA, LDA is found achieving lower EER of 0.78% (PROTO1) and 5.81% (PROTO2) on AT and T dataset and 4.2% (PROTO1) and 3.53% (PROTO2) on CBE dataset. From this, LDA is proven to have better performance than PCA in face biometrics.

IV. CONCLUSION

The methods discussed above are related to the face recognition techniques. Face recognition technique is a challenging problem in the field of image processing and computer vision. Face recognition has received great attention because of lots of application in different fields. In this paper different face recognition algorithms are mentioned with advantages and disadvantages. Although many algorithms and techniques exist but still there is some scope for improvement in order to get better results for face recognition.

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