

A Study of Face Recognition Techniques

Saurabh P.Bahurupi

Dr.D.S.Chaudhari

Abstract- Face recognition is a huge research area in computer vision, pattern recognition and plays a vital role in the applications of image analysis and understanding. In the area of biometrics, face classification becomes one of the most commonly used approaches for personal identification because comparing it with the other biometrics-based system such as speech, iris, fingerprint, signature, etc., face recognition is proven effective for its user friendliness and contactless i.e. the system does not require user to do anything. Another application of face recognition is access control applications, information security, human computer interaction, virtual reality, database retrieval etc. This paper reviewed most conventional face recognition techniques.

Key Word - Face recognition, Principle Component Analysis(PCA), Independent Component Analysis (ICA), Linear Discriminate Analysis (LDA)

I. INTRODUCTION

The face is the primary focus of attention in the society, playing a major role in conveying identity and emotion. Humans often use faces to recognize individuals. Advancements in computing capability over the past few decades now enable similar recognitions automatically. There are many ways that humans can identify each other, and so is for machines. There are many different identification technologies available, many of which have been in commercial use for years. Today, the most common person verification and identification methods are Password or PIN (Personal Identification Number) systems. The problem with or other similar techniques are that they are not unique, and it is possible for somebody to forget, lose or even have it stolen by somebody else. These problems were overcome by developing considerable interest in "biometrics" identification systems, which use pattern recognition techniques to identify people using their characteristics. Some of those methods are fingerprints, retina, face and iris recognition.

Though these techniques are not easy to use. For example in bank transactions and entry into secure areas, such technologies have the disadvantage that they are intrusive both physically and socially. The user must position the body relative to the sensor, and then pause for a second to declare himself or herself. That doesn't mean that face recognition doesn't need specific positioning. Therefore as compare to other biometrics based systems, face recognition is proven effective for its user-friendliness.

II. OVERVIEW OF FACE RECOGNITION SYSTEM

The research on fully automated face recognition has been started from 1960s, in which feature (such as eyes, ears, nose, and mouth) from face image was located. Then

found out the distance and ratio between these features. Recognition task was done by comparing it to the reference data. The problem with these was the measurement and locations were manually computed.

W.Zhao [1] provides up-to-date survey on face recognition and discusses two types of face recognition task which based on still images and video. In addition to this the topics such as psychophysical system evaluation, issue of illumination and pose variation have been covered.

Turk [2] used standard linear algebra technique to calculate the eigenfaces. This eigenface method enabled real-time automated face recognition system. Face images were projected onto a face space defined by the 'eigen-faces' which were the eigenvectors of the set of faces. After that the weights of all the training images are found out and stored. Test image subjected to recognition is also projected to the face space and then the weights corresponding to each eigenface are found out. Now the weights of the test image is compared to the set of weights of the training images and the best possible match is found out. The comparison is done using the Euclidean distance measurement. Minimum the distance is the maximum is the match.

B. Poon[3] proposed face recognition based on PCA or eigenvector. Recognition procedure is affected by illumination and the accuracy of system affected by this thing. Experimental result shows that the error rates as low as 1.5% which, as far as not been accomplished before with the FERET database and pose and expression in face image causes less affect on recognition procedure based on PCA method.

G. J. Alvarado [4] compare the performance of face classifiers i.e. Eigenfaces and Fisherfaces in presence of deteriorated visual information. This paper investigate several typical models of image distortion such as Gaussian noise, salt and pepper, and blurring effect and demonstrate their impact on the performance of the two main types of the classifiers(i.e. Eigenfaces and Fisherfaces). Experimental result shows that introduction of image distortion in the training sets improves the classification performance of Eigenfaces and Fisherfaces face classifiers.

G. Jarillo [5] used different image transformations (such as contrast enhancement and edge detection). The experimental results shown that such transformations can provide unique discriminatory information useful for face classification, namely PCA, LDA, Kernel-PCA, and Isomap. For experiment YALE and FERET database are used.

L. Liao [6] Used fast fourier transform algorithms for the input face image before applying recognition. The FFT algorithm transform input face images into "Whitenedfaces" then perform face recognition using PCA and ICA coding strategies, respectively. Experimental result shows that the whitening processing will bring better recognition performances for both PCA and ICA based face recognition system.

K.Lin [7] proposed Hausdroff distance in recognition step instead of Euclidian distance. Experiments showed satisfactory results in terms of recognition accuracies and processing speed.

Shermina.J[8] used DCT for minimizing the illumination problem in face recognition. DCT applied image later is used in recognition step and for this step PCA approach is used. Experiments showed that illumination normalized image provides more accurate result.

A. Eleyan [9] used wavelet transform along with PCA. Two methods have been proposed first is Multiresolution Feature Concatenation (MFC), where PCA is used for diamentional reduction on each subband and resulting each subband together for performing classification, second is Multiresolution Majority Voting (MMV) where PCA and classification are done separately on each subband. Experimental result showed that both techniques promising the results and NMV approach outperforms the MFC approach.

W. Zuo [10] performed a comparative study between PCA+LDA and Bidirectional PCA (BPCA)+LDA. Experimental result showed that the BDPCA + LDA needs less computational requirement in both the training and the testing phases, faster speed for facial feature extraction, needs less memory requirement and it has a higher recognition accuracy over the PCA + LDA.

L. Wiskott [11] used Elastic Bunch Graph Matching method in which Gabor Wavelets is used for representation of local features.

This paper is arranged in the following manner. Section II introduces the typical structure of face recognition system. Section III describes various approaches for face recognition. Finally, Section IV offers some conclusions and offers some general comments.

II. TYPICAL STRUCTURE OF FACE RECOGNITION SYSTEM

Typical structure of face recognition system consist of three major steps, acquisition and processing of face data, extracting face feature and recognition of face. Fig. 1 shows typical structure of face recognition system. These steps are elaborated as follow.

A. Acquisition and Processing of Face Data

Acquisition & Processing of face data is the very first step in the face recognition system. In this step face images is collected from different sources. The sources may be camera or readily available face image database on the website. The collected face images should have the pose, illumination and expression etc variation in order to check the performance of the face recognition system under these conditions.

There are many standard database available on website among AT&T (ORL Database) database [12], Faces94 Face database [13] widely used.

AT&T (ORL Database) database consist of gray-scale images having 256 gray-levels and size of each image is

112' 92. Faces 94 Face database consist of colour images. The size of each image is 200' 180' 3

Processing of face database require sometimes otherwise causes serious affect on the performance of face recognition systems due changes in the illumination condition, background, lighting conditions, camera distance, and thus the size and orientation of the head. Therefore input image is normalized and some image transformation methods apply on the input image [8].

B. Extracting Face Feature

Feature extraction process can be defined as the process of extracting relevant information from a face image. In feature extraction, a mathematical representation of original image called a biometric template or biometric reference is generated, which is stored in the database and will form the basis(vector) of any recognition task. Later these extracted features used in recognition. A grayscale pixels is considered as initial feature. Feature are classified as visual (such as eyes, ears, nose, and mouth) in the face image, Statistical pixel feature, Transform coefficient feature, Algebraic feature.

C. Recognition of Face

Once the features are extracted and selected, the next step is to classify the image. Appearance-based face recognition algorithms use a wide variety of classification methods Such as PCA, LDA. In classification the similarity between faces from the same individual and different individuals after all the face images in database are represented with relevant features. Sometimes feature extraction & recognition process done simultaneously.

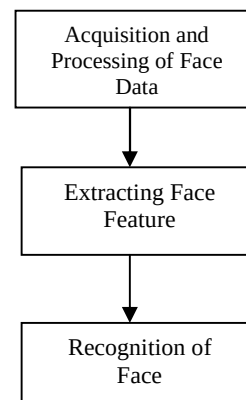


Fig.1 Typical structure of face recognition system

III. FACE RECOGNITION APPROACHES

In general, approaches for face recognition can be divided into two categories[1]:

A. Holistic matching technique and

B. Feature- based (structural) matching technique

Holistic matching technique also called template matching. In this technique input image compare with a set of templates and this templates can be constructed using statistical tools like Principal Component Analysis (PCA), Linear Discriminate Analysis (LDA), Independent Component Analysis (ICA),

Kernel Methods. Constructed templates also called extracted feature and form the basis of any recognition task.

Feature-based (structural) matching methods analyze local facial features such as eyes, nose, mouth and chin and their geometric relationships. This set of features is then matched with the features of known individuals. A suitable metric such as Euclidean distance (finding the closest vector) can be used to find the closest match. The advantage of using geometrical features is that recognition is possible even at very low resolution and with noisy images (images with many distorted pixel intensities). An example of this technique is Elastic Bunch Graph Matching algorithms [13]. Table 1. shows Face Recognition Approaches and techniques for implementation of these.

Table1. Face Recognition Technique

Sr.No.	Face Recognition Approaches	Technique
1	Holistic Matching	Principal-Component Analysis (PCA) or Eigenfaces
		Linear/Fisher Discriminate Analysis (FLD/LDA) or Fisher faces
		Independent Component Analysis (ICA)
2	Feature-based(structural) matching	Elastic Bunch Graph Matching algorithms(EBGM)

3.1.1 Principal Component Analysis (PCA)

[2][3][4]PCA is a statistical technique used for representing features of an image (feature space) while reducing high dimensionality of the original images (faces). PCA is one of the widely used face recognition algorithm based on information theory concepts, seeks a computational model that best describes a face by extracting the most relevant information contained in the face. PCA is also called as Eigenface or Eigenvector in which a small set of characteristics pictures are used to describe the variation between face images. In this method the eigenvectors (eigenfaces) of the covariance matrix is found out. Later, every face image in database is represented by a linear combination of these eigenvectors (eigenfaces).

Recognition is performed by projecting a new image(test image) onto the subspace spanned by the eigenfaces and then classification is done by distance measure methods such as Euclidean or Mahalanobis distance.

3.1.2 Linear Discriminant Analysis (LDA)

[4][5][11]Linear Discriminant Analysis (LDA) is a statistical approach comes as an extension of PCA method based on the same statistical principles as PCA. LDA classifies faces of unknown individuals based on a set of training images of known individuals. In the facial feature space (vectors) this technique finds the underlying vectors that would maximize the variance between individuals (or classes) and minimize the variance within a number of images of the same person (i.e., within a class).

Fig. 8 shows that there is a relatively large amount of variation between the individuals(or classes) and small variations between the varieties of poses of the same individual. LDA technique finds the vectors in the facial feature space (vectors) that would maximize the variance between individuals (or classes) and minimize the variance within a number of samples of the same person (i.e., within a class).



Fig. 8: Example of variation between and within classes^[13]

3.1.3 Independent Component Analysis (ICA)

ICA technique provides an independent rather than uncorrelated image decomposition and representation[6]. ICA finds basic vector that are statistically independent and nongaussian from feature space (vectors) of multivariate (multidimensional) statistical data. As compared with other techniques this technique gives best result for the face images having different orientations and illumination conditions.

Some practical considerations that must be take into account while applying ICA algorithms to the database. For that reason pre-processing technique such as principal component analysis is used for dimension reduction to overcome these practical considerations. ICA provides a more powerful data representation than PCA. Since PCA derives only the most expressive features for face reconstruction rather than face classification, one would usually use some successive discriminant analysis to enhance PCA performance.

3.2 Elastic Bunch Graph Matching algorithms (EBGM)

EBGM[12] is feature-based technique based on the concept of human face[11]. Human face has a similar topological structure and many non-linear characteristics that are not addressed by the techniques discuss earlier, for example variation in illumination, pose and expression.

In EBGM method face are represented as graphs, with nodes positioned at fiducial points. (eyes, nose...) and edges labelled

with 2-D distance vectors. Each node contains a set of 40 complex Gabor wavelet coefficients at different scales and orientations (phase, amplitude). They are called "jets". Recognition is based on the similarity of the gabor filter response at each gabor node. The difficulty with this method is the requirement of accurate landmark localization, which can sometimes be achieved by combining PCA and LDA.

IV. CONCLUSION

In this paper typical structure of face recognition system and the techniques for face recognition has been reviewed. Although automated face recognition have made much useful development in the past decade but system with higher precision is still not achieved. There are several technique available to implement the face recognition system. The most common technique is PCA or eigenface based. On the other hand, next generation face recognition systems are going to have widespread application in smart environments, where computers and machines are more likely to be used. However, significant research remains to be done in making face recognition system work consistently in widely varying conditions.

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AUTHOR'S PROFILE

Saurabh P. Bahurupi

Department Of Electronics And Telecommunication,
Government college of Engineering ,
Amravati Maharashtra,
India, 09604350414,
saurabh.bahurupi@gmail.com

D. S. Chaudhari

Department Of Electronics and Telecommunication,
Government College of Engineering,
Amravati, Maharashtra,
India, 09421821030,
chaudhari.devendra@gcoea.ac.in