Volume-5,Issue-1, Jan - 2016
ISSN (O) :- 2349-3585

A Survey: Face Recognition Techniques

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Abstract— Face Recognition has received a significant attention as one of the most successful applications of image analysis. This system recognizes faces around different poses and illuminations. The face recognition phases include image preprocessing, feature extraction, and clustering. In this paper an attempt is made to review a wide range of methods used for face recognition comprehensively. It includes different techniques such as PCA, LDA, ICA, SVM and 2DPCA. Also Gabor wavelet soft computing tool like ANN for recognition.

Keywords— Face Recognition, Principal Component Analysis, Support Vector Machine, Linear Discriminant Analysis, Artificial Neural Networks Eigenvector, Eigenface.

INTRODUCTION

Biometrics refers to metrics related to human characteristics. Biometrics authentication is used as a form of identification and access control. It is also used to identify individuals in groups that are under surveillance. It uses the property that a person's attribute related to a person itself like structure of finger, face details etc. By comparing the existing information with the incoming information, it is able to verify the identity of a specific person. The existing information is stored in a database. Biometric identifiers are often categorized as physiological and behavioral characteristics.

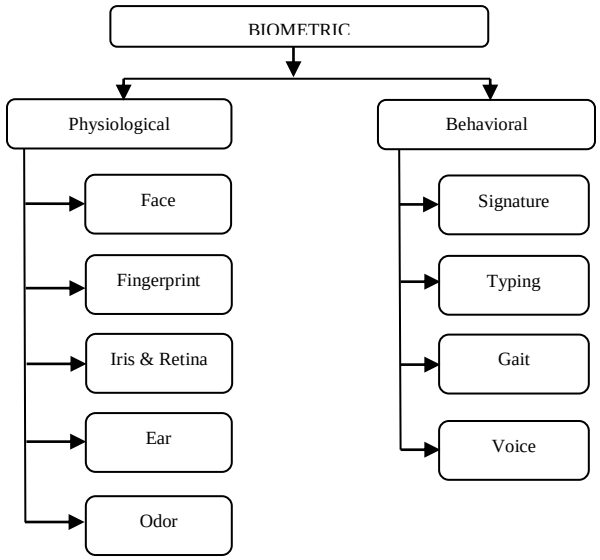

Fig 1: Classification of Biometric Recognition

Face recognition is an integral part of physiological biometrics. The face is a primary focus of attention in social life playing an important role in conveying identity and emotions. In Face Recognition algorithm, a new face is compared to face models stored in a database and then classified to a known individual if a correspondence is found. The performance of face identification is affected by several factors such as scale, pose, illumination, facial expression, and disguise.

LITERATURE SURVEY

Face recognition based on PCA and logistic regression analysis.

Changjun Zhou, Lan Wang, Qiang Zhang and Xiaopeng Wei proposed a novel face recognition method which is based on

PCA and logistic regression. PCA is used to extract logistic regression is used as the classifier[37].

Face Recognition using Principal Component Analysis.

Dian Retno Anggraini presented on developing a face recognition system based on Principal Component Analysis (PCA) and Self-Organizing Maps (SOM). The selected dataset for this research is Essex database and the recognition rate is 95.39%[22].

Face Recognition Through Different Facial Expressions.

Hazar Mliki , Emna Fendri and Mohamed Hammami discussed a paper which performs face recognition and facial expression recognition simultaneously by using Local Binary Pattern (LBP) and principle component analysis (PCA). The experimental studies were carried out on the KANADE database which gives a recognition rate of 99.24% and the JAFFE database which gives a recognition rate of 96.50%[24].

Evaluation of PCA and LDA techniques for Face recognition using ORL face database.

M.Saraswathi and Dr. S. Sivakumari implemented a paper that uses Linear Discriminant Analysis (LDA) as a feature extraction technique. The experimental studies were carried out on the ORL database which gives a high recognition rate of 93.7%[28].

Face Recognition using Principle Component Analysis , Eigenface and Neural Network.

Mayank Agarwal, Nikunj Jain, Mr. Manish Kumar and Himanshu Agrawal presented a methodology for face recognition in two stages – Feature extraction using principle component analysis(PCA) and Recognition using the feed forward back propagation Neural Network. The proposed methods were tested on Olivetti and Oracle Research Laboratory (ORL) face database which gives a recognition rate of 97.018%[2].

Face Recognition Using Principal Component Analysis.

Ningthoujam Sunita Devi and K. Hemachandran presented a methodology for face recognition in two stages – Feature extraction using principle component analysis(PCA) and Recognition using the feed forward back propagation Neural Network. The proposed method has been tested on Oracle Research Laboratory (ORL) face database and the maximum recognition rate obtained is 99.500[9].

Real Time Face Recognition under Different Conditions.

Rajesh Kumar Gupta and Umesh Kumar Sahu focused to find best match of an image captured by camera from the sequence of images. An Eigenface-based face recognition approach is implemented in matlab. This method represents a face by projecting original images onto a linear subspace defined by eigenfaces. The Eigenface approach for Face Recognition is fast and simple which works well under constrained environment[11].

An improved face recognition technique based on modular PCA approach.

Rajkiran Gottumukkal and Vijayan K.Asari proposed a technique in which the face images are divided into smaller sub-images and the PCA approach is applied to each of these sub-images. The accuracy of the conventional PCA method and modular PCA method are evaluated using UMIST and Yale face databases[10].

Performance Analysis of PCA-based and LDA-based Algorithms for Face Recognition.

Steven Fernandes and Josemin Bala discussed performance analysis of Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA) for face recognition. This gives 99.70% face recognition rate using PCA based Immune Networks (PCA-IN) on ORL database[11].

Face Recognition Based on PCA Algorithm.

Taranpreet Singh Ruprah discussed a paper in which the features are extracted using principal component analysis and then classification by creation of back propagation neural network. The primary goal of this paper is to present the performance evaluation carried out through neural network for face verification[27].

Face Databases for 2D and 3D Facial Recognition : A Survey

R.Senthilkumar and Dr.R.K.Gnanamurthy presented a detailed case study of different face databases frequently used for face recognition. The various databases used are ORL database, Yale database, FERET(Facial Recognition Technology) database and CMU PIE (Pose, Illumination and Expression) database. This paper work help to select appropriate face databases for both video face and still face recognition[30].

A Face Recognition Review based on Principal Component Analysis and Local Binary Patterns

Neha V. Tapase and Priyanka Verma discussed face recognition using a simple and widely used Eigenfaces along with PCA method and a relatively new LBP approach. PCA is successful in both detection as well as recognition of faces. The LBP approach provides better tolerance to monotonic gray-scale changes[32].

FACE RECOGNITION TECHNIQUES

1. Principal Component Analysis (PCA)

PCA also known as Karhunen-Loeve method is one of the popular methods for recognition of faces [8]. It is a dimensionality reduction technique based on extracting the desired number of principal components of the multi dimensional data. The goal of PCA is to reduce the dimensionality of the data while retaining as much information as possible in the original dataset. It tends to find a lower dimensional subspace whose basis vectors correspond to the maximum variance direction in the original image space. This reduced data space is used for recognition. The first principal component is linear combination of original dimensions that has the maximum variance; the nth principal component is linear combination with the highest variance, subject to being orthogonal to the n-1 principal components. The main idea of the principal component is to find the vectors that best account for the distribution of face images within the entire image space. These vectors define the subspace of face images known as facespace.

2. Independent Component Analysis (ICA)

Independent component analysis (ICA) is a method for finding underlying factors or components from multivariate (multidimensional) statistical data. There is need to implement face recognition system using ICA for facial images having face orientations and different illumination conditions, which will give better results as compared with existing systems. In ICA, each face image is transformed into a vector before calculating the independent components[8]. It allows a better characterization of data in an n-dimensional space. The comparison of face recognition using PCA and ICA on FERET database with different classifiers [10][19] were discussed and found that the ICA had better recognition rate as compared with PCA with statistically independent basis images and also with statistically independent coefficients. Face recognition using ICA with large rotation angles with poses and variations in illumination conditions was proposed. The ICA can be considered as generalization of PCA. One of its advantage is that the vectors found by the ICA are not necessarily orthogonals, so they reduce the reconstruction error.

3. Linear Discriminant Analysis (LDA)

The linear discriminant analysis (LDA) is a powerful method for face recognition. It yields an effective representation that linearly transforms the original data space into a low-dimensional feature space where the data is well separated[8]. The LDA has been proposed as a better alternative to the PCA. The main aim of the LDA consists in finding a base of vectors providing the best discrimination among the classes.

4. Two-Dimensional Principal Component Analysis (2DPCA)

2DPCA is a state-of-the-art statistical technique developed for image representation. As opposed to principal component analysis (PCA), 2DPCA is based on 2D matrices rather than 1D vectors, making it unnecessary to transform the image matrix into a vector for feature extraction. Overall, the idea of 2D method here originates preliminarily from the direct construction of image scatter matrices by using the original image matrices. Besides, the image covariance matrix and image scatter matrices of 2DPCA can have a much smaller size in comparison with its counterpart PCA method. Therefore, 2DPCA significantly reduces the computational cost and avoids the singularity problem. Its first principal component is a 1D linear subspace where the variance of the data is maximal, and the second principal component is the direction of maximal variance in the space orthogonal to the first principal component. 2D principal components are computed by 2DPCA.

5. Elastic Bunch Graph Matching (EBGM)

The algorithm recognizes novel faces by first localizing a set of landmark features and then measuring similarity between these features. All human faces share a similar topological structure. Faces are represented as graphs, with nodes positioned at fiducial points(like exes, nose) and edges labeled with 2-D distance vectors. Every 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 labeled graphs. A labeled graph is a set of nodes connected by edges, nodes are labeled with jets, edges are labeled with distances. Both localization and comparison uses Gabor jets extracted at landmark positions. In localization, jets are extracted from novel images and matched to jets extracted from a set of training/model jets. Similarity between novel images is expressed as function of similarity between localized Gabor jets corresponding to facial landmarks. Locating a landmark has two steps. First, the location of the landmark is estimated based on the known locations of other landmarks in the image, and second, that estimate is refined by extracting a Gabor jet from that image and comparing that jet to one of the models. The bunch graph is used to refine the precise location estimate for each landmark in each new face image to be recognized. The bunch graph contains Gabor jets from a set of representative images, the model images. A face graph must be created for each image to be recognized. It is the face graphs that are compared during recognition. After the algorithm has created a face graph for two images, their similarity can be computed. There are two different ways to measure the similarity of a face graph. The first method compares of the geometry of the graphs (landmark locations). The second method compares the similarity of the Gabor jets (landmark jets). Estimating the location of the other landmarks is easy based on the known eye coordinates. The overall performance of the algorithm subject to changes in the number of training/model images, choice of specific wavelet encoding and displacement estimation technique[8].

6. Support Vector Machine (SVM)

Support Vector Machines (SVM) are one of the most useful techniques in classification problems. One clear example is face recognition. However, SVM cannot be applied when the feature vectors defining samples have missing entries[8]. A classification algorithm that has successfully been used in this framework is the all-known Support Vector Machines (SVM) [36], which can be applied to the original appearance space or a subspace of it obtained after applying a feature extraction method [6][14]. The advantage of SVM classifier over traditional neural network is that SVMs can achieve better generalization performance[8]. Given a set of points belonging to two classes, a Support Vector Machine (SVM) finds the hyperplane that separates the largest possible fraction of points of the same class on the same side, while maximizing the distance from either class to the hyperplane. PCA is first used to extract features of face images and then discrimination functions between each pair of images are learned by SVMs.

7. Gabor wavelet

Gabor features have been recognized as one of the best representations for face recognition. In recent years, Gabor wavelets have been widely used for face representation by face recognition researchers [24][37]. In the most cases the Gabor filters are then used to extract the main features from the face images. Gabor features are also used for gait recognition and gender recognition recently [25][40]. In this paper, [38] it was observed that though Gabor phases are sensitive to local variations, they can discriminate between patterns with similar magnitudes, i.e. they provide more detailed information about the local image features. Therefore, the Gabor phases can work comparably well with the magnitudes, as long as its sensitivity to misalignment and local variations can be compensated carefully[8]. A technique is presented in [4] by which high intensity feature vectors extracted from the Gabor wavelet transformation of frontal face images combined together with ICA for enhanced face recognition.

8. 3-D Face Recognition

The main novelty of this approach is the ability to compare surfaces independent of natural deformations resulting from facial expressions. First, the range image and the texture of the face are acquired. Next, the range image is preprocessed by removing certain parts such as hair, which can complicate the recognition process. Finally, a canonical form of the facial surface is computed. Such a representation is insensitive to head orientations and facial expressions, thus significantly simplifying the recognition procedure. The recognition itself is performed on the canonical surfaces[8].

9. Artificial Neural Network (ANN)

A new approach to face detection with Gabor wavelets & feed forward neural network was presented in [5]. The method used Gabor wavelet transform and feed forward neural network for both finding feature points and extracting feature vectors. The experimental results, have shown that proposed method achieves better results compared to the graph matching and eigenfaces methods, which are known to be the most successful algorithms. A hybrid neural network solution was presented which combines local image sampling, a self-organizing map neural network, and a convolutional neural network [8]. The self organizing map provides a quantization of the image samples into a topological space where inputs that are nearby in the original space are also nearby in the output space, thereby providing dimensionality reduction and invariance to minor changes in the image sample. The PCA technique used to reduce the dimensionality of image patterns and extract features for the PNN. A novel Haarlet Pyramid based face recognition technique was proposed in [13]. Here face recognition is done using the image feature set extracted from Haarlet on gray plane. A new approach to plastic surgery based face recognition using near set theory was proposed in [20].

10. 3-D Morphable Model

Human face is a surface lying in the 3-D space intrinsically. Therefore the 3-D model should be better for representing faces, especially to handle facial variations, such as pose, illumination etc. A method based on a 3-D morphable face model encodes shape and texture in terms of model parameters, and algorithm that recovers these parameters from a single image of a face[8].

CONCLUSION

This paper has attempted to review a significant number of papers to cover the recent development in the field of face recognition. The main challenges for recognition are illumination, change in pose, background, expression and disguise. Different techniques are implemented to make this easy. Some of the very useful techniques like PCA, LDA, ICA, SVM, 2DPCA, ANN are explained in this paper along with a 3D face recognition technique.

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