Face Recognition: Today's Security Tool

Kailash Chander[1], Poonam[2]

[1]Research Associate, HARSAC, CCS HAU campus, Hisar, India
kcbhati@gmail.com

[2]Assistant Professor, IIET, Kinana, Jind, India
madaan.punam@gmail.com

Abstract

Face and facial feature detection plays an important role in various applications such as human computer interaction, video surveillance, face tracking, and face recognition. Efficient face and facial feature detection algorithms are required for applying to those tasks. Recently face recognition is attracting much attention in the society of network multimedia information access. Face recognition not only makes hackers virtually impossible to steal one's "password", but also increases the user-friendliness in human-computer interaction. Face recognition systems are now replenishing the need for security to cope up with the present day crime. It is really convincing with the market report which clearly depicts the growing popularity of the face recognition system. The face recognition system is proving to be very efficient in the present day market. In today's networked world, the need to maintain the security of information or physical property is becoming both increasingly important and increasingly difficult. From time to time it has been noticed about the crimes of credit card fraud, computer hackings, or security breaches in a company or government building. Government agencies are investing a considerable amount of resources into improving security systems as result of recent terrorist events that dangerously exposed flaws and weaknesses in today's safety mechanisms.

Keywords: Face Recognition; Principle Component Analysis; Linear Discriminant Analysis; Eigenvalues.

I. Introduction

Many recent events, such as terrorist attacks, exposed serious weakness in most sophisticated security systems. Various government agencies are now more motivated to improve security data systems based on body or behavioral characteristics, often called biometrics (Perronnin and Dugelay, 2003). In general, biometric systems process raw data in order to extract a template which is easier to process and store, but carries most of the information needed. It is a very attractive technology, because it can be integrated into any application requiring security or access control, effectively eliminating risks associated with less advanced technologies that are based on what a person have or know rather than whom a person really is.

Face recognition technology is the slightest disturbing and best biometric technology. It works with the most obvious individual identifier– the human face. Face recognition-system analysis the characteristics of a person's face images input through a digital video camera. Base on the input image, system measures the overall face structure, including distances between eyes, nose, mouth and chicks. With the use of these unique characteristics face recognition-system store face template into its database. Badge or password-based authentication procedures are too easy to hack. Biometrics represents a valid alternative but they suffer of drawbacks as well. Iris scanning, for example, is very reliable but too intrusive; fingerprints are socially accepted, but not applicable to non-consentient people. On the other hand, face recognition represents a good compromise between what's socially acceptable and what's reliable, even when operating under controlled conditions. Face recognition gives a new perspective named "Visitor Management System" as shown in Fig.1. For any organization, effective visitor management helps to prevent from intrusion. Conventional pen and paper based visitor management-system cannot give complete security solution. Face recognition based visitor management provides fool proof security solution by identifying each visitor by face. So each new face is identified by the system and a unique visitor id is generated and this also gives facility of printing visitor's identity card.

Now a day's detecting human faces and facial features has become an important task in computer vision with numerous potential applications including human computer interaction, video surveillance, face tracking, and face recognition. The objective of face detection is to determine whether or not there is any face in the image, and if any, then to specify the face location. The goal of facial feature localization is to detect the presence and location of features, based on the locations of faces which are extracted by any face detection method. There are several challenges associated with face and facial feature detection and can be attributed by the following factors [1].

a) *Intensity*: There are three types of intensity- color, gray, and binary.
b) *Pose*: Face images vary due to the relative camera-face pose (frontal, 45_, profile), and some facial features such as an eye may become partially or fully

occluded.

c) *Structural components*: Facial features such as beards, mustaches, and glasses may or may not be presented.
d) *Image rotation*: Face images directly vary by different rotations.
e) *Poor quality:* Image intensity in poor-quality images, such as blurred images, distorted images, and images with noise.
f) *Facial expression:* The appearance of faces depends on a personal facial expression.
g) *Unnatural intensity*: Cartoon faces and rendered faces from 3D model have unnatural intensity.
h) *Occlusion*: Faces may be partially occluded by other objects such as hand, scarf, etc.
i) *Illumination*: Face images may vary due to the position of light source.

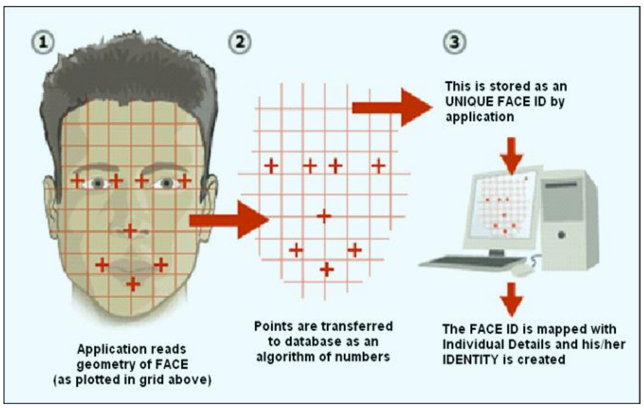

Fig.1 Visitor Management System

The ability to recognize human faces is a demonstration of incredible human intelligence. Over the last three decades researchers have been making attempts to study this outstanding visual perception of human beings in machine recognition of faces [2]. However, there are still sub-stantial challenging problems such as intraclass variations in three-dimensional pose, facial expression, make-up and lighting condition as well as occlusion and cluttered background. To cope with these difficulties, numerous algorithms have been proposed, which can be coarsely classified into two categories: Holistic approaches and Local feature/Component based approaches. Therefore, Holistic approaches do not explicitly utilize the image structure information in feature extraction. They take all pixels of a face image as initial features and extract a set of reliable and discriminative features based on machine learning from an available database. The Principal Component Analysis (PCA) [3] and the Linear Discriminant Analysis (LDA) [4] were introduced into face recognition. In general, the holistic approaches require a preprocessing procedure to normalize the face image variations in pose and scale. This is not an easy task because it depends on the accurate detection of at least two landmarks from the face image [5]. As a result, most approaches work on the normalized face images based on the manually identified landmarks. However, the recognition performance will deteriorate considerably if the manual process is replaced by an automatic landmark detection algorithm. Moreover, global features are sensitive to variations in facial expressions, poses and occlusions. Another intrinsic problem of all Holistic approaches is the dependency on the training databases, because knowledge about the face discrimination is generalized by machine learning from the face samples. A representative training database is necessary, which, however, is not available in most of applications.

II. PREDOMINANT APPROACHES

There are predominant approaches to the face recognition problem: Geometric (feature based) and Photometric (view based). Different algorithms were developed in face recognition: PCA (Principal Component Analysis) and LDA (Linear Discriminant Analysis).

A. *Principal Component Analysis*

Principal component analysis (PCA,) PCA is a statistical dimensionality reduction method, which produces the optimal linear least-square decomposition of a training set. Kirby and Sirovich [3] applied PCA for representing faces and Turk and Pentland [7] extended PCA for recognizing faces. PCA is a useful statistical technique that has found application in fields such as face recognition and image compression, and is a common technique for finding patterns in data of high dimension. PCA commonly referred to as the use of Eigen faces [3]. With PCA, the probe and gallery images must be the same size and must first be normalized to line up the eyes and mouth of the subjects within the images. The PCA approach is then applied to reduce the dimension of the data by means of data compression, and reveals the most effective low dimensional structure of facial patterns. This reduction in dimensions removes information that is not useful and precisely decomposes the face structure into orthogonal (uncorrelated) components known as Eigen faces [6]. Each face image may be represented as a weighted sum (feature vector) of the Eigen faces, which are stored in a 1D array a probe image is compared against a gallery image by measuring the distance between their respective feature vectors. The PCA approach typically requires the full frontal face to be presented each time; otherwise the image results in poor performance as shown in fig.2.The primary advantage of this technique is that it can reduce the data needed to identify the individual to 1/1000th of the data presented.

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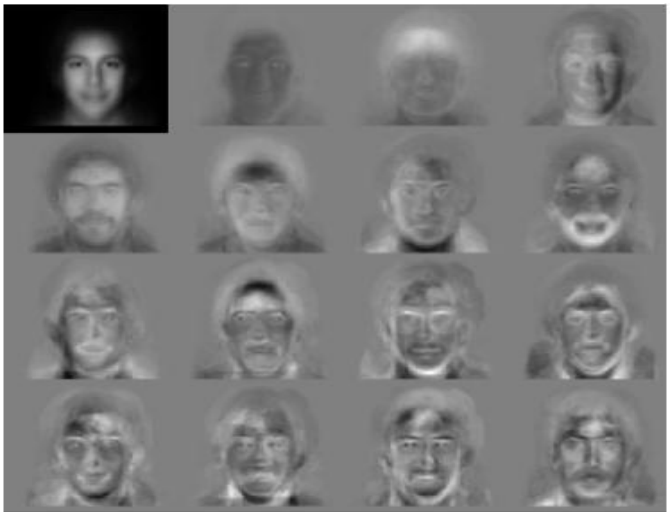

Fig.2.Standard Eigen Faces

The feature vectors are derived using Eigenfaces. Fig.3 shows a typical example of PCA. It can be easily spotted that the majority of 2D points are located closer to the 1st PC line, which means that the projection can be performed with these points on the 1st PC line without losing essential 2D information.

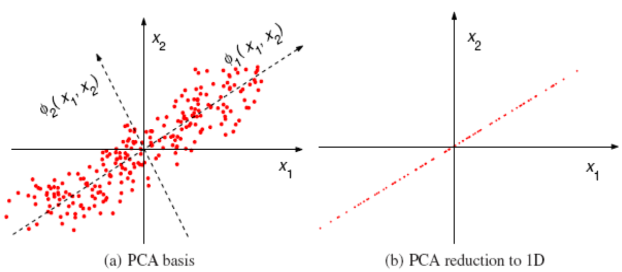

Fig.3.Graphical Example of PCA

PCA Method uses Eigenvectors and Eigen values for representing face images. These Eigenvectors can be thought of as a set of features which together characterize the variation between face images [7]. Each image location contributes more or less to each Eigenvector, so that we can display the Eigenvector as a sort of ghostly face which is called as an Eigenface.

B. Linear Discrement Analysis(LDA)

LDA is a data separation technique. The objective of LDA is to find the directions that can well separate the different classes of the data once projected upon. The set of human faces is represented as a data matrix X, where each row corresponds to a different human face. Each image X, represented by a (n, m) matrix of pixels, is represented by a high dimensional vector of n*m pixels. Turk and Pentland [8] were among the first who used this representation for face recognition. 2-dimensional principal component analysis (2dPCA) [9] was proposed which directly computes the Eigenvectors of the covariance matrix without matrix to vector conversion.2-dimensional LDA [10,11] computes directly the directions which will separate the classes without matrix to vector conversion as well. Higher recognition rate was reported for both cases. Both of these algorithms work in batch mode. The PCA/LDA-based face recognition systems suffer from the scalability problem. To overcome this limitation, an incremental approach is a natural solution. The main difficulty in developing the incremental PCA/LDA is to compute covariance matrix and to handle the inverse of the within class scatter matrix. Online development of 2-d filters requires that the system perform while new sensory signals flow in. When the dimension of the image is high, both the computation and storage complexity grow dramatically. Thus, the idea of using a real time process becomes very efficient in order to compute the principal components for observations (faces) arriving sequentially It should be noted that the incremental PCA-LDA has the following advantages:

a) *Low memory demands*: No need to store all the images (mainly due to the incremental structure of the PCA). All you need to store are the Eigenvectors. Given a new image or a new class, the Eigenvectors will be updated using only the stored Eigenvectors. From a practical point of view, there is no need to store any face database (store the unrecognized Eigenvectors) and some image data could not be presently available. It should be noted that 2dPCA, 2dLDA, and SVD work in batch mode.

b) *Low computational complexity*: The batch PCA-LDA needs to compute all the Eigenvectors of all the data then gets the first k Eigenvectors. The incremental PCA-LDA operates directly on the first k Eigenvectors (unwanted vectors do not need to be calculated). The processing of IPCA_LDA is restricted to only the specified number of k directions and not on all the directions.

c) Better recognition accuracy and less execution time.

d) Updating the inverse of the within class scatter matrix without calculating its inverse.

III. CONCLUSION

Face recognition technology has come a long way in the last twenty years. Today, machines are able to automatically verify identity information for secure transactions, for surveillance and security tasks, and for access control to buildings etc. These applications usually works in a controlled environment and recognition algorithms can take advantage of the environmental constraints to obtain high recognition accuracy. However, next generation face recognition systems are going to have widespread application in smart environments, where computers and machines are more like a helpful assistant. To achieve these goals computers must be able to reliably identify nearby people in a manner that fits naturally within the pattern of normal human interactions. They should not require special interactions and should conform to human intuitions about when recognition is needed. This implies that future smart environments should use the same modalities as humans, and have approximately the same limitations. These goals are now seems to be achieved, however some substantial research remains to be done to make person recognition technology and that should work reliably in widely varying conditions using information from single or multiple modalities.

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