

## A REVIEW OF FACE RECOGNITION

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### ABSTRACT

*Face Recognition is non-intrusive method of identifying individual faces by the feature extraction and classification of faces. Recently face recognition has received lots of attention of researcher; it can be conclude that it is mature yet fruitful area for researcher. In past decades lots of approaches for face recognition and feature extraction techniques have been developed, along with their modification. This paper provides a brief review of major face recognition techniques. Earlier section presents an overview of face recognition and its applications. Then, a literature review of face recognition approaches followed by recent techniques is given. The most prominent feature extraction and techniques are also given. A Brief overview of classifiers is also presented. Finally paper summarized all research results discussed.*

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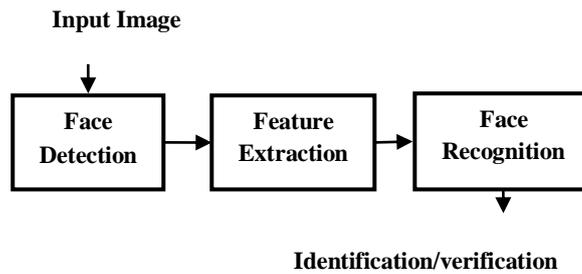
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## 1. INTRODUCTION

Bags of biometric technologies are available like Fingerprint [1], Voice [2], and Signature dynamics [3] and Face recognition [4]. One of the leading biometric technologies is Face Recognition (FR) which employ on automated methods that recognize identity of person based on his or her physical characteristic. There are at least two reasons for the attraction of FR trend: first is wide range of commercial and law enforcement application and second is the availability of feasible technology. Face Recognition is non-intrusive method identifying individuals by the feature of faces. Face recognition work under the two scenario: *Verification and Identification* [5]. The verification (“I am the identity I claim to be?”) scenario is one-to-one match that compare a probe image against a template image in the reference database. The similarity between two face images is measured and result of either match or not match is made. *Identification* is more complex task than verification. It is one-to-many match that compares the similarity of probe image with the all face images available in the database. System that restrains both (identification and verification) scenarios is known as fully automated system and which restrain single is known as partial automated system. The basic face recognition system consists of two main computational stages [6]. First stage is feature extraction and second stage classification. In Figure 1 the configuration of generic face recognition system has been shown. Feature extraction is performed after the detecting the face in image and this will find out key feature that are further used for classifying the face images. With the help of face classifier the extracted features of the image are compared with the image stored in the database.

The application of face recognition has been categorize in two main parts: law enforcement and commercial application [7]. Face recognition technology is primarily used in law enforcement, especially in advance video surveillance, CCTV control, base. portal control. The commercial applications are matching of photograph on credit cards, ATM cards, passports, driver’s licenses, National ID.

Even though current recognition system has reached certain levels of maturity after the enormous research in this field but still faces challenges in some specific domains such as illumination and pose variation [8, 9]. Although numerous methods has been proposed to cope up with such problems.

**Figure 1 Face Recognition processing Flow**

## 2.) LITERATURE REVIEW

Face recognition is an evolving area, changing and improving constantly. This section gives the overview of various approaches and techniques along with their advantages and disadvantages. Different approaches of face recognition can be categorized in three main groups such as holistic approach, feature-based approach, and hybrid approach [10].

### Geometry Feature-based Approach

The geometry feature-based approach methods analyze local features such as nose, eyes and their geometric relationships. Sometimes this approach is known as only feature-based approach [11]. Examples of this approach are Elastic bunch graph matching algorithm [12, 13]. This technique is not used now days.

### Holistic Approach

Many researchers followed this approach. In the holistic approach whole face region is taken into account as input data to the system. Various methods comes under this approach are eigenfaces, fisher faces, support vector machine, hidden markov model (HMM). They all are based on principal component analysis (PCA).

### Hybrid-Approach

Under the hybrid approach the combination of local feature and whole feature is used. Modular eigenface, hybrid local feature methods are for hybrid approach. Human facial feature plays important in face recognition. Research and studies have determined that eyes, mouth and nose are amongst the most significant feature for recognition [14].

### 2.1) Face Recognition Techniques

This section gives the description of various techniques that are used by researchers and mostly apply on frontal faces. Various techniques are Eigen faces, neural network, fisherfaces, Genetic algorithm.

### A.) Eigenfaces

Eigenface appears as a fast, simple, and practical method. Firstly eigenfaces approach in FR was used by L. Sirovich and M. Kirby in 1986 [15]. This method is based on the Principal Component Analysis and the goal was to represent an image in a lower dimension without losing much information, and then reconstructing it [16]. This technique would be later the foundation of the proposal of many new face recognition algorithms [17]. In 1992 Mathew Turk and Alex Pentland of the MIT presented a work which used eigenfaces for recognition [18]. They used PCA projection as a feature vector to solve the problem of face recognition using Euclidean distance as a similarity function. The authors reported 96 percent, 85 percent, and 64 percent correct classifications averaged over lighting, orientation, and size variations, respectively.

Alex Pentland, Baback Moghaddam [19] extended the work of eigenface to eigenfeature corresponding to eigenvector. They use modular approach with this they have been able to demonstrate robustness to localized variations in object appearance. However, in general, it does not provide invariance over changes in scale and lighting conditions. Recently, K. Chang, K.W. Bowyer and S. Sarkar, [20] experiments with ear and face recognition, using the standard principal component analysis approach, showed that the recognition performance is essentially identical using ear images or face images and combining the two for multimodal recognition results is 90.9%, 71.6%, 70.5% respectively.

### B.) Fisherface

Fisher's Linear Discriminant is a "classical" technique in pattern recognition [21], first developed by Robert Fisher in 1936 for taxonomic classification [22]. Fisher's Linear Discriminant (FLD) [22] is an example of a *class specific method*, in the sense that it tries to "shape" the scatter in order to make it more reliable for classification. Belhumeur et al [19] propose fisherfaces method by using PCA and Fisher's linear discriminant analysis. The FLD remove the problem of eigenface method in pentland [18] by taking the advantage of within class information, minimizing variation in same image due to lighting condition.

### C.) Neural Network

The attractiveness of using neural networks could be due to its non linearity in the network. Artificial neural networks are emerging tool in face recognition. One of the first artificial neural networks (ANN) techniques used for face recognition is a single layer adaptive network called WISARD which contains a separate network for each stored individual [23]. From different methods based on neural network [24] and other are for feature extraction, Intrator et. al proposed a hybrid or semi-supervised method. Lawrence et. al. [26] used self-

organizing map neural network and convolutional networks. Self-organizing maps (SOM) are used to project the data in a lower dimensional space and a convolutional neural network (CNN) for partial translation and deformation invariance. The authors reported 96.2% correct recognition on ORL database of 400 images of 40 individuals. The classification time is less than 0.5 second, but the training time is as long as 4 hours. Overall, FFNN and CNN classification methods are not optimal in terms of computational time and complexity [27].

Lin et al. developed a face detection and recognition algorithm using PDBNN kind of network [28]. They applied it to face detection, feature extraction and classification. PDBNN-based biometric identification system has the merits of both neural networks and statistical approaches, and its distributed computing principle is relatively easy to implement on parallel computer. In [28], it was reported that PDBNN face recognizer could achieve up to 96% correct recognition rate in approximately 1 second. Bhuiyan et al. proposed in 2007 a neural network method combined with Gabor filter [29]. Bhattacharjee et al. developed in 2009 a face recognition system using a fuzzy multilayer perceptron (MLP) [27]. The idea behind this approach is to capture decision surfaces in non-linear manifolds, a task that a simple MLP can hardly complete. The results of the algorithm show a 2.125 error rate using ORL database.

#### **D.) Genetic Algorithm**

Genetic algorithm was developed by John Holland- University of Michigan (1970.s)- to provide efficient techniques for optimization and machine learning applications. Genetic programming is an evolutionary algorithm methodology inspired by biological evolution [30]. In Genetic Programming different phases of evolution, namely selection based on individual fitness, reproduction using cross-over and mutation towards better solutions. It is a heuristic method that uses the idea of .survival of the fittest. The Genetic Algorithm (GA) has been widely used in the pattern recognition, feature selection [31], [32]. Liu had been successfully used GAS for feature selection in face recognition problems [33]. There, GAS was used to find the best configuration (rotation) of the axis of the principal components achieving an efficiency of 97.02%. In order to search for the object (face) of interest, lots of data need to be processed. The genetic algorithm has been considered to be a robust and global searching method. Stephen. Kamngam et. al [34] has shown that the genetic algorithm guide template matching produces better results than both the normal template matching method and the distance measure method, the result comes with an accuracy of 95.1%. Most of the author use GA in combination with some of other algorithm. Schackleton [35] uses a population of templates to recognize the face using a GA to find the best fitness of the

templates. Lanitis et al [36] used a combination of PCA and a GA to achieve the recognition. Pinto and Sossa [37] propose a method of invariants combined with a GA for face recognition.

### **3.) FEATURE EXTRACTION**

Facial feature extraction play a significant role for face recognition. Almost every face recognition systems need facial features in addition to the holistic matching methods, for example, eigen faces proposed by Turk and Pentland [18] need accurate locations of key facial features such as eyes, nose, and mouth to normalize the detected face. Neurophysiologic research and studies have determined that eyes, mouth, and nose are amongst the most important features for recognition [37]. Mostly feature extraction technique are sensitive in nature and need accurate result as this will make the base of the next FR stage i.e. classification. Various feature extraction technique has been briefly described and compared below.

#### **3.1) Feature Extraction Techniques**

##### **A.) Geometry-based**

Geometry-based approaches extracted features using geometric information such as relative positions and sizes of the face components. Technique proposed by Kanade [38], also comes under this technique. Mark Nixon presented a geometric measurement for eye spacing with the Hough transform technique to detect the instance of a circular shape and of an ellipsoidal shape. The result of this paper illustrate that it is possible to derive a measurement of the spacing by detection of the position of both the iris, which is a most accurate technique [39]. Nevertheless these techniques require threshold, which given the prevailing sensitivity, may adversely affect the achieved performance.

##### **B.) Template-Based**

This approach, matched facial components to previously designed templates using appropriate energy functional. The best match of a template in the facial image will yield the minimum energy. Yuille et al [40], detecting and describing features of faces using deformable templates. The feature of interest, an eye for example, is described by a Parameterized template. These parameterized templates enable a priori knowledge about the expected shape of the features to guide the detection process [40]. But before the Yuille, Fischler and Elschlager [41], measured features automatically and described a linear embedding algorithm that used local feature template matching and a global measure of fit to find and measure facial features. These algorithms require a priori template modelling, in

addition to their computational costs, which clearly affect their performance. Genetic algorithms have been proposed for more efficient searching times in template matching.

### **C.) Colour- Segmentation Technique**

This approach makes use of skin color to isolate the face. Any non-skin color region within the face is viewed as a candidate for eyes and/or mouth. The performance of such techniques on facial image databases is rather limited, due to the diversity of ethnical backgrounds [42]. This technique doesn't give good results in different expression.

### **D.) Appearance-Based Technique**

This approach generally operates on images or appearances of face objects and process the image as two dimensional patterns. These approaches are commonly used for face recognition rather than person identification. Methods such as principal component analysis (PCA), independent component analysis, and Gabor-wavelets are used to extract the feature vector. Table1 give the overview of all techniques.

Author	Technique	No. of feature	Advantages	Disadvantages
T. Kanade, 1997	Geometry -based	eyes, the mouth and the nose	Small data base Simple manner Recognition rate 95%	Large no. of features are used
A. Yuille, D. Cohen, and P. Hallinan, 1989	Template- based	eyes, the mouth, the nose and eyebrow	Recognition rate 100% Simple manner	-computational complexity -description between template and images has long time
C. Chang, T.S. Huang and C. Novak,1994	color-based	eyes and/or mouth	Small database Simple manner	-discontinuity between colours -in profile and closed eyes has a problem.
Y. Tian, T. Kanade, And J.F. Cohn,2002	Appearance -based Approaches	eyes and mouth	Small no of feature -recognition rate 98%	-need good quality image. -large database require -illumination

**Table1. Feature extraction technique Advantage and disadvantage**

#### 4.) CLASSIFIERS

Classifier has big impact on face recognition. According to Jain, Duin and Mao [43] classifier can be divided into three categories-similarity, probability and decision-boundary. *Similarity*, this approach is simple and intuitive. Patterns that are simple should belong to same class. Method comes under this approach is 1-NN, K-NN, Self Organize Map (SOM).

*Probability* some classifier build based upon the probabilistic approach. Bayes decision rule is often used this approach. Decision-boundary, the main idea behind this approach is minimize the criteria between the candidate pattern and the testing patterns. The method come under this technique is Fisher Linear Discriminant (FLD), Binary Decision Tree, and Radial Basis Network.

#### 4. CONCLUSION

In this paper we give the brief review of classical and heuristic face recognition techniques, with respect to resources discovery. We focused on different technique of face recognition which are existing and some upcoming. We also described feature extraction technique with comparison and give the overview of classifiers.

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