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A Comparative Study of Face Recognition Techniques: ASurvey

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Abstract: Face is the index of mind and the information in a face can be efficiently analyzed among the factors like identity, gender, expression, age, race and pose. Generally, human beings are equipped with the ability of face recognition. So, face recognition is something that human beings usually performs with less effort and without much sensible thought, although it seems to be very difficult in the case of computer vision because of the pose variations, illumination conditions etc. So, it has been drawn considerable interest for researchers and become a very active research area in the Computer Vision and Biometrics fields and is widely applied in new technologies that works beyond the ability of human vision. Here we discuss numerous techniques of automatic face recognition and provide the comparative analysis of them.

Keywords*:* Face recognition, Face detection, Biometrics

I. INTRODUCTION

The human face is a rich source of information — by looking at the person's face, we can immediately identify whether the person is male or female, the person's approximate age, facial expression, and so on. So, human face detection and recognition has been drawn considerable interest for decades. Automatic Face recognition is typically used in security system and can be compared to other biometrics such as fingerprint or iris recognition system and it is one of the biometrics that is being used for the last 50 years or so. The purpose of face recognition is mainly to identify a person, as a key to security (Biometric face recognition technology) and a wide variety of applications such as identification for law enforcement, matching of photographs on passports or driver's licenses, access control to secure computer networks and facilities such as government buildings and courthouses, authentication for secure banking and financial transactions, automatic screening at airports for known terrorists, and video surveillance.Face recognition has attracted much attention and its research has rapidly expanded by not only engineers but also neuroscientists, since it has many potential applications in computer vision communication and automatic access control system and it has the great advantage of being able to work in places with large concourse of unaware visitors because human beings are not capable enough to recognize the strangers. "Face Recognition" generally involves two stages:

a. ***Face Detection***: where a photo is searched to find any face, then image processing cleans up the facial image for easier recognition.

b. ***Face Recognition***, where the detected and processed face is compared to a database of known faces, to decide who that person is.

There are various key factors that can significantly affect face recognition system performances like illumination variations, pose variations, time delay, occlusion, low resolutionand ageing and change in expressions. This paper provides the techniques used for face recognition in last few decades and comparison of these techniques. Finally this paper concludes by proposing the possible future advancements.

II. FACE RECOGNITION TECHNIQUES

A number of methods have been proposed in the area of automatic face recognition. In general, face recognition systems can be broadly classified into three categories and the overview of some of the well-known methods in these categories is given below.

A. Holistic Methods:

These methods are also called appearance-based methods. Appearance-based face recognition methods can be divided into linear analysis methods such as PCA, ICA and LDA and non-linear analysis methods, such as Kernel PCA, Kernel FLD and neural network. Automatic Face Recognition can be seen as a pattern recognition problem. Particularly, we can think of it as a template matching problem, where recognition has to be performed in a high-dimensional space. Since higher the dimension of the space is, more the computation we need to find a match, a dimensional reduction technique is used to project the problem in a lower-dimensionality space.

a. Linear Analysis Methods:

a) ***Principal Component Analysis:*** Principal component analysis is used to calculate the vectors which best represent this small region of image space. The main idea of the principal component analysis is to find the vectors which best describe the distribution of face images within the entire image space. PCA is performed by projecting a new image into the subspace called face space spanned by the eigenfaces and then classifying the face by comparing its position in face space with the positions of known individuals.The Eigenfaces [1] can be considered as one of the first approaches in this sense. Turk and Pentland implemented the Eigenfaces approach [2], which is surely the most popular face recognition method. The principle of PCA can be illustrated in Figure1.

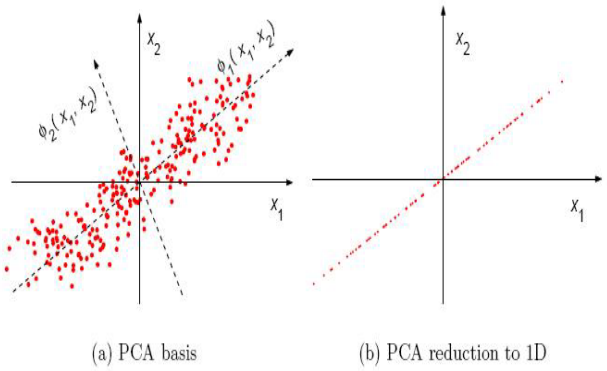

Figure 1:The Principle of PCA (Source [27])

b) Linear Discriminant Analysis:

LDA is also called Fisher Discriminant Analysis. LDA is able to maximize the ratio of between class distribution to that of within-class distribution [3, 4].The LDA [5] has been proposed as a better alternative to the PCA.The LDA technique required computation to a greater extent and so Incremental Linear Discriminant Analysis (ILDA) [6] was formulated. Kim, Wong and Stenger also presented their work on ILDA[7].The principle of LDA can be illustrated in Figure2.

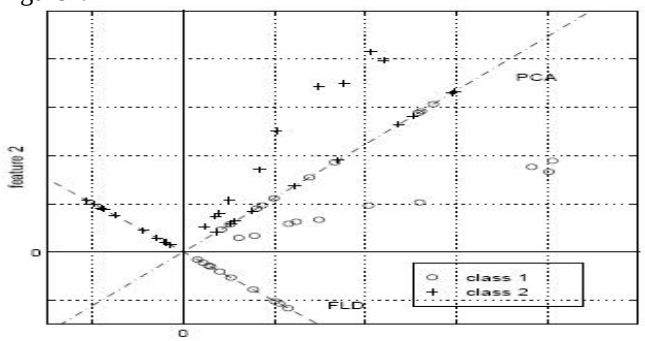

Figure 2: The Principle of LDA(Source [27])

c) Independent Component Analysis:

PCA derives only the most expressive features which are unrelated to actual face recognition, and in order to improve performance additional discriminant analysis is needed. However, ICA provides a more powerful data representation than PCA as its aim is to provide an independent rather than uncorrelated image decomposition and representation.The ICA can be considered as a generalization of the PCA. Bartlett and Sejnowski showed the use of ICA for face recognition [8]. The principle of ICA can be described in Figure 3.

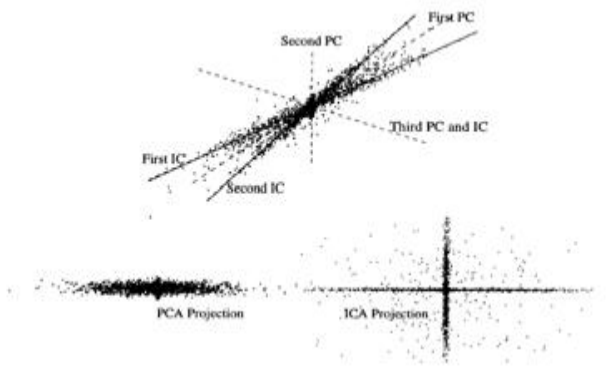

Figure 3: The Principle of ICA (Source [27])

b. Nonlinear Analysis Methods:

a) The Neural Networks: A further nonlinear solution to the face recognition problem is given by the neural networks, largely used in many other pattern recognition problems, and readapted to cope the people authentication task. In [9], Cottrellintroduced a second neuralnetwork that operates in auto-association mode.In a recent work, [10]presented the Probabilistic Decision Based Neural Network (PDBNN) which they modelled for three different applications (a face detector, an eyes localizer and a face recognizer). At last, [11]introduced a hybrid approach, in which, through the PCA, the most discriminating features are extracted and used as the input of aRBF neural network.

B. Feature-Based Methods:

These are also called Structural Mapping Methods. Typically, in these methods, local features such as the eyes, nose and mouth are first extracted and their locations and local statistics (geometric and/or appearance) are fed into a structural classifier.

a. Geometrical feature matching

Geometric feature matching technique is based on the computation of a group of photos from the face geometry. The fact that face recognition is possible even at coarse resolution as low as 8x6 pixels [5] when the single facial features are hardly revealed in detail implies that the overall geometrical configuration of the face features is sufficient for recognition.In recent developments, Zhen *et al*. (2011) presented a recognition approach based on facial geometry.

b. Gabor filters and wavelets

The Gabor filters represent a powerful tool both in image processing and image coding, because of their capability to capture important visual features, such as spatial localization, spatial frequency and orientation selectivity.The Gabor filters are used to extract features from the images using texture component.Wiskott et al. [12]further expanded on DLA and developed a Gabor wavelet based elastic bunch graph matching method (EBGM) to label and recognize human faces. A faster wavelet based approach has been proposed by Garcia et al. [13], which presented a novel method forrecognition of frontal views of faces under roughly constant illumination. Liu [14], proposed a new method using Gabor filters for character recognition in gray-scale images.

c. Dynamic Link Architecture:

This is another method for face recognition named as graph matching approach. Lades *et al*. [15] performs recognition on the basis of stored graph matching algorithms. These are the dynamic graphs that are used to build the decision based neural networks. In [12], recognition is based on a straightforward comparison of image graphs.

d. Hidden Markov Model:

Inactive Stochastic modeling that depends on HMM is an ideal approach for speech applications.Samaria and Fallside [16] uses HMM approach to identify the human face while categorizing the intuitive face into number of features like eyes, nose, mouth, etc. Given that,HMMs need

a series of experimental 1D and 2D images; images should be transformed to either a chronological sequence of 1D or 1D spatial.

e. Convolution Neural Network:

In [17], a fast, automatic system for face recognition which is a combination of a local image sample representation, an SOM network, and a convolutional network for face recognition is presented. In [18], FaceRecognition/detection by probabilistic decision-based neural network is used.

C. Hybrid Approaches –

Hybrid approaches use both holistic and local features-based methods. For example, the modular eigenfaces approach [19] uses both global eigenfaces and local eigenfeatures and the capabilities of the earlier system [2] were extended in several directions. In mugshot applications, usually a frontal and a side view of a person are available; in some other applications, more than two views may be appropriate.One can take two approaches to handling images from multiple views. **The first approach** pools all the images and constructs a set of eigenfaces that represent all the images from all the views. The other approach uses separate eigenspacesfor different views, so that the collection of images taken from each view has its own eigenspace. **The second approach**, known as *view-based eigenspaces*, performs better.The concept of eigenfaces can be extended to eigenfeatures, such as eigeneyes, eigenmouth, etc. For lower-order spaces,the eigenfeatures performed better than the eigenfaces [19].

In [20], Penev and Atick proposed that the leading eigenpicturesare global, integrating, or smoothing filters that are efficient in suppressing noise, while the higher-order modes are ripply or differentiating filters that are likely to amplify noise. Its biological motivation comes from the fact that, though a huge array of receptors (more than six million cones) exist in the human retina, only a small fraction of them are active, corresponding to natural objects/signals that are statistically redundant [21]. In [20], it have been proposed that the whole face region stimulates a full 2D array of receptors, each of which corresponds to a location in the face, but some of these receptors may be inactive. To explore this redundancy, LFA is used to extract topographic local features from the global PCA modes. A flexible appearance model based method for automatic face recognition was presented in [22]. To identify a face, both shape and gray-level information are modeled and used. In [23], Huang described the recent advances in component-based detection/ recognition [24] and 3D morphable models [25].But a major drawback of this system is that it needs a large number of training images taken from different viewpoints and under different lighting conditions. To overcome this problem, the 3D morphableface model [25] is applied to generate arbitrary synthetic images under varying pose and illumination. In[26], also described a hybrid method where a neural network with SVM is presented.

III. COMPARATIVE ANALYSIS OF FACE RECOGNITION APPROACHES

Table: 1

	Approaches/ Algorithm Used	**Merits**	**Demerits**	**References**
Holistic	**Principal Component Analysis**[Eigenvectors of the covariance matrix used]	Dimensionality reduction, No data redundancy, Complexity of grouping the images can be reduced	The seperability of the class remain same. Sensitive to pixel misalignment	Kirby and L. Sirovich et. Al. [1], Turk and Pentland et. Al. [2]
	Linear Discriminant Analysis [Fisherfaces]	Reduces dimensionality, Increase class seperability	It is incorporated when data is continuous.	Plataniotis et. Al.[4], Kim et. Al.[7]
	Independent Component Analysis[local basis images+ factorial face code]	Exploits higher order statistics, Allow better characterization of data in an n-dimensional space		Bartlett and Sejnowski et. Al. [6],
	Neural Networks	Reduces misclassifications among the neighborhood classes.	Breach of privacy, Expensive to implement, Comparatively less accurate	Tamura et. Al.[5]
Feature	**Geometrical feature matching** [global+local feature descriptions]	Applicable to many domains, Allows user to add new feature with less effort	computationally intensive and limited to analytical surfaces	Chellappa and Wilson et. Al.[28]
	Gabor filters and wavelets	Better performance	High dimensionality	Wiskott et. Al.[12], Liu et. Al.[14]
	Hidden Markov Model[top to bottom image segmentation]	Computational speed is fast, which makes it practical for real time applications	Sensitive to geometrical shape	Samaria et. Al.[16]
Hybrid	**3D Facial Aging Model And Simulation Method**	Works with both growth and adult face aging effects	Age estimation is crucial	Unsang et. Al.[29]
	3D Morphable Model [component based face detection]	Good performance even with pose and illumination variation, Better noise handling	High complexity	Huang et. Al.[23]

IV. CONCLUSION

In this paper we discussed the different approaches which have been employed in automatic face recognition like in the geometrical based methods, the geometrical features are selected and the significant facial features are detected and the Hidden Markov model optimizes the parameters to best describe the observations in the sense of maximizing the probability of observations given in the

model etc.. Face recognition promises latest security invents in the upcoming trends based on bio-metrics and pattern matching techniques and algorithms that are used in the various application areas such as information security, video surveillance, law enforcement, identity authentication. These systems are widely used online and provide a very fast recognition rate.

V. FUTURE EXTENSION

Although many previous face recognition methods which have been proposed in past, have shown significant promises but robust face recognition is still difficult. So, the future work can be to combine the advantages of few face recognition techniques and make a more efficient model of face recognition like SVM+NN, 2D+3D based approach and proposes a multimodal face recognition system. This can be the area of further research for making more efficient and reliable face recognition systems.

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