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Comparative Analysis of Different Feature Extraction Techniques used in Face Recognition – A Review

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ABSTRACT: Face recognition has received important attention due of its various applications in security, access control, computer entertainment, surveillance, law enforcement and Internet communication. Besides its popularity, face recognition still faces issues on its accuracy. This paper provides an overview of face recognition and its applications in different fields. A literature review of various techniques of the face recognition is presented. In face recognition system, there are many techniques that are used for features extraction such as Independent Component Analysis (ICA), Principal Component Analysis (PCA), Support Vector Machine (SVM), Local Binary Pattern (LBP). Dimensionality is reduced by using the Eigen-faces approach or PCA. Local Binary Pattern (LBP) is a nonparametric descriptor used for extracting the information that is invariant to local gray-scale variations in the images. The aim of this work is to make a comparative study of different face recognition methods. The analysed methods are robust to incorrect alignment, variations in expressions and face occlusions, to a large degree. Local Binary Pattern (LBP) based methods are an outstanding performance in real time operations as well as high recognition rates.

KEYWORDS: Face Recognition, Feature Extraction, Local Binary Pattern, Principal Component Analysis, Support Vector Machine.

I. INTRODUCTION

Face recognition has obtained an increasing amount of interest in pattern recognition and computer vision over the past few years. The automatic analysis of the human face has become an important area of research in the pattern recognition and artificial vision, due to its significant use in various applications such as electronic transactions, biometrics, forensic and video surveillance. Face recognition is a basic human behaviour that is important for effective communications and interactions between people [1]. The face recognition system usually operates under one of two situations i.e verification (1:1) or identification (1: N). In the process of verification, similarity between two face images is calculated and a decision is made for match or non-match whereas in the process of identification, similarity is computed between a given face image and all other face images in a large database [2]. Face detection is used to detect the position of any faces within an image. Pre-processing is done for two purposes: (i) To decrease noise and possible complex effects of interfering systems and (ii) To convert the image into a different space where classification may verify easier by development of certain features [3]. Feature extraction is consisting of segmentation, image rendering and scaling of face are prepared for identification. Feature extraction algorithms generally categorized into given two parts: statistical feature extraction and geometrical features extraction. In geometrical approach, face is identified in the terms of structural measurements and characteristic facial features which represent the distances and angles among various components of the face. These face components are nose, eyes, mouth, chin and facial templates. Unknown face can be recognized by matching these features to the nearest neighbour in the stored database. A statistical feature extraction is consists of algebraic methods like Principal component analysis (PCA), and Independent component analysis (ICA). Support Vector Machines (SVMs) have been recently developed by Vapnik and his co-workers [4] as a very useful method for classification of images. To improve recognition performance, it is important to extract facial features with high discriminative characteristics of human faces in various scenarios such as disguises,

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facial expressions, and under-sampling of training face images. Feature selection is of great importance in pattern recognition, data observations, multimedia, remote sensing, machine learning, and data mining applications. Face recognition method consists of three components i.e. face detection, feature extraction and classification are shown in Fig. 1.

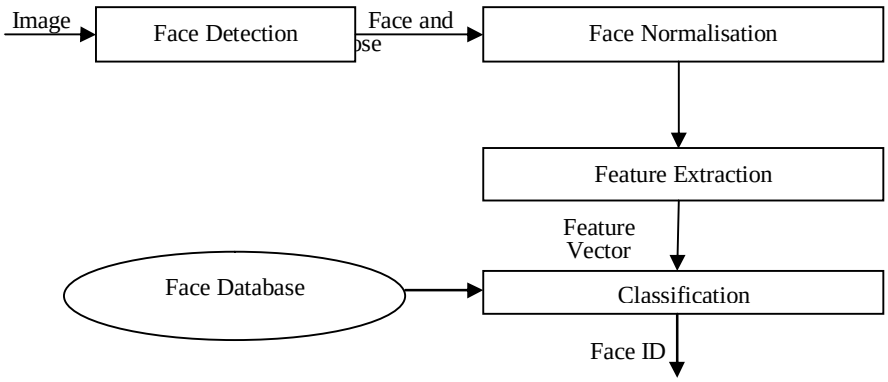

Fig. 1 Block diagram of a general face recognition system

Applications of face recognition:- There are many applications of face recognition such as
1. It used for person verification and to check criminal records.
2. It is used to identification documents (Driver's license, Passports and ID cards) of any person.
3. Used for security purposes such as in airports, government offices, military bases, banking transactions etc.
4. It is used for Multimedia environments with adaptive human computer interfaces, Airplane-boarding gate.
5. Forensic applications, generally a forensic artist is used to draw a sketch of a guilty person with the help of information given by eye witness. With the help of this technique sketch is used to match with different images of criminals in order to find any match [5].

The algorithms that are used for face recognition are Principal component analysis, Independent component analysis [10], Linear discriminant analysis, Genetic Algorithms, Support Vector Machine, Back Propagation Neural Networks. Principal component analysis and linear discriminant analysis both are powerful algorithms used to reduce the dimensionality and extract the features from the image in face recognition technique. The major difference between these two methods is that PCA selects features essential for class representation and LDA selects features that are most helpful for class separability [6]. The major limitations of any face recognition systems are facial aging, pose invariant, lighting conditions, accidental face detection, wearing goggles, specs or another accessories that effect on the results.

The rest of the paper consists of Section II summarizes feature extraction techniques. Section III demonstrates the related work in a summary of the literature reviews: Principal Component Analysis, Local Binary Pattern, Support Vector Machine. Section IV represents the comparative study of different techniques and conclusions are made in Section V.

II. FEATURE EXTRACTION TECHNIQUES

The primary stage in any face recognition system is the extraction of the feature matrix. In the face recognition system, the features are extracted such as nose, eyes, mouth and the extracted features are used as an input to an application for recognition. There are various features approaches in image processing that are used to extract the features from an image [7]. A classification on various categories of recognition algorithms are divided into following four categories:

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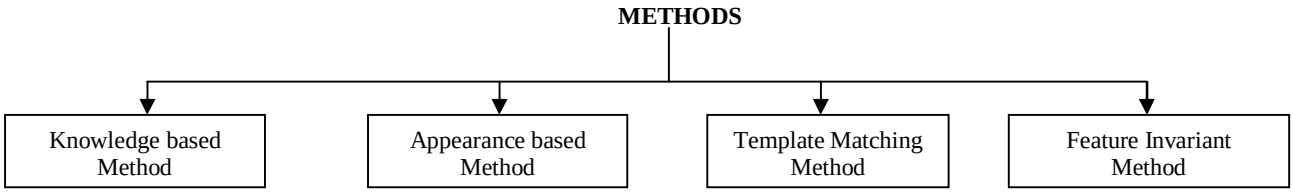

Fig. 2 Different Types of Face Recognition Methods

A. Principal Component Analysis (PCA)

In 1991, Turk and Pentland developed one of the most popular method Principal Component Analysis (PCA) that is used for image recognition with dimensional reduction. With Principal Component Analysis, all the training and test images are projected on to Eigen-space. PCA [3] is a de-correlation technique in statistical signal processing used in pattern recognition. It involves a mathematical procedure to generate principal components. These principal components are generally smaller number of uncorrelated variables obtained by transformation of number of possible correlated variables. A face image is processed to some Eigen-faces which are face templates and a set of features that describe the difference between face images. After obtaining a set of Eigen-faces, a facial image can be rebuilt using a weighted combination of the Eigen faces. Mathematically, Eigen-faces are the eigen-vectors of the covariance matrix, which represents the set of faces or principal components of the faces distribution [8]. However, Principle Component Analysis still has its disadvantages such as improper covariance matrix evaluation and insensitive in capturing variance. It also has problems in dealing with light and expression changes [9].

B. Local Binary Pattern (LBP)

The LBP operator method is one of the great performing texture descriptors, introduced by Ojala et al. [11]. It has verified to be extremely discriminative and its major advantages such as its invariance to monotonic gray-level changes and computational efficiency [12]. LBP is defined as a gray-scale invariant texture measure and is a helpful tool to form texture images. The original LBP operator labels the pixels of an image by thresholding the 3 x 3 neighborhood of every pixel with the value of the central pixel and represented the results binomially to form a decimal number [13]. The center pixel value for every pixel is compared with 3 x 3 neighborhood eight pixel values using subtraction. These values are coded with binary coding in which negative values are coded into zero and all other values are coded with one and a binary number is generated.

LBP code for a center pixel at coordinates (x_c,y_c) is given as follows:

$$LBP_{P,R}(x_c,y_c) = \sum_{p=0}^{P-1} f_1(g_p - g_c)2^p \quad (1)$$

where g_c and g_p indicate a pixel intensity of a center pixel and its pth neighbour in the circular neighbourhood of radius R. Parameter P indicates the total number of neighboring pixels. LBP methodology has been developed with large number of variations such as 1) improvement of its discriminative capability; 2) selection of its neighbourhood; 3) enhancement of its robustness; 4) extension to 3-D data for improved performance in face recognition [14]. LBP method has been used in many applications such as biometric identification, human-computer interfaces, expression analysis, face identification, surveillance etc.

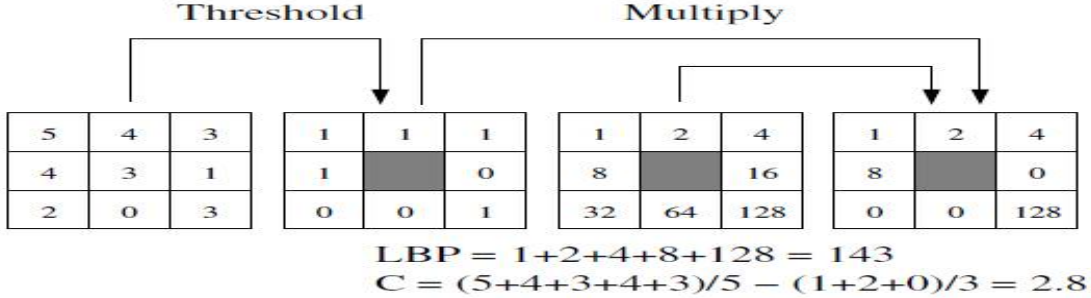

Fig 3. Calculating the original LBP code and a contrast measure

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III. RELATED WORK

Some of the brief surveys on face recognition analysis which uses different feature extraction methods such as PCA, ICA, LBP, LDP were given. Comprehensive survey of different techniques used for face recognition has been shown in this paper. **Ahonen et al.** [12] proposed a technique, namely as LBP histogram Fourier features (LBP-HF), to join the Local binary pattern and the discrete Fourier transform. The LBP-HF descriptor is formed by formulating an LBP histogram over the complete area, and afterwards they are constructing rotationally invariant features from the histogram with Discrete Fourier Transform. That means, rotation invariance is described globally and features are therefore invariant to rotations of the entire input signal. **Sheela Shankar et al.** [15] reviews some of the effective face recognition algorithms as well as proposed an optimized algorithmic chain that gives results optimal classification accuracy and lower execution time. It uses three chains for experimental performance evaluation with the help of AR database. Local binary pattern method used for extracting the features and SVM used as the classifier. Occlusions and expressions on face images can be tackled with portioning process. Number of features selected plays an important role in accuracy, execution time. **Hassaballah et al.** [2] critically explored the steps involved in face recognition and its various applications in security, surveillance etc. The target of this study is to focus on the most important challenges associated with different face recognition algorithms. The author have investigated the current development in the area of face recognition and discussed the major factors and challenges affecting performance of the system. Possible directions for the research is to improve the performance of system are also proposed. Moreover, this research exhibits the scientific and daily life applications of face recognition technology. **Tolba et al**. [1] presented a study on various algorithms designed for face recognition system. The main reason of this research is to give latest review of general trend in the research of face recognition area. They also have investigated the strengths and limitations of certain algorithms on specific face database. They have summarized the face recognition vendor test (FRVT) 2002, which describes the conclusion of large scale analysis of automatic face recognition system. In this research, authors have shown a comparative analysis of various research results. **Di Huang et al.** [14] Represents a detailed study of LBP technique. In this study, it shows that pixel intensity order is preserved in local neighbourhood using LBP operator which is constant to monotonic gray-scale transformations. LBP used for feature extraction for face recognition which consider both texture information as well as shape that are being used to represent face images. This method has been trained with prominent number of variations so that its performance can be improved in various applications. This technique is sensitive to noise. In order to overcome this problem, original LBP is extended with the help of three value codes which is called LTP (Local Ternary Pattern). It is concluded that Local binary pattern is most efficient descriptor to represent local structure but it is affected by noisy, blurred images and severe lighting changes.

IV. COMPARISION OF FEATURE EXTRACTION ALGORITHMS

The comparative study of all feature extraction methods that are discussed above in this paper has been shown in tabulated in Table 1.

References	Database	Feature Extraction Technique	Classifier	Sample size	Performance	Important marks
Jain Yang, David Zhang, 2004 [3]	ORL, AR, YALE Face database	2DPCA	Nearest Neighbor Classifier	1. ORL database contain 40 individuals 2. YALE face database contains 165 images.	ORL = 96% AR = 96.1% YALE = 84.24%	2DPCA is better than PCA in terms of recognition accuracy but was not efficient as in terms of storage requirements.
Lin Ying, Yuan Liang, 2011 [17]	YALE face database	Improved Modular 2DPCA	Nearest Neighbor Classifier	It contains 15 person 11 images	Recognition rate = 90.7 %	Weight the sub matrix can increase the recognition

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				each person total 165 images.		rate .
Zhao Lihong, Yang Caikun, Pan Feng, Wang Jiahe, 2012 [18]	ORL dataset	PCA + 2DPCA + Gabor	Nearest Neighbor Classifier	Total 400 people, 40 people, 10 images per people.	Recognition rate = 96%	2DPCA with PCA method based on the Gabor wavelet is superior to single 2DPCA or PCA.
Aili Wang, Na Jiang and Yuan Feng, 2014[19]	ORL dataset	Wavelet transform and improved 2DPCA	Nearest Neighbor Classifier	40 volunteers have 10 images individual total 400 faces	Recognition rate = 92%	In wavelet transform, the higher decomposition layers will lost a lot of information by which reduce the recognition rate.
Shimin WANG, Jihua YE, Dequanuan YING, 2013 [20]	ORL Database	2DPCA Principal Component uncertainty	Euclidean Distance	ORL database contains 400 face images contains 40 people, 10 images per person	Recognition Rate = 97.8%	To enhance or suppress the 2DPCA principal component and the capability of face recognition also increase.
Mao Lin Huang, Supot Nitsuwat, 2012 [16]	BioID face dataset	Processed histogram based (PHB), principal component analysis , 2D-PCA	Support Vector Machine (SVM) with three types of kernels	Used 115 face images for learning and testing	1. PHB+PSO-SVM = 50% 2. PCA + PSO-SVM = 93% 3. 2D-PCA + PSO-SVM = 95%	The recognition accuracy rate from SVM classification is used for fitness function of the PSO method.
Ghali Ahmed, Benyettou Mohamed, 2014 [8]	Cambridge ORL face database	Principal Component Analysis (PCA) and Wavelets	Support Vector Machine (SVM) with three types of kernels	It consists of 400 images of 40 individuals	Classification rate = 97.9% using Wavelet-PCA	Result shows that performance of polynomial SVMs is better than Linear SVM on the ORL dataset.

Table 1. A Summary of some face recognition system based on Different algorithm

V. CONCLUSION

Recognizing the dissimilar human faces is not a difficult job for humans, but it is relatively hard to the system to recognize the faces of human. Face recognition technologies have found many applications such as surveillance, security, screening, identity verification etc. This paper has tryout to survey a significant number of papers to cover the recent developments in face recognition field. Almost all traditional and recent methods of face recognition are facing the problems such as change in illumination, pose variations as well as change in expressions, aging factors etc. In section II, different face recognition algorithms have been shown. PCA method is used to justify a dataset into lower dimension while achieving the characteristics of dataset. LBP is one of the most powerful descriptors to represent local structures and suitable for feature extraction in face recognition systems. In Table I, we present a comparison of different feature extraction algorithms used for face recognition. In the future work, we plan to improve the recognition accuracy by trying new classification techniques and algorithms can be enhanced by using hybrid methods. Further

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improvements can be made in terms of training for achieving better generalization. LBP based methods are an outstanding descriptors if we need real-time processes as well as greater recognition rates.

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