FACE RECOGNITION: HOLISTIC APPROACHES AN ANALYTICAL SURVEY

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Abstract: *Face recognition has been in spot light for last few decades by keeping in view its increasing usage in real world applications, still challenges are there to meet, especially in real world applications. A lot of work has been reported on face recognition during the recent decades, some of which have also come up with their modifications. This paper presents a detailed analysis on the importance and application of face recognition technology, mentioning the factors affecting its applicability in real life. In addition, several face recognition techniques along with their experimental results are also discussed. The issues that still need to be addressed are mentioned here as well.*

Key words: Face, Recognition, Biometrics, Survey, Holistic

INTRODUCTION

Face recognition technology[1] has been considered seriously by the researchers in the past few years keeping in view its escalating usage in law enforcement and commercial applications[2; 3]. This technology is the result of a long research over a period of 30 years. Although currently available face recognition systems have become quite mature; still their accomplishment is restricted by the problems and situations of real life environment, for there are many factors that affect face recognition [4,5]. For instance, problems of pose and illumination [6] are still a big challenge. Because of this Biometrics, pattern recognition and computer vision communities are paying special attention towards research work going on in this particular field, as a result of which face recognition and image processing have become prominent research areas in the global market. Different methods have been developed based on these techniques [7], some of which are subspace analysis, Log polar gabor, elastic graph matching, neural net-work, support vector machine(SVM), deformable intensity surface, morph able model, etc. Face recognition process requires that an individual is identified successfully. This technique is mainly used in applications providing security and surveillance. Researchers have developed different techniques and algorithms which are quite efficient in the process of recognizing faces under constraints like lighting and pose problems. One approach for handling pose variations and 3S problems for face recognition can be analyzed in [8].There are number of application for face recognition systems. The very first use of such systems is in the security management systems for criminal identification. Face recognition systems can be used in combination with surveillance cameras in order to increase the security system. Pattern recognition is another important application of these systems. Face recognition systems can be used in diverse vicinities of science for evaluating an entity with a set of entities.

Face recognition on the bases of general view point with different backgrounds, illumination changes, different facial expressions and handling age factor is one of the biggest challenges of such systems[9].Together with challenges face recognitions systems are facing some criticisms which include weaknesses, privacy issues and effectiveness. Weaknesses contain many situations including pose, aging and illumination factors. In such situations the available methods are not much effective and efficient. The criticism in terms of privacy issues includes the compromise of privacy through the use of surveillance cameras. Effectiveness is criticized on the bases of inefficiency of such systems to identify a criminal.

Categorization of Face recognition approaches

According to the classification of face recognition systems there are three main approaches. These approaches include:

1. **Holistic Approaches**
2. **Feature based Approaches**
3. **Hybrid Approaches**

Feature based methods:

Feature based methods make use of specific facial feature for the recognition purpose. Huge work has been done in this regard as well. For instance we can analyze [10] here that is using nose heuristics for the recognition of face. Another example of such approaches can be analyzed in [11], where facial features like eyes, nose and lips are extracted from the detected face for the recognition purpose. Localization of facial features including eyes, nose and lips using Gabor filters for face recognition is presented in [12].

Hybrid approaches: Hybrid methods combine above mentioned approaches to achieve the result. This paper includes analysis of holistic face recognition approaches. These methods have a advantage of giving better

performance as compare to holistic and feature based approaches.

Holistic approaches: Holistic approaches take the whole image of human face for the recognition. The main disadvantage of such approaches is handling a very small size images. Holistic face recognition makes use of global data, features or information from faces to carry out face identification. The global features from faces are basically symbolized through a minute figure of features which are openly originated from the pixel statistics of face images. These minute numbers of global information clearly confine the discrepancy between diverse person faces and therefore are used to distinctively recognize individuals.

A complete face recognition system consists of different related operations. Each operation is vital and necessary for the ultimate goal of the system which is to successfully recognize a face. The four main operations that a complete face recognition system may possess are: Face detection [13,14], Face tracking, Face verification, Face recognition [15,16].

FACTORS AFFECTING FACE RECOGNITION

The features of a face should remain unchanged for being a successful biometric. Previous data and theory show that many factors like pose and illumination are still a challenge. Some major factors and challenges that every face recognition system may face are Pose or viewing angle, occlusion [17], Expression [18], Illumination[6.19,20], ageing [21], disguise [27-29]etc.

A suggestion given by the researchers is the usage of simulator software. The facial growth of the face is modeled over a period of time with the help of these techniques. The detail is listed below:

Burt and Perrett [22] proposed an algorithm using compound face images intended for diverse age clusters for age simulation using shape and texture in their paper [22]. Tiddeman [23] anticipated the wavelet transform centered age replication. This was done to prototype the merged facial images.

Lanitis, Taylor and Cootes, [24] gave the idea of statistical models for face simulation in their paper.

Gandhi [25], in his Master's Thesis, used automatic creation of aged face images to forecast the age of forward faces.

Wang *et. al.* [26] used Principle Component Analysis and rebuild the face image according to the desired age.

Ramanathan *et. al.* [27] proposed a model in which characterization is performed on the geometrical changing in human faces during seminal years.

FACE RECOGNITION APPROACHES AND TECHNIQUES IN THE PAST

The information in this section (section 12) is taken from W. Zhao, R. Chellappa's Face recognition literary survey; [30].

There has been a large amount of information found on face recognition from existing literature. Mostly, methods that have been motivated by different values are applied and used on a single system. This mixture of techniques and methods makes it a challenging job to classify the systems on the basis of their working criterion.

There have been several different techniques based on PCA: Eigenfaces [31] by Turk and Pentland; 1991] used a technique that made use of the nearest-neighbor classifier.

ICA is better than PCA because it uses statistics of higher order and has more representative power, and therefore it may also provide better recognition performance than PCA. This was proposed by Bartlett [36] in the year 1998. Later on a method that used learning was applied and was given the name of neural networks/learning. An example is the evolution pursuit (EP) method which was proposed first by Liu and Wechsler in [37].

The early methods of face recognition were based on structural measurement techniques in which the identification process was carried out by matching the distance between the eyes, or between eyes and the mouth or even the head width. An example of this can be the work done by Kelly [38] in 1970. Another related early technique was the one in which identification was done on the basis of eye corner angles, mouth corners and the nostrils etc. One such work was done by Kanade [39] in 1973. Later a different approach was introduced in which a mixture distance was used by extracted distances manually and this was done by Cox [40] in 1996. Another technique was proposed by Nefian and Hayes [41] in 1998 in which strips of pixels covering facial features like mouth eyes and nose were used for recognition process. This technique was called the Hidden Markov Model (HMM)[42] based method. Afterwards, Nefian and Hayes in 1998 used the KL projection and got better results. A better system, graph matching system, was introduced by Wiskott [43] and then Okada in 1998.?

Some more techniques are also presented in [28,33,34,35].

Although several different methods are present nowadays that can perform successful face recognition, but as each one of them has its pros and cons, therefore, it becomes imperative to decide that which system should be applied in a particular situation. The systems of today and tomorrow include other additional tasks such as preprocessing with respect to illumination and pose. Thus, the horizons in this field are expanding day by day.

SOME FAMOUS ALGORITHMS

Principle Component Analysis

Principal component analysis (PCA) [44] is perhaps the most famous algorithm for face recognition. In this algorithm parameters are extracted by mathematical calculations, hence called the principle components, It also has the property to reduce image dimensions(Compression) [45; 46]. The term POD (Proper Orthogonal Decomposition) is also often used to represent it. An overview of PCA is as follows:

PCA is the invention of Karl Pearson [47],. It is also named as Factor Analysis method because it analyzes the factors of

reducing data, a technique initially proposed by Thurstone [48].

The Kaiser Criterion factors having Eigen values above 1 are retained. This implies that a factor is discarded unless it extracts the value equal original variable. Kaiser [49] proposed this method.

A graphical method was proposed by Cattell [50]in 1966 and it was named as screen test. The idea was to plot the Eigen values in a simple line.

Gabriel, K.R. [51] in the year 1971 proposed a method of graphic display of matrices uing the concept of PCA.

The Eigenfaces approach was proposed in 1987 by Sirovich and Kirby [52] in which a group or a vector set called Eigenvectors are used for machine based face recognition. Later on, this technique was used by Matthew Turk and Alex Pentland.

Kernel PCA (KPCA) is an advanced version of PCA uses kernel methods [53].

Sparse PCA; it refers to a particular method which is used mainly in statistical analysis and in the process of analyzing multivariate datasets [54].

PCA is an approach that can be used in combination of different techniques. One of the example for face detection and recognition using PCA in combination of hexagonal image processing can be analyzed in [55].

Shah J. e.t al. presented a survey of different linear and non linear approaches based on PCA[56].

LDA (Linear Discriminant Analysis)

LDA is not much different than PCA, [7]. This method has applications in the fields of machine learning and statistics. Linear combination of features is calculated through LDA which accurately distinguishes two or more than two classes of events. LDA can also be used for reducing dimensions and it also works as a classifier. A brief overview is:

The earliest idea was introduced in Fisher's original article [57].This was a different version as Equal class covariance was not part of the assumption like it is in present form of LDA.

Edward Altman [58] introduced his model in 1968 and it is still in use today [32,33]

Zhao *et al*. [59] presented Fisher discriminant analysis (FLD/LDA).

Liu and Wechsler [60] proposed a "Shape- and Texture-Based Enhanced Fisher Classifier".

Peng Zhang, Norbert Riedel [61] gave a unified approach and hence an advancement of LDA.

LDA can be used in combination with other techniques for instance face recognition using Adaptive Margin Fisher's Criterion and Linear Discriminant Analysis (AMFC-LDA) can be analyzed [62].

Local Feature Analysis

Local Feature Analysis (LFA) is quite a famous algorithm for face recognition. LFA [63] consists of kernels related to the PCA.

ICA (Independent Component Analysis)

ICA is an abbreviation for Independent Component Analysis. This method is used to sort out a multivariate signal into several smaller subcomponents. An overview of this method is as follows:-

Herault and Jutten [64], worked on blind source separation and proposed an algorithm in feedback architecture. This helped in the separation or distinction of different independent (unknown) sources.

The above mentioned technique was modified by Jutten and Herault [65].

Even more modification was done on the above mentioned technique in 1994 by Karhunen and Joutsensalo [66]. The main concept of ICA was given by Pierre Comon [67],

ICA is rated to be more efficient than PCA because it uses statistics of higher order. This was stated by Barlett *et al.* [68].

A. Al Falou and A. Mansour proposed an idea in 2007 which used ICA to perform the task of "optical video image encryption enforced security level".

LBP (Local Binary Pattern)

The LBP [70,48] operator is defined as "a gray-scale invariant texture measure". After recent modifications, LBP is now considered as one of the most efficient algorithms for texture. It has given exceptional results in many empirical studies. An overview of LBP is listed below:-

LBP operator was presented by T. Ojala, M. Pietikainen and D. Harwood [71].

T. Ojala, M. Pietik¨ainen and T. M¨aenp¨a¨a [72] later on introduced an extended technique called The Multi Scale LBP..

Another idea was given by H. Jin, Q. Liu, H. Lu and X. Tong [73] stating that features extracted or defined by LBP do not deal with the local structure under constrained environments and condition. As a result of this idea, an Improved LBP (ILBP) was introduced in 2004.

X. Huang, S. Li, and Y. Wang [74] pointed out that LBP can represent only the initial derivation of the information of images and failed to signify the velocity of the limited local deviation.

A new and dynamic technique of texture recognition was introduced by Zhao G & Pietikainen M [75] in 2007. Combination of LBP algorithm with the laplacian method for face recognition can be analyzed in [76].

CONCLUSION

This paper surveyed recent research in face recognition, presented the background about the working of a face recognition system, discussed factors that affect it and have shown an insight about face recognition advancement over the past. Today several different face recognition techniques are present, each with a different approach; still there are challenges which need to be addressed. Most prominent are three major challenges. First and most important is pose, then the lighting factor or illumination and third one is recognition in real life and outdoor imagery. Along with this

other problems like age, gender and expression also affect the face recognition process and need to be addressed. The study shows that there is still a room for improvement and a lot of work needs to be done to achieve a face recognition technology that could meet the actual real life constraints.

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