Critical Review on Face Recognition Algorithms

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Abstract **-** In the field of computer vision and image analysis developing a automated face recognition presents a challenging task and as such has received a significant of attention of the research community as well as society over the last few years due to its usage in many application domains. Even though current machine recognition systems have reached a certain level of maturity, their success is limited by the conditions imposed by many real applications. This paper provides an overview of some of the well-known methods developed in still- and video-based face recognition research with their benefits and drawbacks. Furthermore, the discussion outlines the incentive for using face recognition in various applications and some of the difficulties plaguing current systems giving the guidelines for further enhancing the current system but still far away from the capability of the human perception system.

Keywords **-** face Recognition, Human Perception, online face recognition, issues etc.

I. INTRODUCTION

In social intercourse face is our primary focus of attention for communication and identification. Human beings have a remarkable ability to summarize intelligence or character from facial appearance and emotions thus one can recognize thousands of faces learned throughout our lifetime and identify familiar faces at a glance even after years of separation. This skill is quite robust, despite large changes in the visual stimulus due to viewing conditions, expression, aging, and distractions such as glasses, beards or changes in hair style etc. Hopefully, building successful face recognition systems can help us understand more about how human perception system works. Machine recognition of human face from still and video images has become an active research area in the communities of image processing, pattern recognition, neural networks and computer vision. The problem of face recognition was considered in the early stages of computer vision and is still undergoing various evolutions from a long period. Different techniques were proposed in past for the enhancement of face recognition. This enhancement is motivated by wide applications ranging from static matching of controlled format photographs such as passports, credit cards, driving licenses, access control systems, model-based video coding, criminal identification and authentication in secure system like computer or bank teller machines etc. to real-time matching of surveillance video images presenting different constraints in terms of processing requirements.

II. APPLICATIONS

Also, being one of the most important applications in computer vision, face recognition has received significant attention in the last three decades. There are two main reasons to explain this popularity. The first is the wide range of commercial and law enforcement applications.
The second reason is the advantages of using faces over other biometric indicators.

Moreover Face recognition has recently seen a lot of success in a family of less-demanding applications such as online image search and family photo album organization (e.g., Google Picassa, Microsoft Photo Gallery, and Apple iPhoto). At the other end of the tractability spectrum, there are the terrorist watch list and mass surveillance applications that have, for the most part, dominated the field of face recognition research [1].

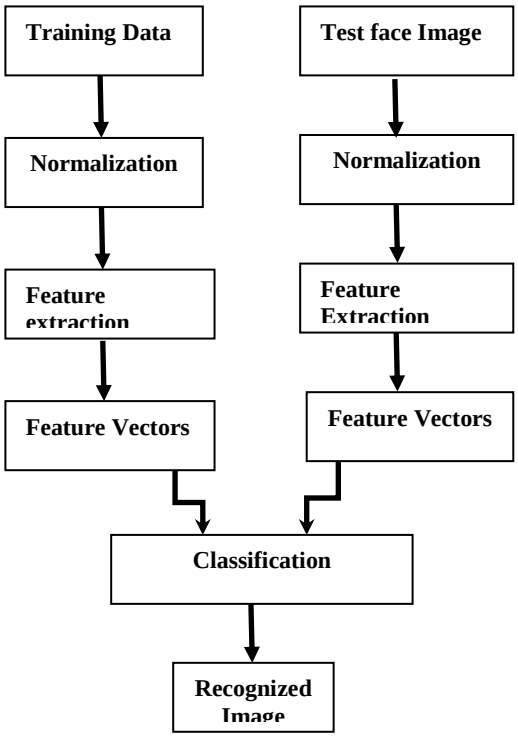

Fig.1: Face Recognition System

Table 1: Applications of FRT

Areas	Applications
Information Security	Access security (OS, data bases), Data privacy (e.g. medical records) ,User authentication (trading, on line banking)
Access management	Secure access authentication (restricted facilities) , Permission based systems Access log or audit trails
Biometrics	Person identification (national IDs, Passports, voter registrations, driver licenses), Automated identity verification (border controls)

Law Enforcement	Video surveillance, Suspect identification, Suspect tracking (investigation) Simulated aging, Forensic Reconstruction of faces from remains,
Personal security	Home video surveillance systems, Expression interpretation (driver monitoring system)
Entertainment - Leisure	Home video game systems, Photo camera applications

III. SIGNIFICANCE OF FACE RECOGNITION

Biometric-based techniques have emerged as the most promising option for recognizing individuals in recent years since, instead of authenticating people and granting them access to physical and virtual domains based on passwords, PINs, smart cards, plastic cards, tokens, keys and so forth, these methods examine an individual's physiological and/or behavioral characteristics in order to determine and/or ascertain his identity. Passwords and PINs are hard to remember and can be stolen or guessed; cards, tokens, keys and the like can be misplaced, forgotten, purloined or duplicated; magnetic cards can become corrupted and unreadable. However, an individual's biological traits cannot be misplaced, forgotten, stolen or forged. Biometric-based technologies include identification based on physiological characteristics (such as face, fingerprints, finger geometry, hand geometry, hand veins, palm, iris, retina, ear and voice) and behavioral traits (such as gait, signature and keystroke dynamics) [1]. Face recognition appears to offer several advantages over other biometric methods, a few of which are outlined here:

Almost all these technologies require some voluntary action by the user, i.e., the user needs to place his hand on a hand-rest for fingerprinting or hand geometry detection and has to stand in a fixed position in front of a camera for iris or retina identification. However, face recognition can be done passively without any explicit action or participation on the part of the user since face images can be acquired from a distance by a camera. This is particularly beneficial for security and surveillance purposes. Furthermore, data acquisition in general is fraught with problems for other biometrics: techniques that rely on hands and fingers can be rendered useless if the epidermis tissue is damaged in some way (i.e., bruised or cracked). Iris and retina identification require expensive equipment and are much too sensitive to any body motion. Voice recognition is susceptible to background noises in public places and auditory fluctuations on a phone line or tape recording.

Signatures can be modified or forged. However, facial images can be easily obtained with a couple of inexpensive fixed cameras. Good face recognition algorithms and appropriate preprocessing of the images can compensate for noise and slight variations in orientation, scale and illumination. Finally, technologies that require multiple individuals to use the same equipment to capture their biological characteristics potentially expose the user to the transmission of germs and impurities from other users. However, face recognition is totally non-intrusive and does not carry any such health risks.

IV. CHALLENGES IN FACE RECOGNITION

The challenges associated with face recognition can be attributed to the following factors:

- Pose: The images of a face vary due to the relative camera-face pose (frontal, tilted, profile, upside down).
- Presence or absence of structural components: Facial features such as beards, mustaches, and glasses may or may not be present and there is a great deal of variability among these components including shape, color and size.
- Facial expression and emotions: The appearance of faces is directly affected by a person's facial expression and emotions.
- Occlusion: Faces may be partially occluded by other objects. For an example, in an image with a group of people, some faces may partially occlude other faces.
- Image orientation: Face images directly vary for different rotations about the camera's optical axis.
- Imaging conditions: When the image is formed, factors such as lightning and camera characteristics affect the appearance of a face.

V. FACE RECOGNITION TECHNIQUES

Face recognition is a technique to identify a person face from a still image or moving pictures with a given image database of face images. Face recognition is biometric information of a person. However, face is subject to lots of changes and is more sensitive to environmental changes. Thus, the recognition rate of the face is low than the other biometric information of a person such as fingerprint, voice, iris, ear, palm geometry, retina, etc. There are many methods for face recognition and to increase the recognition rate. Some of the basic commonly used face recognition techniques are as below:

A. AI based Face Recognition Methods

A neural network learning algorithm called back propagation is among the most effective methods for application in machine learning when the data includes complex sensory input such as images, in this particular study face image. Neural network is a nonlinear network adding features to the learning system. Hence, the features extraction step may be more efficient than the linear Karhunen-Loeve methods that have chosen a dimensionality reducing linear projection that maximizes the scattering of all projected samples [5]. The classification time for this is less than 0.5 seconds, but has training time more than hour or hours. However, the limitation with this approach is that when the number of persons increase, the computing expense will rise [4]. In general, neural network approaches encounter problems when the number of classes, i.e., individuals increases.

B. Geometrical Feature based Matching

This technique is based on the study of a set of geometrical features from the image of a face. The overall configuration can be described by a vector representing the

position and size of the main facial features, such as eyes and eyebrows, nose, mouth, and the shape of face outline [4]. One of the pioneering works on automated face recognition using geometrical features has been undertaken by T. Kanade [4]. Their system achieved a peak performance of 75% recognition rate on a database of 20 people using two images per person, one as the model and the other as the test image. I.J. Cox el [7] introduced a mixture-distance technique which achieved 95% recognition rate on a query database of 685 individuals. In this technique, each of the face was represented by 30 manually extracted distances. Initially, the matching process utilized the information presented in a topological graphics that represented feature points. Then the second and the third and so on will be compensating for the different center location, two cost values, that are, the topological cost, and similarity cost, that have been evaluated. In short, geometrical feature matching based on precisely measured distances between features may be most useful for finding possible matches in a large database.[10].

C. Graph based Matching

Graph matching is another method used to recognize face. M. Lades et al [8] presented a dynamic link structure for distortion invariant object recognition, which employed elastic graph matching to find the closest stored graph. This dynamic link is an extension of the neural networks. The Faces have been represented as graphs, with nodes positioned at facial points, (i.e., exes, nose…,), and edges labeled with two dimension (2-D) distance vector. Each node contains a set of 40 complex Gabor wavelet coefficients at different scales and orientations (phase, amplitude). They have been termed as "jets". Recognition is based on labeled graphs [9]. A jet describes a small patch of grey values in an image I (~x) around a given pixel ~x = (x; y). Each is labeled with jet and each edge is labeled with distance. Graph matching, that is, dynamic link is superior to all other recognition techniques in terms of the rotation invariance. But the matching process has been considered to be complex and computationally expensive Eigenface is a one of the most thoroughly investigated approaches to face recognition [10]. It is also known as Karhunen-Loeve expansion, eigenpicture, eigenvector, and principal component. L. Sirovich and M. Kirby [11, 12] used principal component analysis to efficiently represent pictures of faces. Any face image could be approximately reconstructed by a small collection of weights for each face and a standard face picture, that is, eigen picture. The weights here are the obtained by projecting the face image onto the eigenpicture. In mathematics, eigenfaces are the set of eigenvectors used in the computer vision problem of human face recognition. The principal components of the distribution of faces, or the eigenvectors of the covariance matrix of the set of face image is the eigenface. Each face can be represented exactly by a linear combination of the eigenfaces [10]. The best M eigenfaces construct an M dimension (M-D) space that is called the "face space" which is same as the image space discussed earlier.

Illumination normalization [12] is usually necessary for the eigenfaces approach. L. Zhao and Y.H. Yang [13] proposed a new method to compute the covariance matrix using three images each was taken in different lighting conditions to account for arbitrary illumination effects, if the object is Lambertian A. Pentland, B. Moghaddam [22] extended their early work on eigenface to eigenfeatures corresponding to face components, such as eyes, nose, mouth. Eigenfeatures combines facial metrics (measuring distance between facial features) with the eigenface approach . This method of face recognition is not much affected by the lighting effect and results somewhat similar results in different lighting conditions.

VI. FEATURE EXTRACTION TECHNIQUES

Facial feature extraction is necessary for identification of an individual face on a computer. Like facial features, the shape of facial parts is automatically extracted from a frontal face image. There can be three methods for the facial feature extraction as given below:

i. Geometry-based

In this technique the face feature like the eyes, the mouth and the nose have been localized by using the vertical edge map. This is called thresholds based technique which with the prevailing sensitivity might adversely affect the achieved performance.

ii. Template-based

This technique, matches the facial components to previously designed templates using appropriate energy functional. Genetic algorithms have been proposed for more efficient searching times in template matching.

iii. Color segmentation techniques

This technique makes use of skin color to isolate the facial and non-facial part in the image. Any non-skin color region within the face of the candidate has been viewed as eyes and mouth of the candidate.

Research and experiments on face recognition have been going on since many decades but still there has been no breakthrough in identifying a single algorithm perfect in real time face recognition with all the limitations discussed in second section. The researcher in this chapter proposed a new approach that could help somewhat in overcoming the limitations with least complexity.

VII. FACIAL FEATURE EXTRACTION

In many problem domains combining more than one technique with the other technique(s) often the results convey an.

A. Holistic Based Face Detection

Holistic approaches attempt to identify faces using global representations, i.e., descriptions based on the entire image rather than on local features of the face. These schemes can be subdivided into two groups: statistical and AI approaches. An overview of some of the methods in these categories follows.

1. Eigen faces based Matching (PCA)

Improvement of the performance. Boosting is one of such technique that has been used to increase the performance

result. Facial features have been very important in face recognition. Facial features can be of different types: region [23, 14], key point (landmark) [15, 16], and contour [17, 18]. In this paper a comprehensive study has been attempted on all the algorithms, AdaBoost, a Boosting algorithm with Haar Cascade Classifier for face detection and fast PCA and PCA with LDA for the purpose of face recognition. All these algorithms are explained
one by one..

2. Fisher face based Matching (LDA)

Belhumeur et al [23] proposes fisherfaces method by using PCA and Fisher's linear discriminant analysis to produce subspace projection matrix that is very similar to that of the eigen space method. It is one of the most successful widely used face recognition methods. The fisherfaces approach has the advantage of identifying within-class information; minimizing variation within each class, yet maximizing class separation, the problem with variations in the same images such as different lighting conditions can be overcome. However, Fisherface requires several training images for each face, so it cannot be applied to the face recognition applications where only one example image per person is available for training.

B. AdaBoost- The Boosting Algorithm

AdaBoost is a short form for Adaptive Boosting, which has been widely explored as machine learning algorithm and has been formulated by Yoav Freund and Robert Schapire. It's a metaalgorithm, algorithm of algorithm, and has been used in conjunction with other learning algorithms to improve the performance of that algorithm(s) [19]. In our case abaBoost is combined with haar feature to improve the performance rate. The algorithm, AdaBoost is an adaptive algorithm which serves in favouring the instances of subsequent classifiers that have been misclassified by the previous classifiers. But it is very sensitive to noise data and the outliers.

Ada Boost considers an input as a training set *S* = , where each instance of S,, belongs to a domain or instance space *X*, and similarly each label belongs to the finite label space, that is *Y*. In this paper, the focus is on the binary case when *Y* = The basic idea of boosting has been to use the weak learner of the features calculated, to form a highly correct *prediction* rules by calling the weak learner repeatedly processed on the different-different distributions over the training examples.

C. Haar Cascade Classifier

A Haar Classifier is also a machine learning algorithmic approach for the visual object detection, originally given by Viola & Jones [19, 23]. This technique has originally been intended for the facial recognition but it can be used for any other object. The most important feature of the Haar Classifier is that, it quickly rejects the regions that have been extremely unlikely to be contained in the object. The core basis for Haar cascade classifier object detection is the Haar-like features. These features, rather than using the intensity values of a pixel, use the change in contrast values between adjacent rectangular groups of pixels [266]. The variance of contrast between the pixel groups have been used to determine relative light and dark areas. The various Haar-like-features have been shown in the **figure 2.a**. The set of basic Haar-like-feature as shown in figure **2.b**, have been rotating through which the other features can be generated. The value of a Haar-like feature has been the difference between the sum of the pixel gray level values within the black and white rectangular regions, i.e.,

$$V_{Harr} = (graylevl \sum balckrectagle - whiterecangle)$$

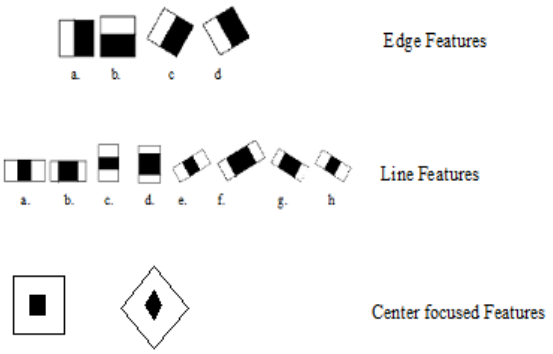

Figure 2. - Haar Like Features

Compared to the raw pixel values, Haar-like features can reduce/increase the in-class/out-of class variability, and thus make classification much easier. The rectangle Haar-like features can be computed rapidly using "integral image". Integral image at location of *x*, *y* contains the sum of the pixel values above and left of *x*, *y*, inclusive:

$$P(x, y) = \sum_{x' \le x, y' \le y} \mathrm{Im}(x', y')$$

$$P_1 = A, P_2 = A + B, P_3 = A + C, P_4 = A + B + C + D$$

$$P_1 + P_4 - P_2 - P_3 = A + A + B + C + D - A - B - A - C = D$$ The sum of pixel values within "D"

Using this Haar-like features the face detection cascade can be designed as in the figure 2., below. In this Haar cascade classifier an image is classified as a human face if it passes all the conditions, {f1, f2…, fn}. If at any stage any of one or more conditions is false then the image does not contain the human

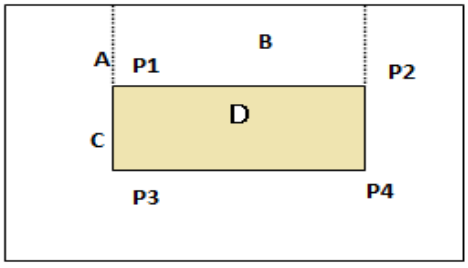

Figure 3. - Haar- Like Features

VIII. CONCLUSION

On the aspect of evolutionary survey study of this paper is mainly focus on the technical, business, legal, and social impact of face technology development in recent era, the recent computing technology is move to Incremental online / Cloud based technical challenged, with rapidly growth the recognition move to detection. We remarked as more challenging task to solve problem in condition of variation of Illumination, pose, occlusion etc., a lot of methodology and algorithmic methods are available , but some more relevant are theoretic and experimental, results of face recognition of PCA and LDA based different intelligent effective and efficient boosted methods of both offline and online challenging problem solving. Hence there is a need of implementation in recent real time applications with maximum sufficient and reliable application of widely independent environment

Remarks

Thanks to all those authors who have made available their views for analysis of the face recognition systems and giving the guidelines of necessary

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