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Face Recognition Techniques: A Survey

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Abstract: ***In recent days, the demand for biometric security system has risen due to a wide range of surveillance, access control and law enforcement applications. Among the various biometric security systems based on finger print, iris, voice or speech and signature, face recognition seems to be easily accessible, non-intrusive, and most universal system. It is easy to use, can be used efficiently for mass scanning which is quite difficult in case of other biometrics, and also increases user friendliness in human computer interaction. Several interesting research attempts are made in the field of face recognition. There are three main divisions of face recognitions based on the face data acquisition type: methods that deal with intensity images, those that operate on video sequences and those that are based on other sensor inputs. This paper provides an overview of few widely used methods in each of these divisions along with the advantages and disadvantages.***
Keywords: biometric security system, face recognition, intensity images, video sequence, sensor input.

I. INTRODUCTION

In computer vision, pattern recognition and image processing, face recognition is one of the most familiar and popular research topic. Face recognition is a crucial task in computer vision applications and a relevant application of image analysis. Automatic face recognition in different background video sequence is very crucial from the point of a wide range of commercial and law enforcement applications. Face detection, tracking and recognizing are key components in video surveillance systems. Face recognition is a challenging problem because of various real life difficult situations, such as the shape, changes in the posture, illumination, motion and occlusion.

Face recognition model includes three steps: face detection, face tracking and face recognition. Face detection is the first step of automatic face recognition and analysis system. Two different techniques are available for face detection: model-based technique and feature based technique. In model-based technique, face can be represented as a whole unit. Feature based technique considers face as a collection of components, extracts characteristics such as points, line segments and image sequences, face tracking stage is then ensured by a matching procedure at every time instant. Face recognition is all about verifying the identity of the person in the input image when a database of face images is given. This paper includes the technical challenges in face recognition, an overview of some of the well-known methods developed for face recognition and finally concludes by proposing the possible future advancements.

II. TECHNICAL CHALLENGES

A. Illumination

The appearance of the face changes along with the variation in illumination. Skin reflectance properties and the internal camera control are the major causes for variations. Under moderate illumination variation, 2D methods do well but when both illumination and pose changes occur, performances drop noticeably.

B. Pose

Pose variation is a serious problem for the identification of the input image, if the database includes only the frontal view and hence the authentication process is severely affected. Most of the face recognition systems assume the availability of frontal faces of similar sizes. Due to the varied nature of face appearance and environment conditions, this assumption may not hold in reality.

C. Expressions

Problems are also imposed by facial expressions in face identification. Most of the existing algorithms till date work robust, except for extreme expressions such as scream.

D. Ageing

Face detection and tracking accuracy also depends on the age variation of the humans. As the person becomes older, the features of

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the face also changes which will affect the accuracy of recognition. The aging modeling technique is quite robust against illumination and pose variation problems.

E. Occlusion

Face detection is severely affected when the face in the input image lacks some parts possibly due to scarf, glasses, beard and moustache.

F. Background Conditions

A face could occur in a complex background and in many different positions. Standard face images based recognition systems are likely to mistake some areas of the background as a face. In order to rectify the problem, the face region has to be localized and extracted.

III. FACE RECOGNITION TECHNIQUES

Face images acquisition method depends upon the underlying application. Surveillance applications are best served when the face images are captured by means of a video camera. Applications related to investigations of the database demand static intensity images, and hence a standard camera can be used for this purpose. Applications such as top security domains require the user to stand in front of an infra-red sensor or a 3D scanner. Therefore, face recognition techniques can be divided into three major categories based on the face data acquisition method: methods that deal with intensity images, those that operate on video sequences and those that are based on other sensor inputs.

A. Face Recognition From Intensity Images

There are two important categories for face recognition from intensity images: feature based and holistic [1-3]. An overview of some of the familiar methods from both the categories is given below.

B. Feature Based

The input image is processed to identify, extract and measure facial features such as the eyes, nose, mouth, skin color and marks, geometric relationship between these facial features is computed and pattern recognition approaches are used to match the faces at the end. The work of kanade [4] extracted facial features by employing an image processing method, Euclidean distance measure was used for matching and achieved 75% accuracy on a database of 20 different people. Better feature extraction techniques make use of Hough transform [5], Deformable templates [6] and morphological processing operations [7]. But all these techniques restrict the searching subspace with geometric conditions. The work of Kaufman and Breeding [8] reported 90% face recognition accuracy, but they used a database consisting of only 10 people. Yongzhen Huang [9] makes a survey on various feature coding methods, along with their inspirations and mathematical representations and then exploit their relations, based on which naming and classification is proposed to reveal their evolution. Color is an important feature of human faces. A survey on pixel-based skin color detection technique can be found in [10]. The combination of skin color and the edge of the input image is used to improve the face detection accuracy and can be found in [11]. Active Appearance Models (AAM) are proposed by cootes [35] for face representation. Texture variations and the shape of the training set and correlations between them are represented very effectively. Active Appearance Model (AAM) is generally considered a complex deformable template model which has previously been applied to still images as well as for tracking. But AAM alone is not sufficient to increase the robustness to a wider range of head pose variations, or to partial occlusions of the face region. Direct Appearance Model [36] is an alternative to AAM which uses texture information to predict the shape linearly.

1) *Advantages And Disadvantages:* Feature based [11] detection demands huge computational effort and low-speed operation. Moreover, the main problem of this approach is that it requires an eye detector, a nose detector, a mouth detector and so on. In these cases the problem of detecting faces has been replaced by the problem of detecting multiple, similarly complex and deformable, parts. Such methods are useful for facial analysis and correspondence in face identification, because detection and alignment of facial features demands images of relatively high spatial resolution. However, in dynamic scenes, face detection often needs to be achieved at much lower resolution. Occlusions caused by changes in the viewpoint are the main problem with the local feature based approaches. In such case, correspondences between certain features do not exist under occlusion. Face detection using skin color as a feature has many advantages. Skin color based processing is much faster than processing other facial features. Color based [11] face detection and tracking has the following drawbacks. It gives a coarse face segmentation

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giving spurious results with a background cluttered with skin colored regions and found to be unsuitable when subjects in the image were skin colored dress or their attire has patches of skin color.

C. Holistic

Holistic approaches employ global representations rather than local features to describe the entire image. A simple holistic approach uses 2D array of intensity values to represent the input image, followed by the direct comparison between the input face image and the faces in the database. This approach works [12] under restricted conditions like equal illumination, scale and pose. But this approach is computationally expensive and since it is straightforward correlation based, suffers from shortcomings such as variable lighting conditions, size, face orientation, noise and background clutter. Principal Components Analysis (PCA) [13] is a dimensional reduction system that minimizes the mean squared error between the original images and the image can be reconstructed for any given level of compression. The input to the algorithm is a training set of images. The representation of the algorithm is characterized by eigenvectors (e_1, …,e_{N-1}) and eigenvalues (λ_1, …,λ_{N-1}). PCA reduces the dimensionality of the data while retaining the variation present in the dataset as much as possible. Sirovich and Kirby [14] utilized Principal Components Analysis (PCA) for the first time to represent face images economically. According to them, any face can be efficiently represented and approximately reconstructed using eigenpictures and their projections. Independent component analysis (ICA) [15] is the generalization of Principal Components Analysis. ICA identifies independent source components and it considers higher order statistics thus providing a more powerful data representation than PCA. The work of Bartlett and Sejnowski [16] showed the use of ICA for face recognition. But in ICA, the distance between the face weights of same person is greater than the distance between different people. So to rectify this, Linear Discriminate Analysis (LDA) [17] technique based fisherfaces [18] method was proposed. In this method, within-class and between-class scatter matrices are calculated. Scatter matrices are used for creating a set of projection vectors to minimize the within-class measure while maximizing the between-class measure simultaneously. This technique performs better than PCA for larger training set. Computation required by LDA technique extended to a greater level and hence Incremental Linear Discriminant Analysis (ILDA) [23] was proposed. Numerous extensions have been suggested to the standard fisherfaces and eigenfaces approaches since their introduction. Examples of recent PCA-based algorithms include two-dimensional PCA [19], eigenbands [20] and Kernal PCA [21]. Some recent advances in LDA-based algorithms include Direct LDA [22] and Incremental LDA [23]. Lu et al. [24] combined the results of PCA, ICA and LDA and created a system that is more robust by fusing the algorithms complementary information. Naive Bayesian [37] classifier depends on Bayes' theorem which works on probabilistic statistical classifier. The Naive Bayesian classifier technique is suited particularly when the inputs dimensionality is high. Despite its simplicity, Naive Bayes' can often outperform more sophisticated classification methods.

1) *Advantages And Disadvantages:* PCA deals with the data as a whole, giving less attention to the underlying structure. Its performance degrades when it encounters higher changes in illumination and pose. PCA is less sensitive to distinct training sets. Experimental results show that ICA outperforms PCA under most of the conditions. LDA performs better than PCA for larger training set.

D. Face Recognition From Video Sequences

Surveillance is one of the major face recognition application where an input image sequence captured using a video camera needs to be recognized in real-time, and hence in recent years, sufficient amount of research has been diverted towards this area.

Video sequence based face recognition system involves three modules: first module detects the face; second module is used for face tracking; and the third module recognizes the face. Most of the systems work first by choosing some good frames and then applying one of the face recognition techniques to those frames followed by identifying the individual. Howell and Buxton [25] used Gabor wavelet and Gaussian filtering for representing feature; and for learning/training, double-layer RBF network [26] adopted. Different sequences taken under both constrained and unconstrained environment were used for face recognition. The reported face recognition accuracies varied, ranging from 67%, using 538 images for testing and 16 for training, to 99%, using 276 testing and 278 training images. Skin color modeling [27] based recognition system proposed by de campos et al. [28] employed GWN [29] to detect and track facial features. Feature selection algorithm is applied over the extracted eigenfeatures. Classifier explained in [30] is applied for identifying the individual and finally the whole video sequence is considered for classification which adopted a voting scheme [31] based on a super classifier. An approach in [32] used audio and video along with 3D information and reported 100% face recognition accuracy for 26 subjects. Bradski [33] modified the existing mean shift algorithm and developed the Continuously Adaptive Mean Shift (CAMSHIFT) algorithm to track a moving face. Mean shift is an iterative kernel-based deterministic

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procedure and is a low complexity algorithm which provides a general and reliable solution to face tracking. The algorithm produces good results for the face region segmentation in a video sequence of images. An in depth survey of advanced schemes for face recognition from video sequences is available in [34].

1) *Advantages And Disadvantages:* Dynamic techniques have the advantage of choosing the frame from the best possible image and refusing the rest, and hence many frames can be grouped while classifying the information to improve frame recognition performance. Dynamic face recognition techniques have the following disadvantages compared to static images: face detection becomes complicated because of cluttered backgrounds; presence of several faces in the picture; and enormous quantity of data to process. Moreover, the size of the face image may be very smaller compared to the size actually required by most of the face recognition modules. The mean algorithm (MA) had an excellent performance in stable environment and complicated environment. But in case of an environment that changes in short time, the mean algorithm yields poor performance.

E. Face Recognition From Other Sensor Inputs

In recent years, research attention has been directed towards sensing modalities such as 3D data and infra-red imagery. Face recognition based on 3D information allows us to use features based on the curvature and shape of the face such as jaw line, cheeks and shape of the forehead. 3D information can be obtained using the following techniques: Laser face scanners of 3D scanners ltd. [38] produce high accurate results; structured light systems make use of stereo vision principles to obtain 3D data; and stereo vision systems are used to extract 3D data from more than two 2D images of the same individual captured from multiple angles. An approach described in [39] calculates the principle curvatures of the face surface from 3D data, this data is used to locate several facial features such as the eyes, nose, forehead, neck and chin. Faces are normalized and re-interpolated, space in between the normalized surfaces becomes a similarity measure. Using 24 face images of 8 people (3 images per individual), adequate facial features were detected for all the faces. The reported face recognition rates were 97% for individual features and 100% for the whole face. Profiles were used in an approach described in [40] instead of frontal images, followed by capturing 3D data using triangulation ending with the comparison of the 3D profile data. In case of aging modeling technique [45], view invariant 3D faces are provided by 2D images. The use of 3D model makes modeling capability more powerful compared to 2D age modeling technique.

Infra-red imagery of faces is insensitive to lighting variations [41], such images can be used for detecting and recognizing faces. According to [42] infra-red facial images reveal the tissue and vein structure of the face which is very unique to each person like a fingerprint, and therefore, some of the face recognition techniques yield better results when applied to infra-red facial images. The eigenface technique [18] used in [42] was applied to a database of 24 subjects and 288 images (low-resolution of 160x120) captured from 3 viewpoints, reported face recognition accuracy of 96% for frontal and 100% for profile views. Some of the recent approaches [43] [44] adopted fusion of face images taken under infrared and visible light spectrum to improve the face recognition performance.

1) *Advantages And Disadvantages:* The method described in [40] requires background restrictions and good user cooperation. Aging modeling technique is quite robust against illumination and pose variation problems due to 2D to 3D domain. But 3D model approach is quite expensive, complexity is high and age estimation is crucial. Since, infra-red imagery of faces are highly insensitive to lighting variations, such images become good option for face recognition. But face recognition using such images is a difficult task because of the following: high cost of sensors, great level of noise in the face images and lack of availability of infra-red images data sets.

F. Comparative Analysis

Fig.1 shows the comparative analysis of the different approaches which are used for face recognition. The graph show that kernel associated memory model i.e., Mean Algorithm, Independent Component Analysis (ICA), Active Appearance Model (AAM), Linear Discriminate Analysis (LDA) encapsulate high efficiency and high accuracy. Since age estimation is crucial, the performance of 3D facial aging method is not up to the mark. Principal Components Analysis, Color and features based and Naive Bayesian approaches work optimistic under different background conditions.

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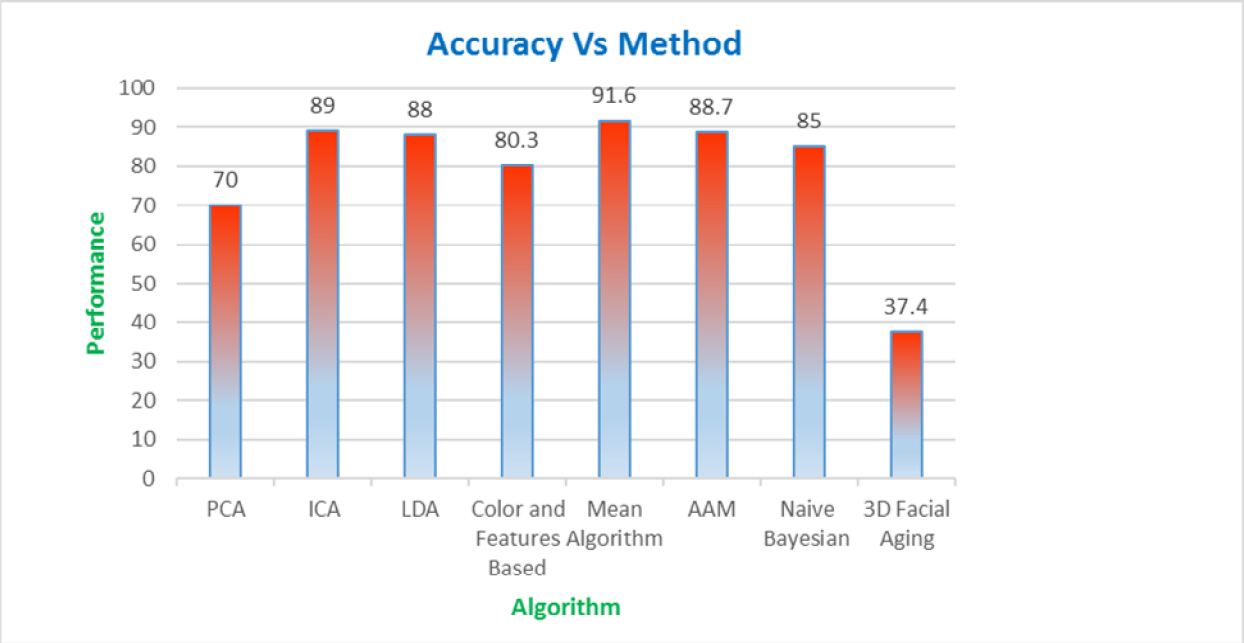


Fig.1. Comparative Analysis

IV. CONCLUSION

Face recognition is an active research area and the technology has come a long way since the survey of chellappa et al.[46]. Some of the best algorithms dealing with complex environments are computationally expensive for real-time processing. But, along with the improvements in computer hardware, this situation is likely to change. So, future work can be done in the direction of implementing an algorithm capable of tracking and recognizing human faces in different background video data with accurate rate. Face tracking with high resolution improves the accuracy rate for face recognition. Parallel algorithms, which speeds up the computation can be adopted. Advanced algorithms can be developed for recognizing the human faces in video data in real-time and in less constrained condition.

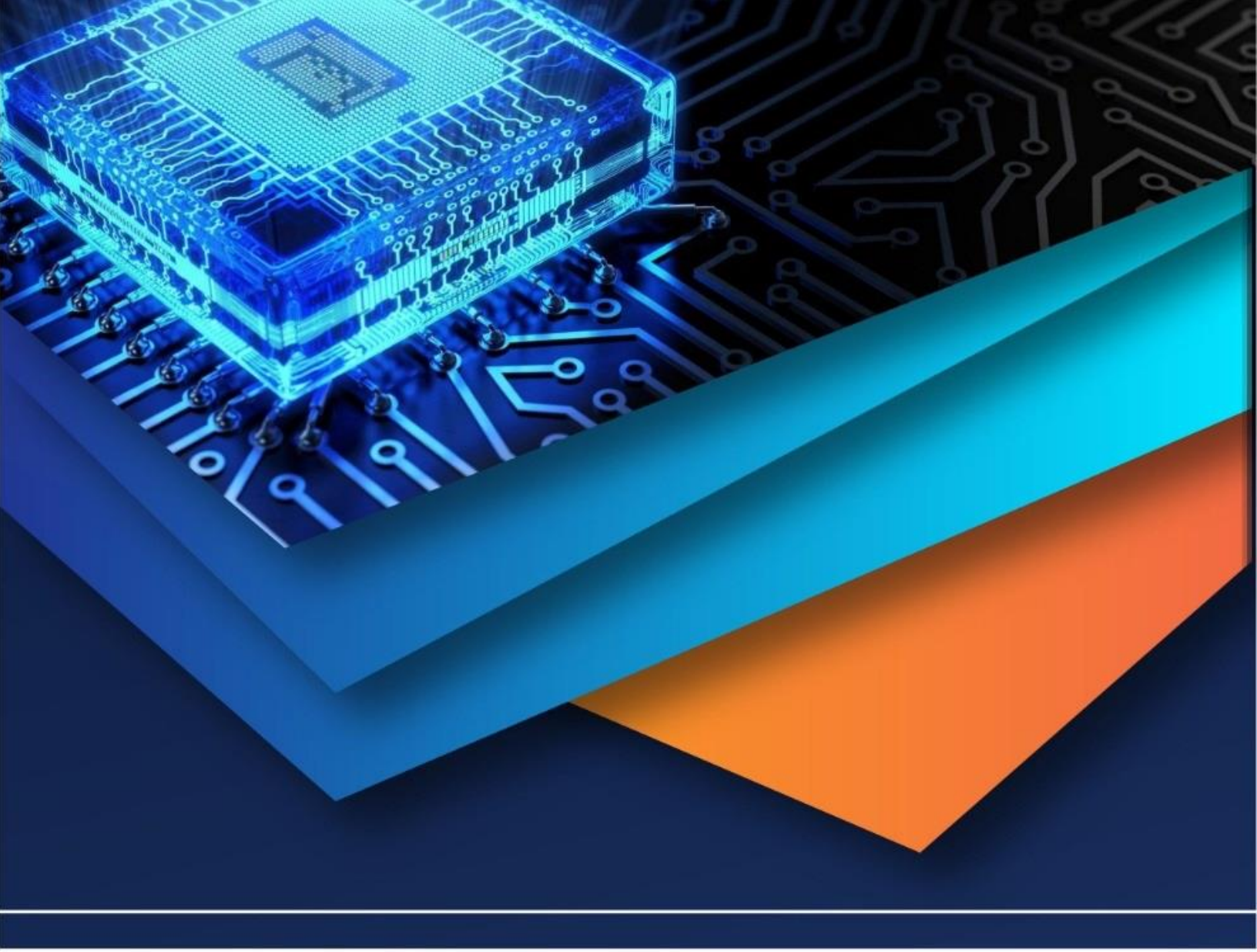
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