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A Literature Review on Appearance Based Face Recognition Techniques

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ABSTRACT: Face is one of the important characteristic features of a human body. The different feelings at various situations are expressed on our face. Humans have an excellent power of recognizing faces. Facial recognition includes the deep and clean details of the face identifying the emotions with the intentions and the person's behavior. For performing this task, humans have the powerful tool i.e. eyes. Humans have a sharp memory and sense of humor for recognizing a face by locating eyes, lips, color, shape, etc. As each human is unique in his structure, human characteristics are been used in the field of digital world. The approach is known as the biometric system, which includes facial recognition and iris recognition. These systems are implemented at various locations for different applications. Face recognition becomes a challenging task due to various factors like ageing, emotions, poses, environmental conditions, etc. Thus, to tackle with these conditions and to achieve the purpose of face detection or recognition, it is necessary to make the comparative analysis of various techniques. There are various techniques which have been developed and used. Each technique has its own characteristics, advantages, disadvantages, performance, representative work etc. In this paper, we are presenting different face recognition techniques mainly focusing on appearance based face recognition techniques.

I. INTRODUCTION

Recently, with the development of hardware technologies and the expansion of software applications, technologies for various contents have emerged. In particular, the recent propagation of smart mobile devices facilitates the public interest in intelligent systems that exploit various machine learning techniques applicable to diverse image data. Among these technologies, face recognition is commonly used and can be applied in various fields including broadcast content, entertainment, access control, security, and surveillance.

The method used in the images of facial elements such as the eyes, nose and mouth as sub-images based on the results obtained from psycho-physical experiments that suggested the prominent facial components that would contain more discriminant information. In a discriminant-analysis-based method was proposed to select pixels for face recognition by quantitatively measuring the amount of the discriminant information of individual pixels constituting a face image. Hybrid methods using the whole image of faces as well as their sub-images have been presented. The methods in and used the holistic features extracted from the whole image of a face and their local features extracted from the sub-images such as features of the eyes, nose, or mouth, as well as sub-images equally divided from the image of a whole face.

Advanced digital cameras can provide features like auto-focus, face detection, etc, for assisting users in capturing better photos, however, it can be challenging for an amateur user to find a good viewpoint in any tourist location. Face recognition is the task of identifying an already detected object as a known or unknown face. Often the problem of face recognition is confused with the problem of face detection. On the other hand is to decide if the "face" is someone known, or unknown, using for this purpose a database of faces in order to validate this input face.

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II. LITERATURE SURVEY

There are various approaches available for the development of face recognition techniques. It is said, a coin has two sides, considering this, each technique has its advantages and disadvantages. The face recognition techniques are mainly classified into six different techniques namely, knowledge -based methods, appearance- based methods, feature-invariant methods, geometry- based methods, template- based methods, and model- based methods.

1. ***Template-based method*:** This method focuses mainly on the use of template. In this method, the whole template of face I.e the complete image is matched with the known individual's images stored in the available database.

2. ***Feature invariant-based method:***This method tries to find invariant features of a face despite its angle or position. It aims to find the structural features that exist even when pose or lightening conditions differ and then use these features to locate faces which provide great advantage in various areas.

3. ***Knowledge-based methods:*** This method is known to be as the rule-based method where the main purpose is to encode the knowledge of human faces such as skin color, shape, etc. This basically relies on the human brain knowledge which is encoded in some form of rules to find the facial features of the exact image or the same image.

4. ***Appearance-based method:*** An extracted characteristic from an image is referred as a feature. Despite of relying on the human brain knowledge, this method gives mainly focuses on the set of training images. It is basically a template matching method, in which pattern database is learn from a set of training images.

5. ***Model-based method:*** This method is basically a combination of, a model of shape variation with the model of appearance variation i.e. the variations in shape of features of face images and the variations in face appearance. This method mainly look for the size and shape of images.

6. ***Geometric-based method****:* Geometric based method is somewhat different from model based method. This basically takes the relative position and size of face into consideration and tries to solve the face recognition problem. This method also works on noisy images and low resolutions.

In this review paper, we mainly focus on appearance based face recognition techniques. Currently these techniques are most widely used for the face recognition problem in different applications.
A single image or a set of multiple images undergo the same process. A set of images is collected and are trained. Later the upcoming image is compared with the available data-set. The analysis is done by performing the methods used for that purpose. The methods include the different algorithms based on the required output from the overall process. The data-set of images are the images mostly taken from the online available data-sets of images. They are namely CMU_PIE, FERET, YALE database, etc. Sometimes, the process is initially tested on the available database and then implemented on real images. Here, the real images defines the live capture of images and executing the whole process.

A. ***Eigen Face Method:*** The main objective of this method is to look for a few linear combinations, which can be used to summarize the data and loses in data as little as possible
For face recognition, we need to reduce the dimensions based on the database. The new dimensions depends on the number of images in the database. Eigenface is one of the most thoroughly investigated approaches to face recognition. It is also known as Karhunen_Loève expansion, eigenpicture, eigenvector, and principal component.
In mathematical terms, eigenfaces are known to be the principal components of the distribution of faces, or the eigenvectors of the covariance matrix of the set of face images. The eigenvectors are ordered to represent different amounts of the variation, respectively, among the faces. Each face can be represented exactly by a linear combination of the eigenfaces.

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B. ***Fisherface method:*** Belhumeur introduced the Fisher Face method in 1997, [43] a derivative of Fishers Linear Discriminant (FLD) which has linear discriminant analysis (LDA) to gain the vast discriminant structures.The main aim of this methhod is to look for dimension reduction based on discrimination purpose. For face recognition, the variance among faces in the database may come from distortions such as illumination, facial expression, and pose variation. We try to find a basis for projection that minimize the intra-class variation but preserve the inter-class variation. Rather than explicitly modeling this deviation, we linearly project the image into a subspace in a manner which discount those regions of the face with large deviation.
Both PCA and LDA which are used to produce a subspace projection matrix is similar to eigen face and Fisher face methods. LDA describes a pair of projection vectors which form the maximum between-class scatter and minimum in the class scatter matrix concurrently produces lower error when compared to Eigen face method.

C. ***Support Vector Machine (SVM):***SVM is a learning technique that is considered an effective method for general purpose pattern recognition. Intuitively, given a set of points belonging to two classes, a SVM finds the hyperplane that separates the largest possible fraction of points of the same class on the same side, while maximizing the distance from either class to the hyperplane.
The face recognition problem is formulated as a problem in difference space, which models dissimilarities between two facial images. In different space they formulate face recognition as a two class problem. The cases are: (i) Dissimilarities between faces of the same person, and (ii) Dissimilarities between faces of different people. The SVM-based algorithm is compared with a principal component analysis (PCA) based algorithm on a difficult set of images from the FERET database.

D. ***Hidden Markov Model:*** HMM was generally employed on images with variations due to lighting, orientation and facial expression and thus it have more advancements over than the approaches.The face arrangements are identified as a continuous of discrete parts. The arrangements of the system are maintained as start from top to bottom from forehead, eyes, nose, mouth, and chin. Encoding the face features is an important task. Thus, Hidden markov model can be easily used to encode the face features. These are the set of statistical models used to characterize the statistical properties of signal [8]. It consists of finite set of states, in which each of state is associated with a multidimensional probability distribution. This model is specially designed to develop higher level emotion states like unsure, interesting, surety, etc. from lower level emotion states like happy, angry, sad, etc.

E. ***Neural Networks:***Non linearity in the network can be said as the attractiveness of using neural networks. Hence, the feature extraction is more efficient than the linear Karhunen-Loève methods. The classification time is less than 0.5 second, but the training time is as long as 4 hours.Artificial Neural Networks is used to solve problems in the same way that the human brain does. It consists of several units of neurons, arranged in layers, which converts an input vector into some output. Each unit takes an input, applies a function to it and then passes the output on to next layer. It can easily tackle with imprecise, noisy, complex, erroneous data and algorithms.

In the paper[1], geometrical approximated PCA (gaPCA) algorithm is used for computing eigenfaces for three different datasets. The face recognition task is performed by applying Euclidean distance for the first two sets, and neural network for the third dataset. The results are compared by using standard PCA algorithm where the accuracy of both methods is measured. In [2], extracting holistic features from the whole face and extracting the local features from the sub-image have pros and cons depending on the conditions is done. In order to effectively utilize the strengths of various types of holistic features and local features while also complementing each weakness, a method to construct a composite feature vector for face recognition based on discriminant analysis is proposed. Firstly, the holistic features and the local features are extracted from the whole face image and various types of local images using the discriminant feature extraction method. The composite features from the proposed method are compared with the holistic features, local features, and others prepared by hybrid methods through face recognition experiments for various types of face image databases. The proposed composite feature vector displayed better performance than the other methods.
This paper [3] explores multi-task learning (MTL) for face recognition. Firstly, a multi-task convolutional neural network (CNN) for face recognition is proposed, where identity classification is the main task and pose, illumination,

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and expression (PIE) estimations are the side tasks. Secondly,a dynamic-weighting scheme is also developed to automatically assign the loss weights to each side task, which solves the crucial problem of balancing between different tasks in MTL. A pose-directed multi-task CNN is also proposed, by grouping different poses to learn pose-specific identity features, simultaneously across all poses in a joint framework. Extensive experiments on the entire multi-PIE dataset demonstrate the effectiveness of the proposed approach.

.The concept of deep learning originated from the ANN,refers to a class of neural networks with deep structure of the effective training methods.Deep learning has been widely used in various fields of handwriting digital recognition,dimension simplification,speech recognition, image comprehension,machinetranslation,protein structure prediction and emotion recognition.In this paper[4], the research on hotspots of face recognition based on depth learning in the field of biometrics is done. In facial expression recognition system,the double local binary pattern (DLBP) to detect the peak expression frame from the video is proposed. The proposed DLBP method has a much lower-dimensional size and can successfully reduce detection time. Also the Taylor Feature Pattern (TFP) based on the LBP and Taylor expansion is proposed to obtain an effective facial feature from the Taylor Feature Map.In [5],experimental results on the JAFFE and Cohn-Kanade (CK) datasets show that the proposed TFP method outperforms some state-of-the-art LBP-based feature extraction methods for facial expression feature extraction and can be suited for real-time applications.

Traditional face super-resolution techniques treat image noise at the pixel level without considering the underlying image structures. In order to overcome this, in paper [6], a unified framework for representation based face super-resolution is introduced by using a locality-constrained low-rank representation (LLR) scheme to reveal the intrinsic structures of input images. The low-rank representation part of LLR clusters an input image into the most accurate subspace from a global dictionary of atoms, while the locality constraint enables recovery of local manifold structures from local patches.

A single-sample face recognition algorithm based on LPP feature transfer is proposed in this paper [7]. The proposed method can effectively deal with the concerns of small sample size and high dimensionality in single-sample face recognition. The use of transfer source increases intangibly the scale of training sets and allows better estimation of within-class and between-class covariance matrices. Different from conventional single-sample face recognition algorithms, feature transfer for a testing samples preserves the global face information as well as takes into account the local feature information of the testing sample. The LPP feature extraction method based on face manifold approximation is superior to the conventional PCA and LDA. It maintains local features and captures face sub-spaces by structuring graphs so that the process of feature transfer can be conducted in a low-dimensional space. Compared with Block FLDA, LPC and other methods, the proposed method can efficiently avoid the problem of global feature information damage due to image segmentation and is robust for face angle change

Most existing regression methods are used in the one-dimensional, pixel-based error model, which characterizes the representation error individually, pixel by pixel, and then neglects the two-dimensional structure of the error image. In this paper [8], the low-rank structural informationpresents a two-dimensional image-matrix-based error model, namely, nuclear norm based matrix regression (NMR), for face representation and classification. NMR uses the minimum of nuclear norm of representation error image as a criteria, and the alternating direction method of multipliers (ADMM) to calculate the regression coefficients.Later a ADMM algorithm is developed to solve the approximate NMR model and show it as a quadratic rate of convergence. Experimental results show the performance advantage of NMR over the state-of-the-art regression-based methods for face recognition in the presence of occlusion and illumination variations.
In paper [9],a hierarchical framework based on Dynamic Bayesian Network for simultaneous facial feature tracking and facial expression recognition is been proposed. By systematically representing and modeling inter relationships among different levels of facial activities, as well as the temporal evolution information, the proposed model achieves a significant improvement for both facial feature tracking and AU recognition, compared to state of the art methods.In this paper,the model is evaluated on posed expression databases from frontal view images.By using appropriate feature

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spaces and the shadow compensation method, this paper [10] demonstrates that the face recognition system based on 2D images can be more efficient and effective under pose and illumination variations.

III. CONCLUSION

On studying the various methods, we come to know the challenges faced in Face Detection. From this literature survey, we conclude that, with the different approaches made by the authors resulting in the growth of accuracy. It is important to remove the background information and irrelevant information like noise, non-face part, etc.

The things which make the face detection complicated are, different facial poses, varied facial expressions, complex background and overlapping background. Depending upon the application, the system can be made more or less conservative by making effect-able changes in the code.

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