A Review on Image-based Face Recognition Techniques

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Abstract— **Face Recognition is an application of Image Processing. Face recognition grabs a huge attention of many researches in the field of computer vision. The main reason behind this attention is the fact that, the face is conventional way which we use to identify each other. The recent interest in face recognition can be attributed to the increase of commercial interest and the development of feasible technologies to support the development of face recognition. Major areas of commercial interest include biometrics, law enforcement and surveillance, smart cards, and access control. Various approaches for face recognition have been proposed in past and the purpose of this paper is to categorize and describe these algorithms. This paper attempts to present the survey on face recognition techniques, with a comprehensive list of references to some recent works.**

Index Terms— **Face Recognition, PCA, LDA, Wavelet Transform, Neural Network.**

I. INTRODUCTION

As one of the most successful applications of image analysis and understanding, face recognition has recently received significant attention, especially during the past few years. The problem of machine recognition of human faces endures to attract researchers from disciplines such as image processing, pattern recognition, neural networks, computer vision, computer graphics, computer art and psychology. The strong need for user-friendly systems that can secure our assets and protect our privacy without losing our identity in dozens of passwords and PINs is obvious. One of the advantages of the personal identification system based on analysis of frontal images of the face regard on other biometric analysis is that it is effective without the participant's cooperation or knowledge. The recognition of faces is very important for many applications such as: video surveillance, retrieval of an identity from a data base for criminal investigations and forensic applications. For face recognition there are two types of comparisons, the first is verification, where the system compares the given individual with who that individual says they are and gives a yes or no decision. The second is identification, where the system compares the given individual to all the other individuals in the database and gives a ranked list of matches. Image based face recognition is divided into two main categories, appearance based face recognition and model based face recognition.

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II. APPEARANCE BASED FACE RECOGNITION

Appearance based face recognition subdivided into linear and non-linear methods. Principal Component Analysis (PCA), Linear Discriminant Analysis (LDA), Independent Component Analysis (ICA) etc. are the linear methods whereas KPCA, ISOMAP, LLE etc. are the non-linear methods.

A. Linear methods

Among the linear methods are Linear Discriminant Analysis (LDA), Bayesian Methods (MAP and ML), Discriminative Common Vectors (DCV), and Independent Component Analysis (ICA), Tensor faces Multi-Linear Singular Value Decomposition (SVD), Two Dimensional PCA (2DPCA), Two Dimensional LDA (2D-LDA) etc., but Principal Component Analysis (PCA) is considered to be one the classic method in this field for dimensionality reduction and feature extraction. In[1] Ningthoujam Sunita Devi et al. presents a methodology for face recognition based on information theory approach of coding and decoding the face image in which there is a combination of two stages, Feature extraction using Principle component analysis and recognition using the feed forward back propagation Neural Network. Bui T.T.T proposed a complex algorithm based on Viola-Jones method, wavelet transform and Principle component analysis for multiple face detection and recognition in video sequence [2]. Boualleg proposed a new hybrid method for the face recognition by combining the neural networks with the Principal Component Analysis [3]. Sajid I et al. presented a High performance FPGA based Face recognition system, where they used fixed point technique with software hardware co-design methodology which reduces cycle and provides the flexibility in face[4]. Hossein Sahoolizadeh proposed a new face recognition method based on PCA, LDA and Neural Network. The proposed method was tested on orl database for face. Experimental results on this database label the effectiveness of the proposed method for face recognition with less misclassification in comparison with previous methods [5]. Sathaporn Visakhasart presented new multi-pipelined architecture for face recognition system on FPGA. This architecture helps to reduce the recognition time through its pipeline process and also encourage the reduction in hardware resources [6]. Mohod approach [7] rate the face recognition problem as an fundamentally two dimensional (2D) recognition problem rather than requiring recovery of 3D geometry, proceeds advantage of the fact that faces are normally upright and thus may be described by a small set of 2D characteristic views. Manisha Satone et.al [8]

presented a method of face recognition in which features are extracted by applying Principal component analysis on wavelet sub band then support vector machine and nearest distance methods are used for classification. Among the subspace reduction methods Linear/Fisher Discriminate Analysis (LDA/FDA) [9, 10] is used for facial feature classification under varying light and pose. Carlos E. Thomaz and Duncan F. Gillies [11] proposed a maximum uncertainty LDA-based method which is based on a straight forward stabilisation approach for the within-class scatter matrix. In order to estimate its effectiveness, experiments on face recognition using the well-known ORL and FERET face databases were carried out and compared with other LDA-based methods. Chen et al. [12] have proposed another LDA-based method, which overcomes the singularity problems related to the direct use of LDA in small sample size applications, particularly in face recognition. Yu and Yang [13] have developed a direct LDA algorithm (DLDA) for high dimensional data with application to face recognition. Yang and Yang [14] have proposed a linear feature extraction method, which is capable of deriving discriminatory information of the LDA criterion in singular cases.

B. Non-linear methods

Traditional PCA only allows linear dimensionality [15] reduction. However, if the data has more complicated structures, which cannot be simplified in a linear sub-space, traditional PCA will become invalid. Fortunately, Kernel PCA allows us to generalize traditional PCA to nonlinear dimensionality reduction. A kernel principal component analysis (PCA) was previously proposed as a nonlinear extension of a PCA. The basic idea is [16] to first map the input space into a feature space through nonlinear mapping and then compute the principal components in that feature space. In a similar way to KPCA, K2DPCA can also, extract the nonlinear features effectively instead of projecting the image on to the subspace [17]. Ivanna K. Timotius, Iwan Setyawan, and Andreas A. Febrianto have present a face recognition method based on the combined kernel principal component analysis (KPCA) and support vector machine (SVM) methods [18]. Yang et al., [19] presented a symmetrical principal component analysis (SPCA) algorithm according to the symmetry of human faces. SPCA utilizes efficiently the symmetry of facial images. But SPCA also has some disadvantages; for example, when the asymmetry increases, the performance of SPCA will degenerate rapidly. By integrating the advantages of kernel method with ones of SPCA algorithm, a kernel based SPCA (KSPCA) algorithm was proposed[20], which, based on theoretical analysis and experimental results, has better performance in comparison with SPCA and KPCA. Self-organizing maps [21] and talent variables models [22] are also examples of non-linear dimensionality reduction methods. Due to their non-linearity which considers the global optimality, these methods tend to involve more free parameters such as learning rates, convergences criteria, and architectural specifications. Roweis and Saul [23] proposed a LLE and a related method called ISOMAP has been introduced by Tenenbaum [24]. Due to the fact that face images contain essential non-linear structures that are invisible to linear methods, many methodologies consider such data to assess the robustness of their algorithms. Lips and facial expressions were considered in [23] while experiments with synthetic face images in different lighting directions and poses were performed with ISOMAP [24]. A. Hadid, O. Kouropteva, and M. Pietikäinen proposed the locally linear embedding (LLE) for dimensionality reduction and to make this evaluation more efficient and objective, they considered PCA as a representative method for linear mapping and SOM for non-linear methods and also propose an extension to LLE which permits to apply the method for classification [25]. Jie Chen proposed a ISOMAP Based on the Image Euclidean Distance in which an improved manifold learning method when the input data are images are presented [26].

III. MODEL-BASED FACE RECOGNITION

The model based face recognition scheme is intended at constructing a model of human face, which is capable to capture the facial variations. Model based approach includes elastic bunch graph matching, active appearance model and 3D morphable model methods. Cootes et al. [27] proposed AAM for multi pose fitting by conjoining a small number of 2D AAM models. Blanz and Vetter [28,29] overcome the drawbacks of the 2D AAM by creating a 3D Morphable Model (3DMM). The 3DMM is a statistical model of shape and texture based on data developed from a laser scanner. One attempt to fit a 3DMM more efficiently was proposed in [30]. In [31] an extension to the classical AAM approach is proposed. They construct 3D anthropometric muscle based active appearance model by means of a generic 3D face shape. They adopt the 3D shape model so that the projected 3D vertices best fit to a facial 2D image. Xiao et al. [32] propose a real time combined 2D+3D AAM to fit 3D shapes to images. A feature-based system, based on elastic bunch graph matching was developed by Wiskott et al.[33]. By integrating both shape and texture, Cootes et al. [34,35] established a 2D morphable face model, through which the face variations are learned. Blanz [36] proposed a method based on 3D morphable face model that encodes shape and texture in terms of model parameters, and an algorithm that improves these parameters from a single image of a face. Jennifer Huang [37] presents a novel approach to pose and illumination invariant face recognition that chains two recent advances in the computer vision field: component-based recognition and 3D morphable models. Husken et al. [38] put forward a fusion between 2D and 3D Hierarchical Graph Matching (HGM) to perform face recognition. This approach uses an elastic graph that carries texture information and positions of facial landmarks. Maurer et al. [39] introduce a method that combines 3D and 2D face images. Kakadiaris et al. [40] present a fully automated framework for 3D face recognition using the Annotated Face Model (AFM) to overcome the facial expression complications. Al-Osaimi et al. [41] presented a methodology for 3D face recognition using deformable models. Chaua C. Queirolo [42] presented a 3D Face Recognition Using Simulated Annealing and the Surface Interpenetration Measure. Zhe Guo et al. [43] presented a method for 3D face recognition, in which the 3D facial surface is first charted into a 2D domain using specified

resolution through a global optimization by constrained conformal geometric maps. Wei Jen Chew et al. [44] proposed the 3D face matching technique for 3D model based face recognition that is able to recognize faces at various angles and uses only the three dimensional range images for matching. Michael De Smet et al. [45] describes an algorithm for pose and illumination invariant face recognition from a single image under occlusions. The method iteratively estimates the parameters of a 3D morphable face model to approximate the appearance of a face in an image. Kwang Ho An and Myung Jin Chung presented a new method, 3D head tracking and pose-robust 2D texture map-based face recognition by means of a Simple Ellipsoid Model[46].

IV. COMPARATIVE STUDIES

There are several comparative studies in the literature that evaluate face recognition methods. It must be noted that different studies use different datasets and possibly different parameter settings. Also resolution of the acquired images is an important factor in selecting the suitability of an approach for the face recognition. Therefore conclusions on the suitability of some approaches, recently cited in the literature, based on the image resolution, computational complexity, and performance would be useful. From the review it has been resolved that appearance based techniques are more popular and gives best results than the model based approaches. P.E. Robinson [47] tested the PCA and PCA+LDA algorithms and concluded that LDA + PCA algorithm performed better than the PCA algorithm in recognition tasks. Also, Dao-Qing Dai and Hong Yan [48] has been proved that Wavelets have been successfully used in image processing. Their ability to capture localized spatial-frequency information of image motivates their use for feature extraction. In the Comparative Study [49] on Daubechies Wavelet Transformation, Kernel PCA and PCA as Feature Extractors, Elly Matul Imah tried to address the effectiveness of Kernel PCA, PCA and Daubechies wavelet for dimensionality reduction during the feature extraction process and the best feature extraction method in this experiment is Daubechies WT.

CONCLUSION

The review of face recognition methodologies using image processing techniques gives us possible trend of this application area. The image based face recognition techniques were classified into two main categories, appearance based face recognition and model based face recognition. From the review it has been concluded that appearance based techniques gives best results than the model based approaches. In appearance based techniques, PCA, LDA and wavelet transform are most efficient techniques for dimension reduction, feature extraction and classification in the face recognition.

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