Performance Comparison of Various Face Detection Techniques

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Abstract -- **Face recognition has been a fast growing, challenging and interesting area in real time applications. A large number of face recognition algorithms have been developed in last decade. In this paper an attempt is made to review a wide range of methods used for face recognition comprehensively. This includes PCA, LDA, ICA, SVM, Gabor wavelet soft computing tool like ANN for recognition and various hybrid combination of these techniques. This review investigates all these methods with parameters that challenges face recognition like illumination, pose variation and facial expressions.**

Keywords: Principal Component Analysis, Support Vector Machine, Gabor Filters, Independent Component Analysis, Artificial Neural Networks.

I. INTRODUCTION

FACE recognition is an important part of the capability of human perception system and is a routine task for humans, while building a similar computational model of face recognition. The computational model not only contribute to theoretical insights but also to many practical applications like automated crowd surveillance, access control, design of human computer interface (HCI), content based image database management, criminal identification and so on. The earliest work on face recognition can be traced back at least to the 1950s in psychology [1] and to the 1960s in the engineering literature [2]. Some of the earliest studies include work on facial expression emotions by Darwin [3]. But research on automatic machine recognition of faces started in the 1970s [4] and after the seminal work of Kanade [5]. In 1995, a review paper [6] gave a thorough survey of face recognition technology at that time [7]. At that time, video-based face recognition was still in a nascent stage. During the past decades, face recognition has received increased attention and has advanced technically. Many commercial systems for still face recognition are now available. Recently, significant research efforts have been focused on video-based face modeling/tracking, recognition and system integration. New databases have been created and evaluations of recognition techniques using these databases have been carried out. Now, the face recognition has become one of the most active applications of pattern recognition, image analysis and understanding.

II. FACE RECOGNITION ALGORITHMS

Principal Component Analysis (PCA) : PCA also known as Karhunen-Loeve method is one of the popular methods for feature selection and dimension reduction. Recognition of human faces using PCA was first done by Turk and Pentland [8] and reconstruction of human faces was done by Kirby and Sirovich [9]. The recognition method, known as eigenface method defines a feature space which reduces the dimensionality of the original data space. This reduced data space is used for recognition. But poor discriminating power within the class and large computation are the well known common problems in PCA method. This limitation is overcome by Linear Discriminant Analysis (LDA). LDA is the most dominant algorithms for feature selection in appearance based methods [9]. But many LDA based face recognition system first used PCA to reduce dimensions and then LDA is used to maximize the discriminating power of feature selection. The reason is that LDA has the small sample size problem in which dataset selected should have larger samples per class for good discriminating features extraction. Thus implementing LDA directly resulted in poor extraction of discriminating features. In the proposed method [10] Gabor filter is used to filter frontal face images and PCA is used to reduce the dimension of filtered feature vectors and then LDA is used for feature extraction. The performances of appearance based statistical methods such as PCA, LDA and ICA are tested and compared for the recognition of colored faces images in [11]. PCA is better than LDA and ICA under different illumination variations but LDA is better than ICA. LDA is more sensitive than PCA and ICA on partial occlusions, but PCA is less sensitive to partial occlusions compared to LDA and ICA. PCA is used as a dimension reduction technique in [12] and for modeling expression deformations in [13].A recursive algorithm for calculating the discriminant features of PCA-LDA procedure is introduced in [14]. This method concentrates on challenging issue of computing discriminating vectors from an incrementally arriving high dimensional data stream without computing the corresponding covariance matrix.The proposed incremental PCA-LDA algorithm is very efficient in memory usage and it is very efficient in the calculation of first basis vectors. This algorithm gives an acceptable face recognition

success rate in comparison with very famous face recognition algorithms such as PCA and LDA. Two appearance–based techniques such as Modified PCA (MPCA) and Locality Preserving Projections (LPP**)** are combined in [15] to give a high face recognition rate. PCA is used as a feature extraction technique in [16]. These feature vectors are compared using Mahalanobis distances for decision making. Tensor based Multilinear PCA approach is proposed in [17] which extracts feature directly from the tensor representation rather than the vector representation. This method shows a better performance in comparison with the well known methods in distance varying environments.

PCA can outperform over many other techniques when the size of database is small. In proposed algorithm [18] the database was subgrouped using some features of interest in faces. Only one of the obtained subgroups was provided by PCA for recognition. Despite the good results of PCA, this technique has the disadvantage of being computationally expensive and complex with the increase in database size, since all the pixels in the image are necessary to obtain the representation used to match the input image with all others in the database.

Different dimensionality reduction techniques such as PCA, Kernel PCA, LDA, Locality preserving Projections and Neighborhood Preserving embedding were selected and applied in order to reduce the loss of classification performance due to changes in facial appearance. The performance of recognition while using PCA as well as LDA for dimensionality reduction seems to be equal in terms of accuracy. But it was observed that LDA requires very long time for processing more number of multiple face images even for small databases. In case of Locality Preserving Projections (LPP) and NPE methods, the recognition rate was very less if increasing number of face images were used as compared to that of PCA and KPCA methods. The proposed method [19] provided considerable improvements in the case of illumination variations, PCA and kernel PCA are the best performers.

Modified PCA algorithm for face recognition were proposed in [20], this method was based on the idea of reducing the influence of eigenvectors associated with the large eigen values by normalizing the feature vector element by its corresponding standard deviation.

The simulation results show that the proposed method results in a better performance than conventional PCA and LDA approaches and the computational cost remains the same as that of PCA and much less than that of LDA.

A new face recognition method based on PCA, LDA and neural network were proposed in [21]. This method consists of four steps: i) Preprocessing ii) Dimension reduction using PCA iii) feature extraction using LDA and iv) classification using neural network. Combination of PCA and LDA were used for improving the capability of LDA when a few samples of images were available and neural classifier was used to reduce number misclassification caused by not-linearly separable classes. The proposed method was tested on Yale face database. Experimental results on this database demonstrated the effectiveness of the proposed method for face recognition with less misclassification in comparison with previous methods.

A different approach for face detection was proposed in [22] which minimizes computation time while achieving higher detection accuracy. PCA was used to reduce the dimension extracting a feature vector. GRNN used as a function approximation network to detect whether the input image contains a face or not and if existed then reports about its orientation. The proposed system had shown that GRNN can perform better than backpropagation algorithm and give some solution for better regularization.

Support Vector Machine (SVM): Support Vector Machines (SVM) are one of the most useful techniques in classification problems. One clear example is face recognition. However, SVM cannot be applied when the feature vectors defining samples have missing entries. A classification algorithm that has successfully been used in this framework is the all-known Support Vector Machines (SVM) [23], which can be applied to the original appearance space or a subspace of it obtained after applying a feature extraction method [24] [25] [26]. The advantage of SVM classifier over traditional neural network is that SVMs can achieve better generalization performance.

Independent Component Analysis (ICA): Independent component analysis (ICA) is a method for finding underlying factors or components from multivariate (multidimensional) statistical data. There is need to implement face recognition system using ICA for facial images having face orientations and different illumination conditions, which will give better results as compared with existing systems [27] [28] [29] . What distinguishes ICA from other methods is that, it looks for component that are both statistically independent and non gaussian [27]. The ICA is similar to blind source separation problem [30] that boils down to finding a linear representation in which the components are statistically independent. The comparison of face recognition using PCA and ICA on FERET database with different classifiers [31] [32] were discussed and found that the ICA had better recognition rate as compared with PCA with statistically independent basis images and also with statistically independent coefficients. Face recognition using ICA with large rotation angles with poses and variations in illumination conditions was proposed in [33]. A novel subspace method called sequential row column independent component analysis for face recognition is proposed in [34]. In ICA each face image is transformed into a vector before

calculating the independent components. RC_ICA reduces face recognition error and dimensionality of recognition subspace becomes smaller. A novel technique for face recognition combined the independent component analysis (ICA) model with the optical correlation technique was proposed in [35]. This approach relied on the performances of a strongly discriminating optical correlation method along with the robustness of the ICA model. Independent component analysis (ICA) model had sparked interest in searching for a linear transformation to express a set of random variables as linear combinations of statistically independent source variables [36]. ICA provided a more powerful data representation than PCA as its goal was that of providing an independent rather than uncorrelated image decomposition and representation. A fast incremental principal non Guassian directions analysis algorithm called IPCA_ICA was proposed in [37].This algorithm computes the principal components of a sequence of image vectors incrementally without estimating the covariance matrix and at the same time transform these principal components to the independent directions that maximize the non-Guassianity of the source. IPCA_ICA is very efficient in the calculation of the first basis vectors. PCA_ICA achieves higher average success rate than Eigenface, the Fisherface and FastICA methods.

Gabor wavelet: For enhancing face recognition high intensity feature vectors extracted from Gabor wavelet transformation of frontal face images combined together with ICA in [38]. Gabor features have been recognized as one of the best representations for face recognition. In recent years, Gabor wavelets have been widely used for face representation by face recognition researchers [39] [40] [41] [42] [43], because the kernels of the Gabor wavelets are similar to the 2D receptive field profiles of the mammal cortical simple cells, which exhibits desirable characteristics of spatial locality and orientation selectivity. Previous works on Gabor features have also demonstrated impressive results for face recognition. Typical methods include the dynamic link architecture (DLA) [39], elastic bunch graph matching (EBGM) [40], Gabor Fisher classifier (GFC) [41], and AdaBoosted GFC (AGFC) [42]. Gabor features are also used for gait recognition and gender recognition recently [44] [45]. In this paper, [46] it was observed that though Gabor phases are sensitive to local variations, they can discriminate between patterns with similar magnitudes, i.e. they provide more detailed information about the local image features. Therefore, the Gabor phases can work comparably well with the magnitudes, as long as its sensitivity to misalignment and local variations can be compensated carefully. In previous work, authors proposed to represent face images using the local Gabor binary patterns (LGBP), which combines Gabor magnitudes with local binary patterns (LBP) operator [47]. Improved results were achieved when compared with the LBP and the GFC. Since face representation with LGBP based on local histograms, which were insensitive to local variations [48], similarly local histograms of LGBP can be used to suppress the sensitivity of Gabor phases to local variations. By encoding Gabor phases through LBP and local histograms, a very impressive recognition rates comparable with those of Gabor magnitudes-based methods were achieved, which shows effectiveness of Gabor phases in the discrimination of different faces. A novel method for extraction of facial features was proposed in [49] based on Gabor wavelet representation of face images and kernel least squares discrimination algorithm. The experimental results based on XM2VTS [50] and ORL [51] databases shown that Gabor based kernel least squares discrimination approach outperforms feature extraction methods such as PCA, LDA, Kernel PCA or Generalized Discriminant Analysis (GDA) as well as combination of these methods with Gabor representations of face images. A technique is presented in [52] by which high intensity feature vectors extracted from the Gabor wavelet transformation of frontal face images combined together with ICA for enhanced face recognition.Among the new techniques used in the literature for feature extraction, it is proved that Gabor filters can extract the maximum information from local image regions [53] [54] and it is invariant against, translation, rotation, variations due to illumination and scale [55] [56] [57]. In [58] [59] Gabor wavelets & neural network was presented for face detection, A. Khatun *et al* [60] propose a hybrid neural network solution for face recognition trained with Gabor features.

P. Latha *et al* [61] use Gabor wavelet to present face, and applied neural network to classify views of faces. The dimensionality was reduced by the principal component analysis. A technique to extract the feature vector of the whole face in image database by using Gabor filters, known to be invariant to illumination and facial expression, developed in [62] .This network achieved higher recognition rate and better classification efficiency when feature vectors had low dimensions.

Linear Discriminant Analysis (LDA): The linear discriminant analysis (LDA) is a powerful method for face recognition. It yields an effective representation that linearly transforms the original data space into a low-dimensional feature space where the data is well separated. However, the within-class scatter matrix (SW) becomes singular in face recognition and the classical LDA cannot be solved which is the undersampled problem of LDA (also known as small sample size problem). A subspace analysis method for face recognition called kernel discriminant locality preserving projections (MMDLPP) was proposed in [63] based on the analysis of LDA, LPP and kernel function. A non linear subspace which can not only preserves the local facial manifold structure but also emphasizes discriminant information.

Combined with maximum margin criterion (MMC) a new method called maximizing margin and discriminant locality preserving projections (MMDLPP) was proposed in [64] to find the

subspace that best discriminates different face change and preserving the intrinsic relations of the local neighbourhood in the same face class according to prior class label information.The proposed method was compared with PCA as well as locality preserving projections (LPP**)** ORL , YALE, YALEB face database and authors had shown that it provides a better representation of class information and achieved better recognition accuracy. Illumination adaptive linear discriminant analysis (IALDA) was proposed in [65] to solve illumination variation problems in face recognition. The recognition accuracy of the suggested method (IALDA), far higher than that of PCA method and LDA method.The recognition accuracy of the suggested method was lower than that the nearby in the output space, thereby providing Logarithmic Total Variation (LTV**)** algorithm [66]. However, The LTV algorithm has high time complexity. Therefore, the LTV method is not practically applicable. At the same time, this also indicates that the proposed IALDA method is robust for illumination variations. David Monzo *et. al.* [67] compared several approaches to extract facial landmarks and studied their influence on face recognition problems. In order to obtain fair comparisons, they used the same number of facial landmarks and the same type of descriptors (HOG descriptors) for each approach. The comparative results were obtained using FERET and FRGC [68] datasets and shown that better recognition rates were obtained when landmarks are located at real facial fiducial points. In this work, comparison was done using Principal Component Analysis (PCA) [69], Linear Discriminant Analysis (LDA) [70] and Orthogonal Linear Discriminant Analysis (OLDA) [71]. OLDA is one of the many variations of LDA which aims to tackle the problem of undersampling. The key idea of OLDA, the discriminant vectors are orthogonal to each other. In [71] Ye provides an efficient way of computing OLDA.

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Artificial Neural Network (ANN): Multi-Layer Perceptron (MLP) with a feed forward learning algorithms was chosen for the proposed system because of its simplicity and its capability in supervised pattern matching. It has been successfully applied to many pattern classification problems [72]. A new approach to face detection with Gabor wavelets & feed forward neural network was presented in [73]. The method used Gabor wavelet transform and feed forward neural network for both finding feature points and extracting feature vectors. The experimental results, have shown that proposed method achieves better results compared to the graph matching and eigenfaces methods, which are known to be the most successful algorithms. A new class of convolutional neural network was proposed in [74] where the processing cells are shunting inhibitory neurons. Previously shunting inhibitory neurons have been used in a conventional feedforward architecture for classification and non-linear regression and were shown to be more powerful than MLPs [75] [76] i.e. they can approximate complex decision surfaces much more readily than MLPs. A hybrid neural network solution was presented in [77] which combines local image sampling, a self-organizing map neural network, and a convolutional neural network. The self-organizing map provides a quantization of the image samples into a topological space where inputs that are nearby in the original space are also nearby in the output space, thereby providing dimensionality reduction and invariance to minor changes in the image sample, and the convolutional neural network (CNN) provides for partial invariance to translation, rotation, scale, and deformation. PCA+CNN & SOM+CNN methods are both superior to eigenfaces technique even when there is only one training image per person.SOM +CNN method consistently performs better than the PCA+CNN method. A new face detection method is proposed in [78] using polynomial neural network (PNN) [79] [80]. The PNN functions as a classifier to evaluate the face likelihood of the image patterns of the multiscale shifted local regions. The PCA technique used to reduce the dimensionality of image patterns and extract features for the PNN. Using a single network the author had achieved fairly high detection rate and low false positive rate on images with complex backgrounds. In comparison with a multilayer perceptron, the performance of PNN is superior. To best reflect the geometry of the 3D face manifold and improve recognition, Spectral Regression Kernel Discriminate Analysis(SRKDA) [81] based on regression and spectral graph analysis introduced in proposed [82] method. When the sample vectors are linearly independent, which is usually the case for small sample size problems; SRKDA can efficiently give more exact solutions than ordinary subspace learning approaches. It not only solves high dimensional and small sample size problems, but also enhances feature extraction from a face local non-linear structure. Detailed comparisons between SRKDA [81], PCA [8], LPP [83], OLPP [84], SR [81], and KDA [81] to show the efficiency of proposed method for 3D face recognition, especially with respect to expression variations.

SRKDA only needs to solve a set of regularized regression problems and no eigenvector computation involved, which is a huge saving in computational cost.

A novel Haarlet Pyramid based face recognition technique was proposed in [85]. Here face recognition is done using the image feature set extracted from Haarlets on gray plane. PCA is usually used but it is very time consuming. In paper [86] authors have shown the comparative study of different face recognition algorithm for plastic surgery Based on the experimentation carried out by authors it has been concluded that face recognition algorithm such as PCA ,FDA ,LLA ,LBP & GNN have shown recognition rate more than 40% for local plastic surgery. A new approach to plastic surgery based face recognition using near set theory was proposed in [87] [88]. An approach based on near set theory for comparing pre and post surgical facial images is proposed in [89].

III. CONCLUSION

This paper has attempted to review a significant number of papers to cover the recent development in the field of face recognition. Present study reveals that for enhanced face detection new algorithm has to evolve using hybrid methods of soft computing tools such as ANN, SVM and Gabor filter (Feature Extractor) that yield better performance in terms of face detection rate and accuracy. References provide more detailed understanding of the approaches described.

IV. REFERENCES

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