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GABOR FEATURED STATISTICAL MODELING IN FACE RECOGNITION WITH CHAOTIC DATABASE

C. MageshKumar[1], G. Ragul [2], R.Thiyagarajan[3]

[1]*HCL Technologies Ltd., Chennai, India.*
[2]*MPNMJ Engineering College, Chenimalai, India.*
[3]*Annamalai University, Annamalai Nagar, India.*

kummagi@gmail.com

Abstract

For a real time face recognition system, restraints like orientation, lighting and pose are the major challenges to be addressed. In the proposed work, to eliminate the variations due to pose, lighting and features to some extent, Gabor wavelets are used in preprocessing of human face image. Principal Component Analysis (PCA) has been widely adopted as the unpretentious potential face recognition algorithm which extracts low dimensional feature vectors from face. Linear Discriminant analysis (LDA) is applied on the reduced features from PCA, to get more discriminating features. The classification is done using distance measure classifiers and Support Vector Machine. Here, the train dataset is considered in randomized fashion, means the database contains a set of images of an individual in which different set of train dataset is generated randomly to choose the trained set that gives high rate of recognition. This will support in plummeting the overall database size and upsurge the enactment of the system. The system has been successfully tested on ORL face database with 400 frontal images corresponding to 40 different subjects of variable illumination and facial expressions. The proposed system gives a better recognition rate when compared to other standard techniques and achieves better accuracy with increased number of features.

***Keywords*--Face recognition; Gabor Wavelets; PCA; LDA; Randomized Dataset**

I. INTRODUCTION

Anthropoid face detection and recognition is one of a bouncing area of study crosswise a number of disciplines such as image processing, computer vision and pattern recognition, information security, access management with wide range of applications such as advanced human-computer interaction, video-surveillance, identity verification, facial expression extraction, access security, data privacy. A diktat to develop full-bodied face recognition system is due to worse recognition performance and highly multilayered spreading as a result of wide-range variations of human face due to illumination, pose and expression. In prototypical face recognition system, preprocessing is used to diminish noise and count on precise registration and classification. Classification is usually one of a number of standard methods: common examples are minimum distance classifiers. In this work, Euclidian Distance method, Mahalanobis Metric distance method, and Support Vector Machine (SVM) are employed as classifiers. Feature extraction is the area that tends to differentiate. In this work the feature extraction is addressed by Gabor wavelets; Principal Component analysis (PCA) and Linear Discriminant analysis (LDA) on face images.

The methods for face recognition can be estranged into two dissimilar classes: Template matching and Geometrical features matching. In template matching, the face image is represented as a two-dimensional array of intensity values and this is compared to a single or several templates as a replacement on behalf of a whole face. Under this approach, face is matched through identifying its underlying statistical regularities. With this extracted facial features, classification and recognition is done. The choice of facial features extracted by system and handled by the classifier results in respectable impression of several face recognition method. In pattern recognition, the feature selection from the raw input data can be consummated using a standard feature extraction method much reduces the data used for processing and also made simpler to provide better discriminating ability[1].

The preprocessing is accomplished using Gabor filters and shapes a feature vector called Gabor features of raw face images. Gabor transformed face images revile durable characteristics of spatial locality, scale, and orientation selectivity. In template matching approach, face is matched through identifying its underlying statistical regularities.

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Recognition of human faces using PCA was first done by Turk and Pentland [2], is one of the popular methods for feature selection and dimensionality reduction. A good survey of face recognition system is found in [3]. The Eigen face method defines a feature space which reduces the dimensionality of the original data space. This reduced data space is used for recognition. LDA is one of the most dominant algorithms for feature selection in appearance based methods that maximizes the discriminating power of feature selection. Implementing LDA directly results in poor extraction of discriminating features due to the small sample size problem in which dataset selected should have larger samples per class for good discriminating features extraction. The extracted features from the train and the test sections are classified using Euclidean distance measure method; Mahalanobis Metric distance method and Support Vector Machine (SVM).

In the proposed method, the frontal face images were Gabor filtered. PCA is used to reduce Gabor filtered feature vectors dimension, LDA is used to get more judicious features and these features were extracted for training SVM and there is no specific train and test database is considered. Train database is generated randomly. For each generated train set the recognition rate is compared with average matching score [4]. The set with matching score greater than average value is considered as the unrivaled selected train set. In comparison with the conventional use of PCA, the proposed method gives good discriminatory power and better recognition rate. In the proposed approach ORL face database with 400 frontal face images is taken in which 200 samples for training and 200 samples for testing the algorithm. The probability of the new approach has been demonstrated in experimental results.

This paper is organized as follows. Section 2 minutiae the basics of Gabor wavelet and Gabor features. Section 3 and Section 4 reviews the Eigen face, PCA and LDA background. Section 5 presents the classifier part. Section 6 rationalizes the proposed method. Investigational results are unbolted in section 7 and section 8 gives the conclusions.

II. Gabor Wavelets

In face recognition scheme, template based process catches the significant features on the face in a well-organized fashion. Physiological studies found that the cells in the human virtual cortex are capable of being selectively tuned to orientation and to spatial frequency.

This substantiates that the response of the simple cell could be approximated using 2D Gabor filters is given by J.G.Daugmann [5]. In image processing, Gabor wavelet was introduced because of their biological relevance and computational properties [5, 6]. The kernels of Gabor wavelets are comparable to 2D receptive field that profiles the mammalian cortical simple cells. These kernels exhibit desirable characteristics of orientation selectivity and spatial locality.

The extraction of local features of an image can be effectively done using Gabor wavelets. Using Gabor wavelets is a healthy way to do away with illumination, poses and facial expression changes. Considering all Gabor kernels, all the features are concatenated to form a Gabor feature vector. This high dimensional Gabor vector space is much reduced by applying arithmetical modeling method, PCA to obtain more independent and discriminating features. All Gabor kernels are self-similar since they are generated by scaling and rotation from mother vector using the wave vector.

In most of the cases, Gabor wavelets of five different scales, $v \in \{0,1,2,3,4\}$ and eight orientation $\mu \in \{0,\ldots..7\}$ were used for representational purpose. Therefore, the augmented Gabor feature vector encompasses all the elements (down sampled) of the Gabor wavelet representation set $S = \{O\mu,v(z): \mu \in\{0,\ldots..7\}, v \in \{0,\ldots..4\}\}$ as important discriminating information forms the Gabor wavelet representation of the image [7]. The sample input frontal face image as shown in **Fig. 1** is preprocessed using the kernels and the resultant convolution output of the image and the kernels are as shown in **Fig. 2** and **Fig. 3**. Concatenating all these Gabor representation is done to encompass different spatial frequencies (scales), spatial localities, and orientation selectivity into a single augmented feature vector.

Fig. 1. Sample frontal image

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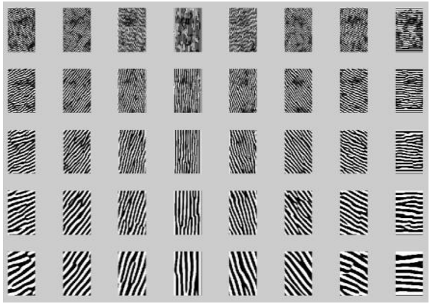

Fig. 2. Real part of the convolution output of sample image

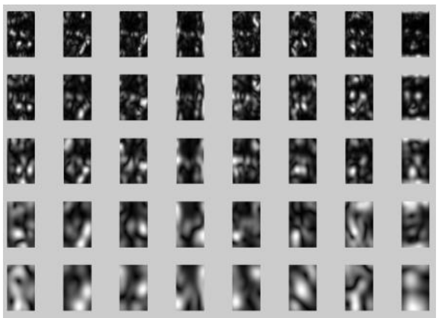

Fig. 3.Magnitude of the convolution output of the sample image

III. Principal Component Analysis

In image compression, Principal Component Analysis is one of the most successful techniques. The large dimensionality of the observed variables (data space) is reduced to the smaller built-in dimensionality of independent variables (feature space). This is the case when there is a strong correlation between observed variables and main purpose of using PCA. It is capable of transforming each original image of the training set into a corresponding Eigen face using PCA. The original face image can be reconstructed accordingly by adding up all the Eigen faces in the right proportion. The reconstruction of any original image from the training set by combining the Eigen faces is an important feature of PCA which are nothing but characteristic features of the faces.

Each Eigen face represents only certain features of the face, which may or may not be present in the original image. If the particular feature is not present in the original image, then the corresponding Eigen face should contribute a smaller part to the sum of Eigen faces. If, by contrary, the feature is present in the original image to a higher degree, the share of the corresponding Eigen face in the "sum" of the Eigen faces should be greater [8].

So, the reconstructed original image is equal to a sum of all Eigen faces, with each Eigen face having a certain weight and this weight specifies, to what degree the specific feature (Eigen face) is present in the original image. By using all the Eigen faces extracted from original images, exact reconstruction of the original images is possible by choosing only the most important features [4]. The reduced data is taken as input to the next stage to extract more discriminating features [9].

IV. Linear Discriminant Analysis

Linear Discriminant Analysis is one of the successful methods used for dimensionality reduction for many classification problems. The main intention of this method is to find a projection that maximizes the ratio of between - class matrix and against within – class scatter. In high dimensional pattern recognition tasks Fisher Discriminant Analysis (FDA) based algorithms has small sample size problem(SSS) which exists where the number of available samples is smaller than the dimensionality of the samples [10]. Due to this problem, many variants of the original FDA algorithm have been proposed for face recognition [11]. Perform dimensionality reduction while preserving as much of the class discriminatory information as possible. LDA seeks to find directions along which the classes are best separated. That takes into consideration the scatter within-classes but also the scatter between-classes.

The eigenvectors of LDA are called "fisherfaces". LDA transformation dependence on number of classes, number of samples, and original space dimensionality. LDA derives a low dimensional representation of a high dimensional face feature vector space. The discriminating feature vector is given by the coefficients of the covariance matrix for the LDA method. The transformation matrix projects the face vector. The projection coefficients are used for the feature representation of each face image. In the proposed scheme the column vectors of the matrix are referred as fisherfaces.

V. Classifier

In wide-ranging image classification schemes, they analyze and organize the numerical properties of image features. In practice, the mean distance classifier works well when the distance between means is large compared to randomness of each class with respect to its mean.

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The distance is defined as an index of similarity so that the minimum distance is identical to the maximum similarity. The minimum distance classifier is used to classify unknown image data to classes where minimum distance between the image data and the class in multi-feature space exists. There exist various types of distance classifier techniques. The type of distance classifiers, namely Euclidean distance method and Mahalanobis Metric distance method are considered for the proposed approach.

Euclidian Distance: $d(x,y) = kx - yk1$ (1)

Mahalanobis: $d(x, y) = \mathrm{sqrt}((x - y)^T C^{-1}(x - y))$ (2)

Where:

x is the train feature
y is the test feature
k and k1 are constant
C is the covariance matrix of the training set.

Support Vector Machine as the classification tool for face authentication is a good choice because SVM do not need large amounts of training data [12]. The task of face authentication is accomplished using two phases: training phase and classification phase. During the training phase, the training set is constructed from input images and the SVM decision function is found. For the classification phase, testing images different from the training set are used to validate the decision function. The way the data are preprocessed affects the accuracy of the system because good data will produce a more accurate decision function that can then be used for image classification.

VI. PROPOSED METHOD

From the literature it is found that the train and check set were redefined and certain researches were conceded out by altering the train and test set that resulted in healthier classification. The database is alienated haphazardly. For each of the randomly formed train and test set the proposed algorithm is applied and the recital measure for each set is found out. The set with preeminent classification score is well thought-out as the best train and test set.

The threshold for this case is obtained by considering (PCA+ED) algorithm for the whole randomly generated database. The proposed method slot in the ORL database acquired at the Olivetti Research Laboratory is completely considered as input to the system. The block diagram of the proposed system is as shown in **Fig. 4**.

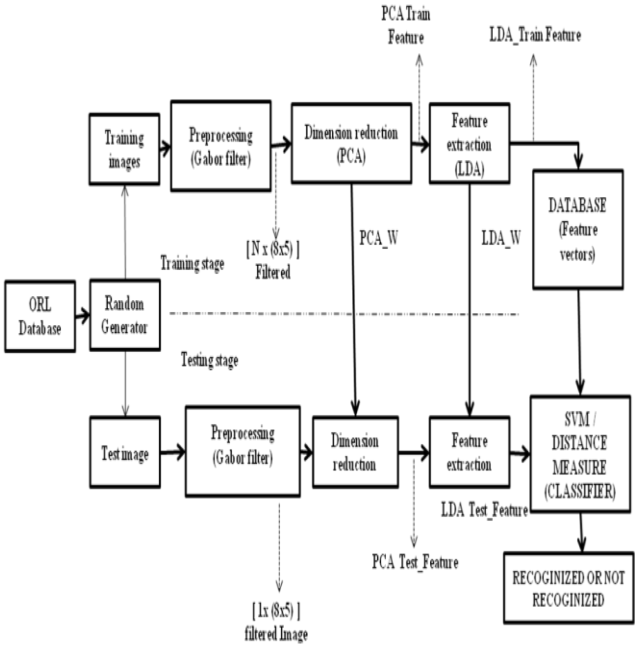

Fig. 4. Block diagram of the proposed face recognition system

The ORL database consists of 400 face images that corresponds 40 dissimilar individuals. In upshot, each class in the database corresponds to 10 distinctive facial images of illumination, pose, facial expression and presence/absence of details like glass, beard. From the randomized database, 5 images from each class were considered for training and remaining 5 images from each class were used for testing. To be precise, 200 images for training and 200 images for testing the system were taken totally. The images are stored at a resolution of 92 × 112 and 8 bit grey levels. Sample train and test set are shown in **Fig.5** and **Fig.6**.

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Fig. 5. Scaled training samples

Fig. 6. Scaled test samples

In this system template based approach is followed and primarily consists of two stages, training and testing. In training stage, the preprocessing stage uses Gabor wavelet. To smooth the progress of the Gabor wavelet representations, the ORL images are dimensioned to 128x128 using bicubic interpolation. The Gabor kernels uses five different scales and eight orientations which results in 40 different filters. The input image is convoluted with the Gabor kernel and the convoluted real and magnitude response is given in **Fig. 2** and **Fig. 3**. This convoluted feature vector is then down sampled by a factor of $\rho = 64$. An augmented Gabor feature vector is drawn from concatenated Gabor wavelet features to embrace all the features fabricated by 40 different Gabor kernels.

The consequential high dimension Gabor feature vector is taken as key to the next stage.

In the next stage PCA is used for reducing the dimension of Gabor feature vector and extracts the principle features. Here the Eigen vectors are calculated and sorted in ascending order followed by the exploitation of top Eigen vectors for representation of feature vectors (PCA_Feat). Also the weight matrix is computed PCA_W simultaneously which is used to find the PCA test features. This Eigen projection is then used as input to the next stage of LDA. The same procedure is applied for feature extraction using LDA. Here using PCA_Feat is used as input to the LDA block. The between class and within class scatter matrix is obtained using this projection matrix. LDA gives the projected weight matrix LDA_W, which is used to find the LDA test features.

In the recognition stage, the test samples were taken and the initial pre-processing is done as done for the training frontal images. The test image matrix (Test) is multiplied with PCA_W and this result in test PCA features (PCA_test). This PCA_test when convoluted with LDA_W gives the test features (LDA _test). The LDA_Train feature is stored in database as feature vectors. This feature vector is used as input to train SVM. After training test features (LDA _test) for a new, unknown face image of the same individuals is given to classifier in order to recognize it.

VII. RESULTS AND DISCUSSION

The proposed system is tested with ORL face database. The extracted features are used as it is and its effectiveness is shown in results. Using the above said feature extraction and classification methods, the recognition rate is obtained with fixed number of PCA features and the performance comparison is revealed in **Table 1**, the recognition rate for different number of features of all Gabor+PCA methods is exposed in **Fig.7** and the overall performance comparison of different methods in shown in **Fig. 8**. The recognition rate of proposed system for different Dataset (chaotic database) is shown in **Table 2**. Here each database contains distinctive facial images of same class giving different rate of recognition. This process is repeated for a fixed number of times depending upon the system requirements and the dataset having highest rate of recognition is elected as best database. The purpose of selecting this kind is to reduce the overall database size, inturn increase the robustness of the total face recognition system.

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The successfulness of the proposed system is compared with popular face recognition schemes like Gabor wavelet based classification and PCA method. From **Table 1** it is clear that the recognition rate increases when there is a increase in number of features. Mahalanobis distance method gives better recognition than Euclidian method in all methods and SVM gives better recognition rate then distance methods for Gabor+PCA approach.

Table 1.
Performance Comparison Of Different Methods

Algorithm	Classifier	Number of Features				
		40	50	66	100	199
PCA alone	Euclidian	82.12	84.38	87.25	88.32	89.23
	Mahalanobis	83.45	87.5	88	89.7	91.5
Gabor with PCA	Euclidian	87	89.3	90.2	92.7	93.1
	Mahalanobis	86.5	89.5	92	92.5	92.9
	SVM	88.36	89.8	92.37	95.8	97.88
Gabor with PCA and LDA	Euclidian	89	91.3	94.4	95.3	96.8
	Mahalanobis	90	90.5	93.4	96.1	97

Table 2.
Recognition Rate Of GABOR+PCA+LDA+ED System For Different Dataset

Random Dataset (number of features -199)	Recognition Rate
Dataset 1	96.10
Dataset 2	89.30
Dataset 3	97.98
Dataset 4	93.75
Dataset 5	96.64

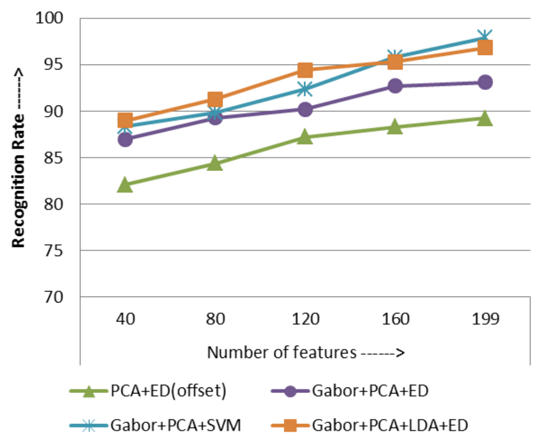

Fig. 7. Performance Comparison of Gabor+PCA methods

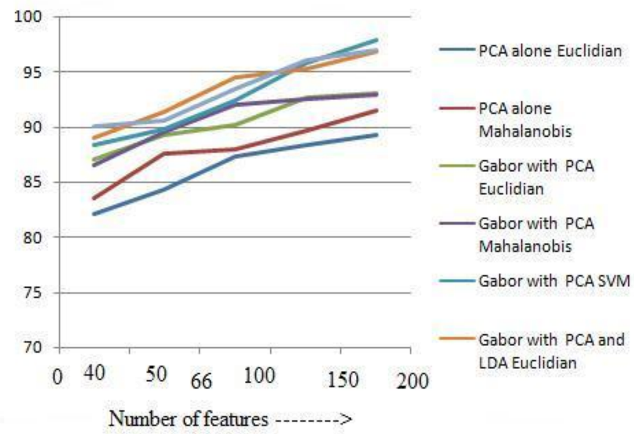

Fig. 8. Performance Comparison of Different methods

VIII. CONCLUSION

In this proposed system, to increase the robustness of the face recognition system, Gabor feature based method which eliminates the variations due to pose, lighting and features is used. For different scales and orientations of the Gabor filter, the input image is convoluted with Gabor filters and from this convoluted image feature vectors were formulated using PCA. Using PCA, the high dimensionality of these feature vectors is reduced and the more discriminant features from the input image were extracted using LDA. This discriminating feature space is used as the training feature space for distance measure methods and SVM in the classification stage. From the simulation results, it has been found that the recognition rate is high with features extracted from PCA and LDA based Gabor methods than simple PCA methods. It is observable from the result, as the number of features selected in PCA increased, it leads to obtain more discriminating features and this consecutively increases the recognition rate. But this in turn increases the computational load. Meanwhile, best dataset for an individual can be selected by running the system with different dataset of an same individual with different facial images that enhances the overall performance of the face recognition system and helps to reduce the database size remarkably in real time environment. From **Table 1** it is clear from the result that the proposed Gabor features based PCA method following SVM classifier and Gabor features based PCA+LDA method following Mahalanobis distance measure method gives better recognition rate and they nigh on same rate of recognition.

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