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Feature Extraction Technique for Human Face Recognition – A Hybrid Approach

Jageshvar K. Keche, Dr. Mahendra P. Dhore

***Abstract* — This paper presents a new feature extraction technique for recognizing human faces. The proposed method uses hybrid feature extraction techniques such as Principal Component Analysis and Gabor Wavelet are combined together. The classifier k-Nearest Neighbor is used for classification. For experimentation JAFEE and YALE face databases are used to test and achieved better performance of proposed method. The performance of proposed method on JAFFE and Yale face database are compared with known other methods.**

***Keywords* — PCA, Wavelet, k-NN, JAFEE database, Yale face databases.**

I. INTRODUCTION

Human face recognition [1-5] has become the important area of research in computer vision, pattern recognition. It is one of the most successful applications of image analysis and processing. It has lot of attention to the researchers in recent years. Face recognition is considered to be an important part of the biometrics technique, and meaningful in scientific research [1]. Human face recognition task is actively being used for personal identification and authentication, information security, crime investigation, entrance control in buildings, passport verification, access control at automatic teller machines and they shows very good performance[3]. Most of the face recognition algorithms consist of two parts: a) Face localization & normalization b) Face identification. Dimensional reductions techniques are used in reducing complexity of the recognition process such as Principal Component Analysis (PCA) [4-5] have now been successfully applied to this problem. Face Recognition can be simply defined as the visual perception of familiar faces or the biometric identification by scanning a person's face and matching it against a library of known faces. The available face information is to distinguish a particular face from all other faces in the face database.

A proposed feature extraction method for human face recognition combines PCA, Gabor Wavelet, and k-NN algorithm. The main contribution is its performance and efficiency is better than other method with scale and poses invariance.

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Jageshvar K. Keche, Department of Computer Science, SSESA's, Science College, Congress Nagar, Nagpur (MS), India, 9850325524,

Dr. Mahendra P. Dhore, Department of Electronics & Computer Science, RTM Nagpur University Campus, Nagpur (MS), India, 9423103043,

The proposed method contains two parts. The first part is constructing the feature descriptors. The second part is matching the features to classify the face images. For this purpose we apply k-Nearest Neoghbor algorithm to clustering face image features and then calculate similarity between images to classify the face images. The performance under different conditions is evaluated to demonstrate the superiority of the proposed method.

The rest of the paper is organized as follows. In section II, we present the review of the related work. In section III, we present the feature extraction method and proposed technique. In Section IV, we describe the face databases JAFFE and Yale. The performance of our method is evaluated and discussed in Section V. Finally, we conclude the paper in Section VI.

II. RELATED WORK

The feature extraction of face image is an important procedure for face recognition. There are some traditional algorithms for face recognition such as PCA [4,6] and LDA [7] that are classical methods based on representing features of holistic image with the projection in subspace. The DWT [8] and DCT [9] have been utilized to extract feature information in various studies on face recognition. The LBP [10] and Gabor filter [11] were proposed to increase the performance of recognition. Yan et al. [12] proposed a method to combine LBP and Gabor filter for improving the recognition rate. This method uses LBP and Gabor filter to extract the descriptor and combines the similarity score matrix of LBP and Gabor to obtain the improved performance in face recognition.

Shishir Bashyal et al. [13] discussed the application of Gabor filter based feature extraction in combination with learning vector quantization (LVQ) for recognition of seven different facial expressions from still pictures of the human face. Tudor Barbu [14] proposed a novel supervised human face recognition approach based on two-dimensional Gabor filtering and supervised classification. The main contribution of this method is 2D Gabor filter-based feature extraction that produces robust three-dimensional face feature vectors. Another contribution is the supervised classifier used for facial feature vector classification. Yuehui Chen et al. [15] proposed a new face recognition approach by using the Discrete Cosine Transform (DCT) and hybrid flexible neural tree (FNT) classification model. DCT is employed to extract the input features to build a face recognition system, and the flexible neural tree is used to identify the faces. The

presented Flexible Neural Tree (FNT) model for face recognition with a focus on improving the face recognition performance by reducing the input features.

Sangeeta Kakarwal and Ratnadeep Deshmukh [16] proposed a Wavelet Transform based analysis method for Face Recognition. The author investigated the feasibility and effectiveness of using correlation and threshold values for face description and recognition. Bruce A. Draper et al. [17] compared the performance of two subspace projection techniques (PCA and ICA) on face recognition tasks in the context of a simple baseline system. The author shows how the relative performance of PCA and ICA depends on the task statement, the ICA architecture, the ICA algorithm, and (for PCA) the subspace distance metric.

Seyed M. Lajevardi et al. [18] investigated a novel facial expression recognition system based on hybrid face regions (HFR). The system is fully automatic with modules like face detection, facial detection, feature extraction, optimal features selection, and classification. The system automatically recognizes six expressions such as anger, disgust, fear, happiness, sadness and surprise. The selected features are classified using the Naive Bayesian (NB) classifier.

Kuldeep Singh Sodhi et al. [19] discussed and compare the performance of various PCA-based face recognition techniques. The performance of PCA is better in the cases when sum of Euclidean distance, City Block Distance, Angle, Mahalanobis Distance (E+C+A+M) is taken as distance classifier. The system combines all these features to form a face recognition System.

III. FEATURE EXTRACTION METHODOLOGY

The proposed method is shown in figure 1. The face recognition method read face image from face database. Pre-processing is done for following purposes.

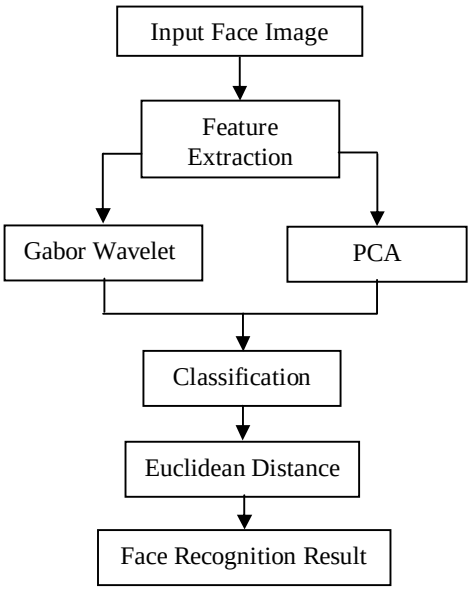

Fig.1 Proposed Method

The face recognition system is implemented in two stages: training and testing. In training stage first, images are read and features are extracted using combined features of Principal Component Analysis (PCA) and Gabor Wavelet. The classification is done by using k-Nearest Neighbor (k-NN) classifier. Euclidean distance is most often used to compare profiles of respondents across variables. Our data consist of face information on a sample of individuals, arranged as a variable matrix. We evaluate the similarity (distance) between any pair of rows. Same steps are repeated in testing stage. Finally, Euclidean Distance is used as the right measure for comparing face images to get face recognition result.

A. Principal Component Analysis

Principal Component Analysis is a dimensionality reduction technique that is used for image recognition and compression. It is also known as Karhunen-Loeve transformation (KLT) or eigenspace projection [20]. PCA is a method of transforming a number of correlated variables into a smaller number of uncorrelated variables. It decomposes a signal (or image) into a set of additive orthogonal basis vectors or eigenvectors. PCA can be applied to the task of face recognition by converting the pixels of an image into a number of eigenface feature vectors, which can then be compared to measure the similarity of two face images.

In PCA, faces are represented as a linear combination of weighted eigenvectors called as Eigenfaces [21]. These eigenvectors are obtained from covariance matrix of a training image set called as basis function. The number of Eigen faces that obtained would be equal to the number of images in the training set. Eigenfaces takes advantage of the similarity between the pixels among images in a dataset by means of their covariance matrix. When a face image is projected to several face templates called eigenfaces then the difference between the images will be calculated which can be considered as a set of features that are considered as the variation between face images. When a set of eigenfaces is calculated, then a face image can be approximately reconstructed using a weighted combination of the eigenfaces. The Euclidean distance is used to find out the distance between two face keys vectors.

B. Gabor Wavelet

The important issue in the design of Gabor filters for face recognition is the choice of filter parameters. The Gabor wavelets are self similar that is, some filters can be generated from one mother wavelet by dilation and rotation. To extract the facial appearance changes, Gabor wavelets are used as a set of multistage and multi orientation coefficients. Gabor filters [22] approach is used for face recognition to construct a filter bank with filters of different scales and orientations and to filter the given face image. A well-designed Gabor wavelet captures the properties of orientation selectivity, spatial localization and optimally localized in the space and frequency domains. It has been extensively and successfully used in face

recognition [23]. The 2D Gabor wavelet representation pioneered by Daugman in computer vision in 1980's [24].

The commonly used 2-D Gabor filters in face recognition area [23,25] are defined as in eq. (1) and (2).

$$\Phi(x,y) = \frac{f^2}{\pi\gamma\eta} \exp\left(-\left(\frac{f^2}{\gamma^2}x_r^2 + \frac{f^2}{\eta^2}y_r^2\right)\right)\exp(j2\pi f x_r) \quad ...(1)$$

$$x_r = x\cos\theta + y\sin\theta, \quad y_r = -x\sin\theta + y\cos\theta \quad ... (2)$$

where, f is the frequency of the modulating sinusoidal plane wave, γ is the spatial aspect ratio and θ is the orientation of the major axis of the elliptical Gaussian.

The modified Gabor wavelet Φ(phi) is defined as in eq. (3):

$$\Phi(x,y) = \frac{f^2}{\pi\gamma\eta} \exp\left(-\left(\frac{f^2}{\gamma^2}x_r^2 + \frac{f^2}{\eta^2}y_r^2\right)\right)(\exp(j2\pi f x_r) - K) \quad ... (3)$$

where, K is an offset parameter dependent on γ(gamma) and η(eta).

C. Classification

In this paper k-Nearest Neighbor [26] classification method is used. It is a non-parametric method for classifying objects based on closest training samples in the feature space. In k-NN classification, an object is classified by a majority vote of its neighbors, with the object being assigned to the class most common among its k nearest neighbors (k is a positive integer). If k = 1, then the object is simply assigned to the class of that single nearest neighbor. The k-NN algorithm is among the simplest of all machine learning algorithms.

D. Algorithm of Proposed Method

The proposed method of feature extraction for human face recognition divided into two parts: feature extraction, and feature classification. The algorithm of proposed method is based on PCA, LDA, and Wavelet based feature extraction techniques. After extracting the combined features, the k-Nearest Neighborhood classifier [26-28] is used for classification. The algorithm of proposed method for human face recognition is given below.

1. Load face images from face database
2. Partitioned database into training data and testing data.
3. Converting each image matrix into column vector.
4. Create image-space-matrix of size (128 x 128) pixels.
5. Apply Gabor wavelet filter to determine the features
6. Convert the training data and testing data in PCA space.
7. Determine the features using PCA.
8. Combine the Wavelet feature and PCA feature.
9. Apply classifiers – k-NN
10. Analyze the performance using Euclidean Distance

IV. FACE DATABASE

A. JAFFE Database [29]

Japanese Female Facial Expression (JAFFE) Database contains 213 images of 7 facial expressions (6 basic facial expressions + 1 neutral) posed by 10 Japanese female models. Each image has been rated on 6 emotion adjectives by 60 Japanese subjects. The database was planned and assembled by Michael Lyons, Miyuki Kamachi, and Jiro Gyoba. The photos were taken at the Psychology Department in Kyushu University.

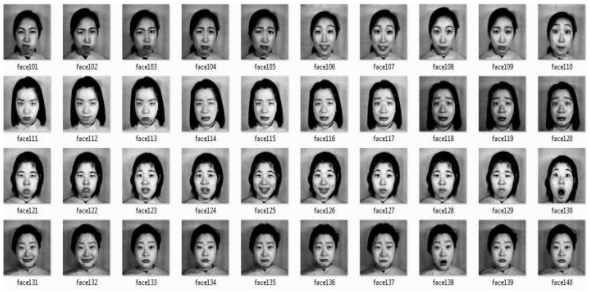

Fig.2 Some face images from JAFEE database

B. The Yale Face Database [30]

The Yale Face Database (size 6.4MB) contains 165 greyscale images in GIF format of 15 individuals. There are 11 images per subject, one per different facial expression or configuration: centre-light, w/glasses, happy, left-light, w/no glasses, normal, right-light, sad, sleepy, surprised, and wink.

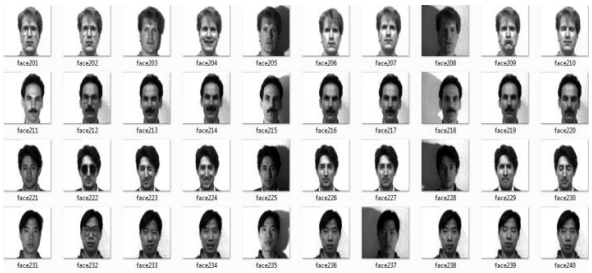

Fig.3 Some face images from Yale database

V. EXPERIMENTAL IMPLEMENTATION RESULTS

We used MATLAB 7.6.0(R2008a) to implement the experimentation of proposed method of feature extraction for human face recognition on JAFFE and Yale face databases. The proposed system consist matching techniques based on different similarity and dissimilarity measures. The template stored in the database after feature extraction is compared with input face identity based on Euclidean distance measure.

In this section, we demonstrate the efficiency of the proposed method on 40 test Images from JAFFE database and 40 test Images from Yale face database. For that we used following Mathematical and Statistical methods:

1. **False Positive** (FP) are also known as False Match (FM), False Accept or False Hit or Type 1 error
2. **False Negative** (FN) are also known as False Non-Match (FNM), False Reject or False Miss or Type 2 error.
3. **Sensitivity** or True Positive Rate (TPR) recall rate (R) is defined as the ratio of the correctly recognized faces to sum of correctly recognized faces and incorrectly rejected faces (false negative).

$$Sensitivity = TPR = R = \frac{TP}{TP + FN} \quad \ldots(4)$$

4. **Precision** also called as positive predictive value (PPV). Precision rate (P) is defined as the ratio of correctly recognized faces to the sum of correctly recognized faces and incorrectly identified faces (false positive)

$$Precision = PPV = P = \frac{TP}{TP + FP} \quad \ldots(5)$$

5. **F-Score** can be used as a single measure of performance of the test for the positive class. The F-score is the harmonic mean of precision and sensitivity/recall.

$$F\_score = 2 * \frac{Precision * Recall}{Precision + Recall} \quad \ldots(6)$$

6. **Recognition Performance Rate (RPR)** is the ratio of number of correct recognized faces and total number of test faces multiplied by 100.

$$RPR = \frac{Number\ of\ correct\ recognized\ faces}{Total\ Number\ of\ test\ faces} * 100 \quad ..(7)$$

Sample Results of Face Recognition

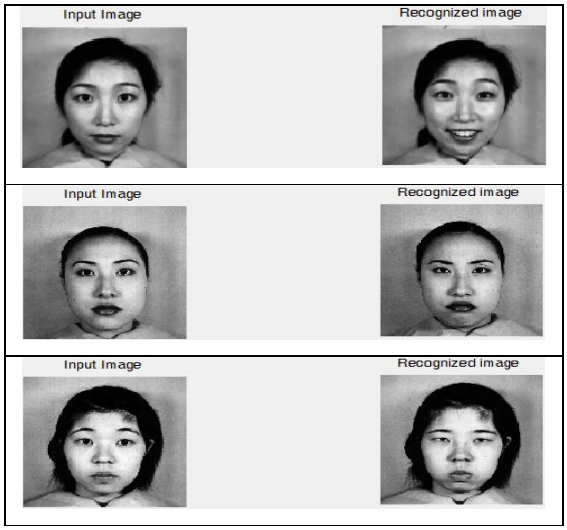

Fig. 4 Some input and recognized face recognition results from JAFFE database

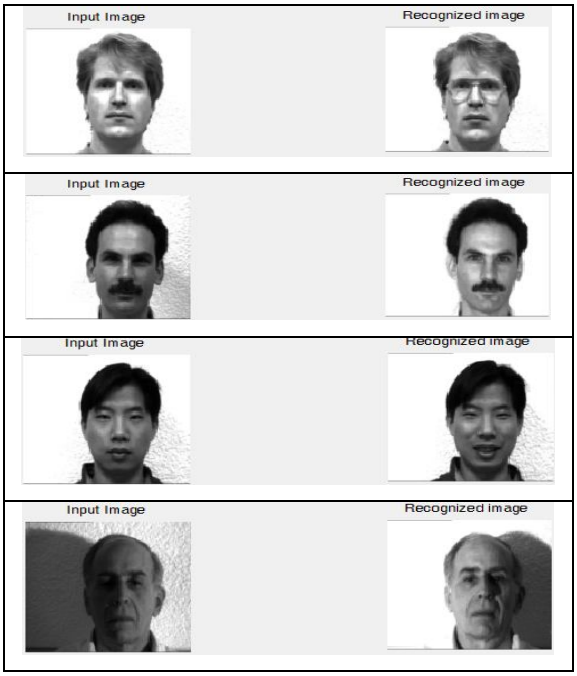

Fig. 5 Some input and recognized face recognition results from Yale database

Table 1: Performance analysis of JAFFE-DB

SNo.	Performance Parameter	Result
1	TP	35
2	FP	05
3	FN	0
4	Precision/PPV	0.875
5	Sensitivity/TPR	1
6	F-score	0.933
7	**Recognition Performance Rate**	**87.5%**

The results obtained on JAFFE database for the proposed method are promising and the system is able to achieve good performance in human face recognition. The recognition rate of proposed method is found to be **87.5%**.

Table 2: Performance analysis of the Yale-DB

SNo.	Performance Parameter	Result
1	TP	34
2	FP	06
3	FN	0

4	Precision/PPV	0.85
5	Sensitivity/TPR	1
6	F-score	0.9189
7	**Recognition Performance Rate**	**85%**

The results obtained on Yale database for the proposed method are promising and the system is able to achieve good performance in human face recognition. The recognition rate of proposed method is found to be 85%.

Table 3: Performance Comparison of proposed Method on JAFFE Database with other known method

Author	Technique	Recognition Performance
Shinohara [31]	HLAC + Fisher weight maps	69.4%
Lyons [32]	Wavelet + PCA + LDA	75%
Huang, M. W. [33]	GPLVM + SVM	65.24%
Mingwei Huang [34]	SNE + SVM	73%
C. Shan et al. [35]	LBP +Template Matching	79.1%
	LBP+SVM(RBF)	88.9%
Proposed Method	**PCA+Wavelet with k-NN**	**87.5%**

Table 4: Performance Comparison of proposed Method on the Yale Face Database with other known method

Author	Technique	Recognition Performance
Ripal Patel et al. [36]	Cross Correlation	64.7%
	PSR (Peak to side-lobes ratio)	68.3%
	Eye Distance	72.72%
	PCA	75%
Zhou D. et al. (2006)[37]	LDA	81.89%
	2D-LDA	86.57%
Proposed Method	**PCA+Wavelet with k-NN**	**85%**

VI. CONCLUSION

The proposed approach is definitely simple, easy and faster to implement identification, verification and authentication. The input face image from JAFFE and Yale face databases (testing dataset) and it is recognized from the training dataset. Recognition is done by finding Euclidean distance between the input face image and our training face dataset. Our method was tested on two datasets JAFFE and Yale. The simulation results showed that our proposed method achieved promising performance measures sensitivity, recall, F-score and recognition performance rate than other known methods. In future this work will be extended to improve the recognition accuracy of the algorithms.

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Jageshvar K. Keche is a Research Scholar Pursuing Ph. D. in Computer Science. He is currently working as Lecturer in Department of Computer Science, SSESA's, Science College, Congress Nagar Nagpur.
Email Id- jkkeche@gmail.com, jkkres@gmail.com

Dr. Mahendra P. Dhore is Associate Professor in Computer Science, Department of Electronics & Computer Science, RTM Nagpur University, Nagpur. He is having teaching experience of more than 18 years at UG & PG level. His research areas include Digital Image Processing, Document Image Analysis, Mobile Computing & Cloud Computing. He is Member of IEEE, IAENG, IACSIT, IETE, and ISCA.
Email Id–mpdhore@ieee.org, mpdhore@rediffmail.com