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PERFORMANCE ANALYSIS OF HUMAN FACE RECOGNITION

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ABSTRACT

Human Face recognition is one of the most important and challenging research area in computer vision and pattern recognition. It has potential applications in different aspects of day-to-day life. To identify the human face image by matching the main features of face image is one of the hot topics in biometrics. This paper discusses the feature extraction techniques for human face recognition and performance analysis with other methods. For that purpose we used different distance metrics such as Euclidian distance, City block distance and Chess board distance. The proposed method test image features are compared with training face features using distance metrics. The experimentation is performed on JAFEE and Face94 face databases. Here two hundred images from two databases are taken and calculates the correct and wrong recognitions of human face. The obtained results compared with other methods on same databases. The proposed method is promising to achieve good performance in human face recognition.

Keywords: *PCA, LDA, Gabor wavelet, EUC, CTB, CSB, Face databases JAFEE and Face94.*

I. INTRODUCTION

In biometrics basic traits of human face is matched tithe existing face data and depending on result of matching identification of a human face being is traced. 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[1].

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.

Because of the nature of the problem, not only computer science researchers are interested in it, but neuroscientists and psychologists also. It is the general opinion that advances in computer vision research will provide useful insights to neuroscientists and psychologists into how human brain works, and vice versa [2].

Most of the commercial applications of the face recognition are identity authentication, criminal identification, security system, image and film processing, video conferencing and credit-card verification. Face recognition is considered to be an important part of the biometrics technique, and meaningful in scientific research [3]. It has the potential of being a non-intrusive form of biometric identification.

In this paper, we studied and presented face recognition using PCA, LDA, and Gabor wavelet method. The rest of this paper is organized as follows: In Section II introduces and discusses the used feature extraction techniques PCA, LDA, Gabor wavelet method for face recognition in detail. In Section III discusses distance metrics. In Section IV discuss the proposed method. In Section V, shows experiments on JAFEE and Face94 face databases. Finally, conclusions are drawn with some discussions.

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II. USED FEATURE EXTRACTION TECHNIQUES

a. Principal Component Analysis

Principal Component Analysis (PCA) [4-5] is a dimensionality reduction technique that is used for image recognition and compression. This reduction in dimensions removes information that is not useful and precisely decomposes the face structure into orthogonal (uncorrelated) components known as Eigen faces.PCA is used in all forms of analysis, from neuroscience to computer graphics. Because it is a simple, non-parametric method of extracting relevant information from confusing data sets. When a set of eigenfaces is calculated, then a face image can be approximately reconstructed using a weighted combination of the eigenfaces.

PCA algorithm consists of mathematical calculation of shape vector, mean vector of all face images, covariance matrix and Eigen vectors. The mean vector consists of the means of each variable and the variance-covariance matrix consists of the variances of the variables along the main diagonal and the covariance's between each pair of variables in the other matrix positions. Mathematically, recognition is finding the minimum Euclidean Distance (EUC), between a test image and a training image. When the new face image (test dataset) to be recognized its eigenvalue and weights are calculated. Then these weights are compared with the weights of the known face images in the training dataset. It is done by calculating the Euclidian distance, City block distance and Chess board distance between the new face image and the faces in training set.

b. Linear Discriminant Analysis

Fisherfaces approach is based on Fisher's famous Linear Discriminant Analysis. LDA [6-7] is a powerful face recognition technique that overcomes the limitation of Principal Component Analysis technique by applying the linear discriminant criterion. The main aim is to find the linear combinations of the data that maximize the between-class variability while minimizing the within-class variability. This means it tries to find a new reduced subspace that provides the best separation between the different classes in the input data.

Linear discriminant methods group images of the same classes and separates images of the different classes. To identify an input test image, the projected test image is compared to each projected training image, and the test image is identified as the closest training image. This method provides better ability to recognize a face and provides better discrimination between faces. Fisher LDA works well for different illumination and different facial expressions. A good recognition system should have the ability to adapt over time.

c. Gabor Wavelet

Gabor wavelet [8] 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 [9,17].The characteristics of Gabor wavelets are quite similar to those of human visual system for frequency and orientation representations. Wavelets are functions that satisfy certain mathematical requirements and are used in presenting data or other functions, similar to sine and cosine in the Fourier transform. However, it represents data at different scales or resolutions, which distinguishes it from the Fourier transform. An advantage of wavelet transform over other transforms is it allows good localization both in time and spatial frequency domain. Because of their inherent multi-resolution nature, wavelet coding schemes are especially suitable for applications where scalability and tolerable degradation are important.

III. DISTANCE METRICS

Normally, the classification of database images and the given query image is performed by using some distance metrics that estimates the similarity between them through some defined function. Several similarity metrics have been proposed in literature, some of which have been applied in this research work and the same are briefly described here.

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a. Euclidean distance (EUC)

It is also known as L2 − norm or nearest neighbor classifier. The basis of many measures of similarity and dissimilarity is Euclidean Distance. It is the square root of the sum of squared differences between corresponding elements of the two vectors.

EUD = sqrt[$(x_1-y_1)^2+ (x_2-y_2)^2 + (x_3-y_3)^2$ ....] …(i)

In order to compute similarities or dissimilarities among rows, we do not need to try to adjust for differences in scale. Hence, Euclidean Distance is usually the right measure for comparing face images.

b. City Block distance (CTB)

It is also known as L1 − norm, absolute value distance or Manhattan distance. It represents the shortest distance along each axis between two points. It measures the distance between two sets of feature vectors separately as:

$$d(x,y) = |x-y| = \sum_{k=1}^{L} |x_k - y_k| \quad \ldots(ii)$$

Where x and y are the feature vectors of database and the query image, respectively and L is the number of features in these vectors.

c. Chess Board distance (CSB)

The distance between two points is the sum of the (absolute) differences of their coordinates. The chessboard distance d(x,y) between the vectors x and y in an n-dimensional real vector space is given as follows.

$$d(x,y) = abs[\max(|x_i - y_i|)] \quad \ldots(iii)$$

Above similarity metrics are used in order to carry out the experimentation of the proposed framework of feature extraction for human face recognition. Next chapter covers the experimentation, performance evaluation and results.

IV. PROPOSED METHOD

The feature extraction is used to reduce the dimension of the face space by transforming it into feature representation. Features may be symbolic, numerical or both. The symbolic feature is color and numerical feature is weight. Features may also result from applying a feature extraction algorithm, classification and calculating distance measures of testing and training dataset. The combined feature extraction of PCA, LDA and Gabor wavelet are used in proposed feature extraction algorithm for human face recognition system.

The recognition result of specific person can be obtained by applying feature extraction algorithm. The related problems of feature selection and feature extraction must be addressed at the outset of any face recognition system design. The key is to choose and to extract features that are computationally feasible and reduce the problem data into a manageable amount of information without discarding valuable information.

An automated system for human face recognition is extremely desirable. The successful feature extraction for recognition of human face should have the following properties.

- Geometrical facial characteristics like the eyes, nose, mouth and chin.
- Appearance based characteristics
- Feature selection
- Filtering feature and decomposition
- Finding statistical measures
- Pattern matching and recognition

The above desirable properties are considered in feature extraction process [10].

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V. RESULTS AND PERFORMANCE ANALYSIS

In order to achieve good recognition accuracy and better performance, the experimentation of the proposed framework is carried out on both color and gray-scale face databases. For that we have used two face databases (JAFEE and Face94) which are publicly available.

a. JAFFE Database

Japanese Female Facial Expression (JAFFE) database [11] contains 213 images of 7 facial expressions (6 basic facial expressions + 1 neutral) posed by 10 Japanese female models. The photos were taken at the Psychology Department in Kyushu University. Table 1 shows the properties of JAFFE database and figure 1 shows some sample face images from the JAFEE database.

Table 1: Properties of JAFFE face Database

Name	**Description**
Color images	No (Only gray images)
No. of unique Japanese Female	10
No. of face images per female person	Some images are 20, 22, and 23 per female
Total no. of images	213
Image size	256x256
Image format	.TIFF
Different conditions	All frontal faces with different facial expressions with different pose(7 facial expressions: 6 basic facial expressions + 1 neutral)

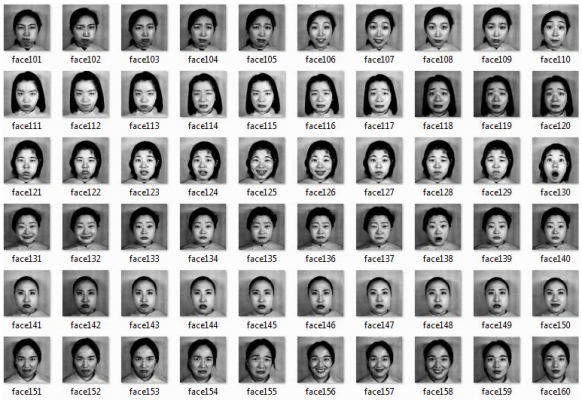

Fig. 1: JAFEE Face Database [11]
(Sample images of 10 different images per person)

b. Face94 Database

Face94 database [12] contains 3060 color face images in JPEG format of 153 individuals. Table 2 shows the properties of the Face94 database. Some color face images from the Face94 database are shown in figure 2 and the converted color to gray face images are shown in figure 3.

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Table 2: Properties of the Face94 Database

Name	Description
Color images	Yes
No. of unique persons	153 (Female- 20, Male- 113 and Male staff-20)
No. of face images per female person	20
Total no. of images	3060
Image size	180x200
Image format	.JPEG
Different conditions	All frontal faces with slightly different facial

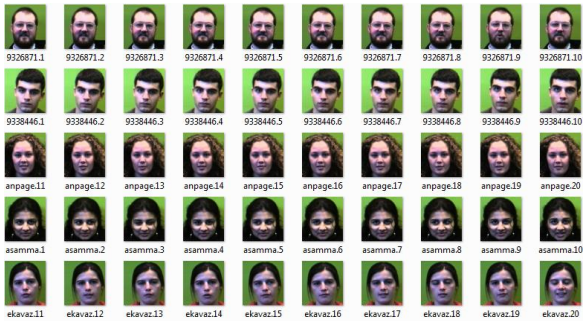

Fig. 2: Face94 Face Database (Color Faces) [12]
(Sample images of 10 different images of per person)

Fig. 3: Face94 face database
(Converted Color to Gray Faces)
(Sample images of 10 different images per person)

c. Results:

The performance evaluation of the results obtained for the face images from the respective human face databases is discussed in the subsequent sections.

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Sample results of face recognition

Fig. 4 Face recognition results from JAFFE database

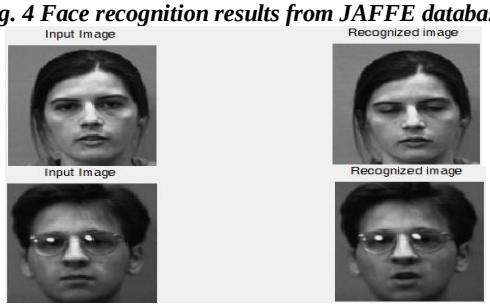
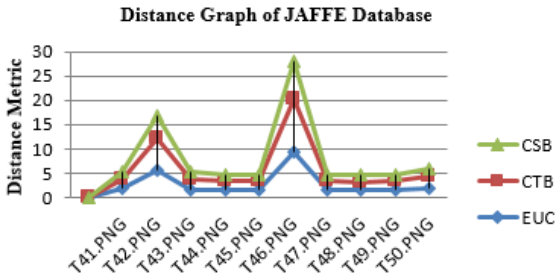


Fig. 5 Face recognition results from Face94 database

The results obtained for the proposed method are promising and the system is able to achieve good performance in human face recognition. In JAFEE database, 36 images are correctly recognised and 4 images are incorrectly recognised out of 40 test face images. This means the recognition rate of proposed method is found to be 90%.

Graph 1 and graph 2 shows the plots of Euclidean distance (EUC), City-Block distance (CTB) and Chessboard distance (CSB) results on JAFFE and Face 94 face database respectively. The results are calculated on 40 test face images and verified proposed method of feature extraction technique for human face recognition system.



Graph 1: Test face images from JAFEE database

The face images are considered here from the Face94 face database consists of frontal faces with slightly different facial expressions. In Face94 face database, 37 images are correctly recognised and 3 images are incorrectly recognised out of 40 test face images. This means the recognition rate of proposed method is found to be 92.5%.

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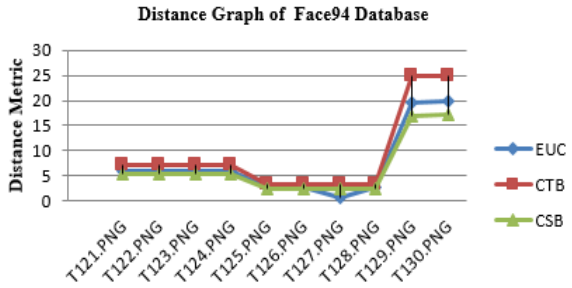

Graph 2: Test face images from Face94 database

d. Performance Analysis

The success rate of proposed method is **90%** on JAFFE Database and face recognition system achieved promising performance than most of the known methods/techniques.

Table 3: Performance Comparison of proposed Method on JAFEE database with other known methods

Author	Technique	Recognition Accuracy
Shinohara [13]	HLAC + Fisher weight maps	69.4%
Huang, M. W. [14]	GPLVM + SVM	65.24%
Mingwei Huang [15]	SNE + SVM	73%
C. Shan et al. [16]	LBP +Template Matching	79.1%
	LBP+SVM(RBF)	88.9%
Proposed Method	**PCA+LDA+Gabor wavelet**	**90%**

The success rate of our method is **92.5%** on Face94 face database.The proposed face recognition system achieved promising performance than most of the known methods. The performance evaluation of our method on Face94 dataset is listed in Table 4 along with the known methods reported and the proposed method.

Table 4: Performance Comparison of proposed Method on Face94 face database with other known methods

Author	Technique	Recognition Accuracy
S.N. Kakarwal et al.[8]	Chi Square+Entropy +FFNN	92 %
K M Poornima et al. [22]	DWT+k-NN	83.50%
Proposed Method	**PCA+LDA+Gabor wavelet**	**92.50%**

The performance of Recognition Rate on Face94 database is higher than JAFEE database. Performance of proposed method has given promising excellent result on Face94 face database. Wavelet based approaches are used to obtain good spatial frequency features. Dimensional reduction technique PCA and LDA based approach are used to extract the feature space significantly. The proposed feature extraction technique is superior to existing traditional

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techniques. This proposed method is superior in recognizing frontal face images.This research work will be important in a number of biometric applications and future research directions.

VI. CONCLUSIONS

Face recognition is a challenging and complicated process as human face changes due to different facial expressions, lighting conditions, pose variations and occlusions. The increased knowledge about the different ways, people identified and recognize each other may help to develop practical automatic face-recognition systems.

The proposed method of human face recognition is based on PCA, LDA, Gabor wavelet. PCA, LDA and Gabor wavelets are used to reduce the dimensionality of face images. PCA employs holistic features for face recognition and LDA has been used for extracting the independent features. Recognition is done by finding EUC, CTB and CSB between the input face image (testing dataset) and our training face dataset. The results were obtained using proposed method using MATLAB.

The overall Recognition Performance Rate (RPR) of our method is 90% on JAFFE database and 92.5% on the Face94 face database.The proposed face recognition method achieved better performance than most of the other known methods/techniques on JAFEE and Face94 face databases.Some of the biometric factors such as Iris and Finger print recognition can be added with Face recognition to improve the performance.

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