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Efficient Facial Recognition Using PCA-LDA Combination Feature Extraction with ANN Classification

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Abstract- Biometrics is a rapidly growing technology, which has been widely used in forensics such as prison security, criminal identification and secured access. Face is one of the commonly acceptable biometrics used by humans in their visual interaction. The challenges in face recognition stem from various issues such as aging, facial expressions, variations in the imaging environment, illumination and pose of the face. In this paper, we propose combination of two techniques Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA) for extraction of facial features and classification of faces with artificial neural networks. Then, we compare the results of proposed technique with PCA and LDA classification using Euclidean Distance. The principal objective of facial feature extraction is to capture certain important features that are unique for a person.

Keywords- Face Recognition, Feature extraction, Classification, PCA, LDA, ANN, Euclidean Distance and ORL Database.

I. INTRODUCTION

Biometric recognition means automated recognition of individuals based on the biological and behavioural traits. Examples of biometric traits are fingerprint, face, palm print, retina, hand geometry, iris, voice, and signature.

Face Recognition- Face recognition is a rapidly growing area today for its many uses in the fields of security, biometric authentication, and other areas. There are many problems that exist due to the number of factors, which can affect the facial images. When processing images, one must take into account the different parameters such as, variations in light, facial expressions, image quality, persons pose. In order to successfully be able to identify persons correctly, there must be some ways to account for these variations.[10]

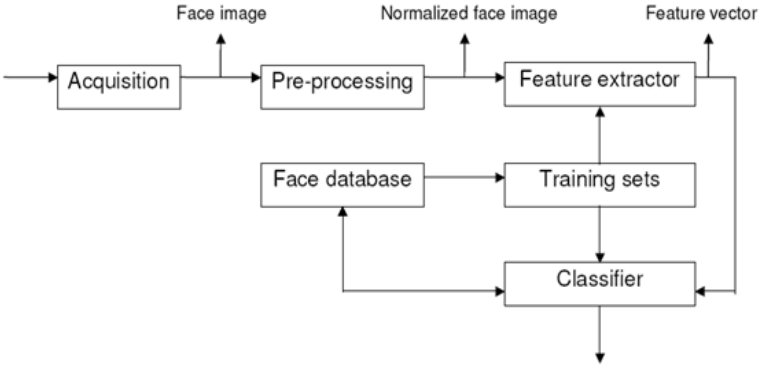

Fig1. Face recognition Steps

Many researchers are working on this field from many of the years, many algorithms and techniques are developed to update the traditional systems such as are PCA, LDA, and Gabor etc. But these approaches individually are not that much efficient in some of the cases, so the mixing of the algorithms are done as an example if PCA approach is used, it will provide better results for small datasets. So to overcome these disadvantages the continuous research is processed to get better results. There is one issue too if the algorithms are not getting advanced the fake parties are also able to make the algorithm crack able. So there is a need to develop an algorithm which will work as advanced and modified approach to make classification that much complex that will not be easy to crack up to an extent.

This paper is organized as follows: Section II describes the related work, Section III describes the techniques of feature extraction and classification and Section IV describes the experimental conditions and results. Finally conclusion is stated in Section V.

II. RELATED WORK

Many face recognition techniques have been proposed in past. Abhishek Bansal, proposed two algorithms for feature extraction and also explained the challenges associated with face recognition such as intensity, pose, structural

components, Image rotation, poor quality, facial expression, unnatural intensity, occlusion. Illumination etc [1]. Amritpal Kaur, proposed PCA based on eigen faces which reduce dimensions using covariance matrix and LDA based on linear discriminant or scatter matrix. Merits and demerits of both methods are compared and concluded that LDA can give effective results by combining with PCA [2].

Dian Retno Anggraini, explained three steps for face recognition which are image pre-processing, feature extraction and clustering. The database used in this research is Essex database which consists of 7900 images of 365 individuals both male and female. This concluded that Essex dataset give better results using PCA [3].

Erwin Hidayat, presents a comparative study of feature extraction using PCA and LDA with time and accuracy as evaluation parameters for both algorithms. This experiment was conducted in five face datasets with different disturbances. In the end result showed that LDA is better in accuracy while PCA is faster [4].

Gin-Der Wu, described that fuzzy neural network (FNN) used for classification purpose. PCA coverts the images into uncorrelated variables known as eigen faces or principal components and LDA updates the weights which are efficient for discrimination. FNN use the gradient descent method to reduce the cost function. Thus, this experiment verifies that proposed method works well [5].

Lerato Masupha, focus on different types of recognition approaches which are holistic, feature or geometry based and hybrid approach and also explains the challenges faced by all the approaches. Moreover, different performance metrics are explained for eg False rejection ratio (FRR), False acceptance ratio(FAR), Equal error rate(ERR) etc[6].

N.G.Chitaliya, proposed an efficient face recognition method which is based on discrete Contourlet transform using PCA and Neural Network. The Contourlet coefficients of low frequency and high frequency in distict scales and various angles are obtained. These coefficients used to match the feature vector coefficients of training dataset using Neural Network Classifier and these results are compared with the Euclidean Distance Classifier[7].

Nan Zhao, proposed a dimension reduction method which may be considered as hybrid of both PCA and LDA. It only considered reduction to 1-D space and limit the discrimination performance on data which has more clustering patterns. In addition to this, it develop computational strategies to estimate optimal subspace[8].

Navneet Jindal, demonstrated the face detection system of coloured face images which is invariant to the background and other acceptable illumination conditions. The global features extraction is completed using PCA eigen face computation method and the detection part is evaluated using multi layered feed forward Neural Networks with back propagation[9].

Steven Fernandes, evaluate the face recognition rate of various algorithms. The experiment used the ORL and SHEFFIELD databases consisting 100 components give the face recognition rate of 100%. The next best was 99.70% on PCA-IN on ORL database. Among different LDA algorithms , it was found that IALDA gives the best recognition rate of 98.9%. [10]

III. PROPOSED TECHNIQUES

Pre-processing- Image pre-processing includes histogram equalization, image size normalization, and conversion rgb or coloured images into grey scale images. This module automatically reduce every facial image to X*Y pixels based on user request.

A. Feature Extraction Techniques-

The goal of feature extraction is to extract important set of interpersonal discriminating both geometrical and photometrical features of the face. Methods for feature extraction include PCA, LDA, LBP, SIFT, SURF etc.

1) Principal component analysis- PCA is a statistical approach. The main purpose of this approach is to reduce the dimensionality of the face image space to the similar intrinsic dimensionality of the feature space. The Principal component analysis is used widely in image compression and feature extraction. This method involves a mathematical function which transforms a number of correlated variables into a number of uncorrelated variables known as principal components or eigen faces. It also computes a optimal and compact description of the data set.[1] This algorithm has various steps-

Let total M images with dimension N×N i.e $N^{2.}$

X_i is the mean of ith image.

i. Total mean $\bar{X}$

$$\bar{X} = \frac{1}{M}\sum_{i=1}^{M} X_i$$

ii. Subtract the total mean from individual mean of each image.

$\Phi_i = X_i - \bar{X}$

iii. Form the normalized vectors

$A= [\Phi_1,\Phi_2,\ldots\ldots\Phi_M]$ $N^2 \times M$

iv. Co-variance matrix

$C=AA^T$

$C=\frac{1}{M}\sum_{n=1}^{M} \Phi_n \Phi_n^T$

Dimensions $N^2 \times M$, $M \times N^2 = N^2 \times N^2$ dimensions

So reverse it

C= A^TA

Dimensions $M \times N^2$, $N^2 \times M = M \times M$

v. Compute eigen values and eigen vectors of covariance matrix, Select eigen faces with maximum eigen values

$\lambda_1 > \lambda_2 > \cdots \ldots \lambda_n$

$V_1, V_2, \ldots\ldots V_n$

2) Linear Discriminant Analysis- LDA is a statistical approach used for classifying samples of some unknown classes on the basis of training samples with known classes. LDA uses PCA for low dimensional representation and project this representation onto a lower dimensional space where the ratio of within class scatter matrix and between classes scatter matrix is calculated. LDA uses classes based on the face images in database. It divides the databases into some classes according to different persons. Based on these classes LDA performs the required operations. These classes are created randomly.[2]

i. Take images and classify them in C classes.

ii. μ_i is the mean vector of class i= 1,2,3……C

iii. Let M_i is the number of samples within class i

iv. Total number of samples M

M= $\sum_{i=0}^{C} M_i$

v. Calculation of within and between class scatter

Within Class Scatter matrix

$S_w = \sum_{i=1}^{C} \sum_{j=1}^{M_i} (y_j - \mu_i)(y_j - \mu_i)^T$

Y_j is the total mean of each sample

Between Class Scatter Matrix

$S_b = \sum_{i=1}^{C} (\mu_i - \mu)(\mu_i - \mu)^T$

Mean of entire dataset

$$\bar{\mu} = \frac{1}{C} \sum_{i=1}^{C} \mu_i$$

Ratio of scatter between class and within class

Maximize $\left(\frac{S_b}{S_w}\right)$

B. Classification Methods-

Classification or feature matching is the actual recognition process. The feature vector obtained from testing set is matched with training set. Minimum distance classifier is a simple method which includes Euclidean distance, Normalized Euclidean distance and Mahalanobis Distance. Other advanced method is artificial neural networks.

1) Euclidean Distance- Euclidean distance is the straight line distance between two points or two pixels. The two points P and Q in 2- dimensional Euclidean spaces. P with the coordinates p1, p2 and Q with coordinates q1, q2. The distance between two points that is p and q is calculated by finding square root of the sum of the squares of the differences between the respective coordinates of the these points. The two dimensional the Euclidean distance between two points is defined as-

$$d(\mathbf{p}, \mathbf{q}) = \sqrt{(p_1 - q_1)^2 + (p_2 - q_2)^2 + \cdots + (p_n - q_n)^2} = \sqrt{\sum_{i=1}^{n} (p_i - q_i)^2}.$$

2) Artificial neural networks (ANNs)- In the field of machine learning and cognitive science, Artificial neural networks are a family of models which are inspired by biological neural networks. These are used to approximate or estimate functions that can depend on a very large number of inputs and which are generally unknown. Like other machine learning neural network has been used to solve a wide range of tasks that are very difficult to solve using simple rule based programming, including speech recognition and also computer vision. In artificial neural network, simple nodes are called neuron. All neurons are connected together to form a network that mimics a biological neural network. These neurons exchange messages between each other and connections have numeric weights that can be tuned on the basis of experience.[9]

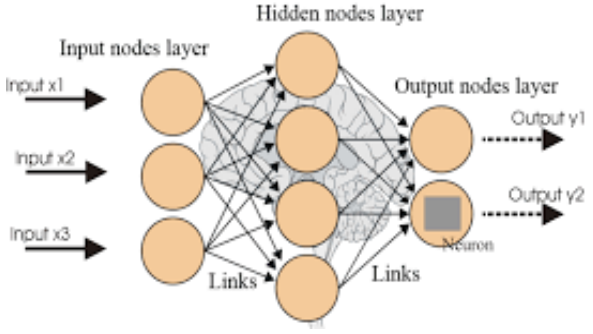

Fig.2 Neural Network Structure

IV. EXPERIMENTAL PROCEDURE AND RESULTS

Database- In this paper we have used ORL database. There are total 400 images in which total 40 subjects and ten different images of each subject. For some individuals, the images were taken at different times, varying lighting conditions, different facial expressions such as open or closed eyes, smiling or not smiling and facial details for eg glasses / no glasses. The original image size is 92×112 with 256 gray-scale.

Experimentation-

I. Pre-processing - In first step we have taken 20 sample images for training from ORL database. Then normalize the sample images to reduce the lighting variations and other disturbance so that further algorithm can run with better accuracy.

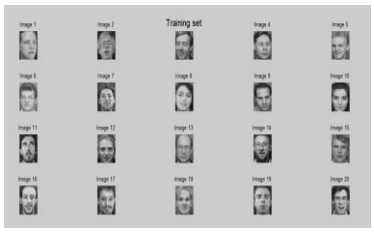

Fig.3 Training sample images

II. Run PCA algorithm to find mean of all training images and corresponding eigen faces- which includes the eigen vectors with highest eigen values.

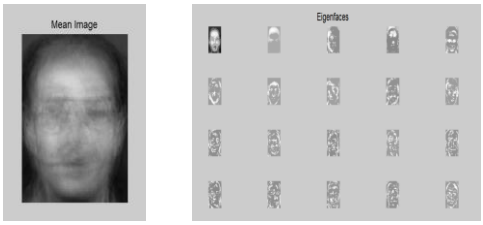

Fig.4 Average face and eigen faces

III. Then PCA algorithm gives the recognized image with the help of Euclidean distance. The Euclidean distance between test and correct recognized image is very less while it is more in case of false recognized image.

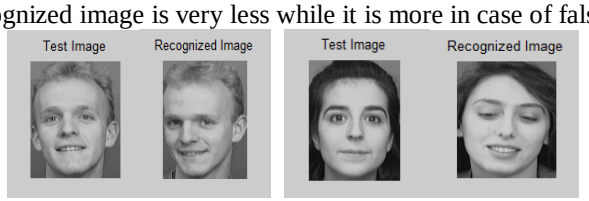

Fig.5 Test images and Recognized images

IV. Classification with ANN - Training of neural network with combined features. Combined features are calculated by merging the eigen faces and fisher faces obtained by PCA and LDA respectively. In the experiment a back propagation neural network is used with newcf function. It is a two hidden layer neural network with one input and one output layer. This function takes 20 neurons as an input argument and trained on 100 epochs. After Neural network trainings, the image for testing is selected and it recognized corresponding image from database.

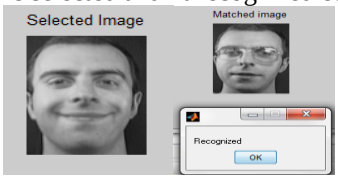

Fig.6 Test image and Recognized image

V. If the user input the query image of a person whose images are not present in the training set then this algorithm simply display image is not recognized, instead of displaying other person's image. So False Acceptance Rate (FAR) is zero.

Fig.7 Image not matched with trained data set

From the ORL database we have taken different number of images to form trained set. Then calculate recognition accuracy, computational time and false rejection rate (FRR) for all the three techniques.

In first sample total 10 persons are selected –5 images of each individual are used for training set and remaining 5 are used for testing set i.e total 50 for training and 50 for testing. After that, for second and third the number of training images are 100 and 150 respectively.

I. Recognition accuracy in terms of percentage on three types of training samples.

Table.1 Recognition accuracy

Training Images	Test Image	PCA Euclidean Distance	LDA Euclidean Distance	PCA+LDA+ANN
50	50	96	98	100
100	100	86	91	100
150	150	85.33	90.6	100

II. Computational Time in seconds for three techniques.

Table.2 Computational Time

Algorithms	Computational Time(seconds)
PCA +Euclidean Distance	1.18
LDA +Euclidean Distance	2.71
PCA+LDA+ANN	18.5

III. False Rejection Rate (FRR) - reject individuals who are registered or trained in database.

Table.3 False Rejection Rate

Training Images	Test Images	PCA+ Euclidean Distance	LDA+ Euclidean Distance	PCA+LDA+ANN
50	50	0.04	0.02	0
100	100	0.14	0.09	0
150	150	0.146	0.093	0

IV. Bar graph for recognition accuracy in percentage (%).

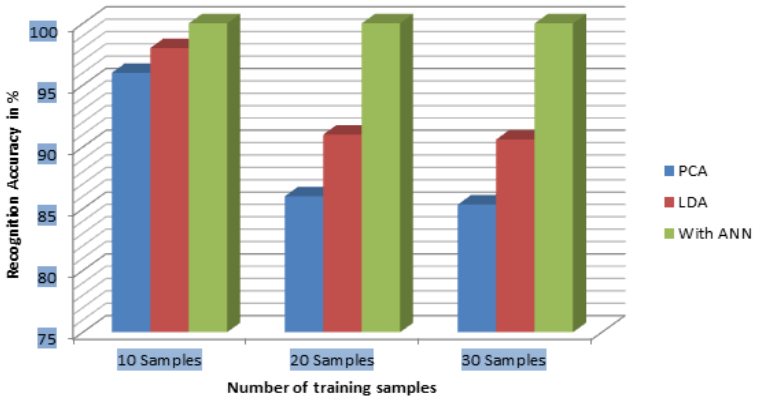

Fig.8 Recognition accuracy

V. CONCULSION AND FUTURE SCOPE

Conclusion: Face recognition systems are widely used biometric systems that plays important role in the surveillance systems as they don't required the objects. From the results obtained it is concluded that this proposed method is better than the traditional method of the face recognition as this system is more accurate. ANN classifier gives more accuracy on larger database i.e 100% while PCA with Euclidean distance gives less recognition accuracy i.e 85.33%. Computational time of both PCA and LDA is less than that of proposed techniques of ANN. False rejection rate (FRR) of PCA+LDA+ANN is negligible.

Scope for Future Work: In future this technique can be enhanced further by using some other classifier that can increase the accuracy of the system. Various trending techniques can be used for the feature extraction process. Better are the extracted features, more accurate is the system and thus the efficiency of the system would increase.

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