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Face Recognition Using PCA, FLDA and Artificial Neural Networks

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Abstract— Face recognition is a system that identifies human faces through complex computational techniques. The paper explains two different algorithms for feature extraction. These are Principal Component Analysis and Fisher Faces algorithm. It then explains how images can be recognized using a backpropagation algorithm on a feed forward neural network. Two training databases one containing 20 images and the other containing 80 images are used to test the proposed techniques. Later the results are compared and tabulated.

Keywords— eigenfaces, fisherfaces, neural network, backpropagation, minimum euclidean distance

I. INTRODUCTION

Biometrics based human computer interfaces(HCI) are gaining popularity day by day. These HCI methods are influenced by the ability of humans to perceive and interpret audio and visual information. Such systems identify humans by their characteristics or traits and this forms the basis of authentication and access control. This allows for the development of much better security and access control systems. Face recognition is such a system that distinguishes among various human faces and identifies a face from a digital image or a video frame from a video source. One of the ways to do this is by comparing selected facial features of the image with those in a facial database. The way humans recognize faces is highly remarkable and efficient irrespective of the changes in the visual input due to lighting conditions, background, aging, glasses.[1] To build a system that can match humans in this process is highly desirable yet very difficult to build. A basic face recognition system can be divided into following sub-modules. Detection, alignment, feature extraction, and matching.[2] The detection and alignment are preprocessing steps before face is recognized. Face detection locates a face in an image.. *Face alignment* aims to normalize the face images with respect to geometrical properties, such as pose and size, using geometrical transformation. The face is usually further normalized with respect to photometrical properties such illumination and gray scale. After a face is normalized geometrically and photometrically, *feature extraction* is performed to provide effective information that is useful for distinguishing between faces of different persons and stable with respect to the geometrical and photometrical variations. For *face matching*, the extracted features of the input face is matched against those faces stored in the database; it outputs the identity of the face when a match is found with sufficient confidence or indicates an unknown face otherwise[1].

II. RESEARCH METHODOLOGY

A. Proposed System

In the proposed system, the process of face recognition will be sub-divided into following tasks. These are

- Training
- Learning
- Identification

1) Training: A training set will be created that will contain n number of images. The features of every image contained in this set will be extracted using PCA or FLDA. The output is a set of Eigen Faces or Fisher Faces. This particular set is found to represent the pattern of that image.

2) Learning: Once the pattern of the test image is obtained it is given to the learning module which implements the neural network. Then the neural network is taught to identify the correct person by giving this pattern as input. A neural network is a network that imitates the working of the neural brain. The output of this module is a weight file that represents each image as a weight percentage of eigenfaces or fisher faces.

3) Identification: A person's image is given as input. Then it extracts the patterns from the image as in training face. Then by using the weight file which is generated in the training module the values of the image are compared with the values of the images stored in the database by using regression. Then it identifies the correct person and provides the person's name as output.

B. Database Design: The project aims to identify a given input image. For this two types of image databases are required training and testing database. There are two databases that have been selected as the training database the first is as follows.

1) Training Database1: The database consists of a set of 80 colored JPEG images of size 200 X 180. These are 8 images each of 10 individuals with two or three changes in the expressions. This acts as a repository through which the validity of the input image is checked.

2) Training Database2: The database consists of a set of 20 colored JPEG images of size 200 X 180. These are 2 images each of 10 individuals with changes in the expressions.

3) Testing Database: The database consists of a set of 10 colored images. These are used to serve as input to the face recognition system.

III. IMPLEMENTATION

Two algorithms for feature extraction are being used in this project. The first is Principal Component Analysis (PCA) and the other is Fishers Discriminant Analysis. After the features are extracted neural networks and mininmum Euclidean distance are used as classifiers that recognize image.

The project aims to implement four different techniques these are as follows:

- Principal Component Analysis (PCA) and Minimum Euclidean Distance
- Principal Component Analysis and Artificial Neural Networks
- Fishers Linear Discriminant Analysis (FLDA) and Minimum Euclidean Distance
- Fishers Linear Discriminant Analysis and Artificial Neural Networks

A. Principal Component Analysis and Minimum Euclidean Distance

Principal component analysis is applied to find the aspects of face which are important for identification. Eigenvectors (eigenfaces) are calculated from the initial face image set. New faces are projected onto the space expanded by eigenfaces and represented by weighted sum of the eigenfaces. These weights are used to identify the faces[3]. The process converts every image into a one dimensional array and stores them together in a matrix. After this the mean image of the database is calculated which is as follows.

Fig. 1. Mean Image

This image is subtracted from every image in the database and later a set of 19 eigenfaces for each image are calculated and stored in a matrix. When a test image is entered its eigenfaces are calculated using the same technique. And the image is recognized by these values with the ones of the training database using Minimumum Euclidean Distance.

B. Principal Component Analysis and Feedforward Neural Network

This implementation is similar to the one mentioned above except here a feedforward neural network is implemented as classifier in place of minimum Euclidean Distance. The eigenfaces of the training database are used to train a feedforward neural network that implements backpropagation algorithm[4,5]. The parameters of the neural network are as follows.

- Number of layers: 3 (input, one hidden, output layer)
- Number of neurons in input layer : Number of eigen faces to describe the faces (19)
- Number of neurons in hidden layer : 10
- Number of neurons in output layer : 80/20(large/small database)

C. Fishers Linear Discriminant Analysis:

It is a mathematical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into set of values of linearly uncorrelated variables called Principal Components. In this project the Fishers Discriminant analysis is applied to find the aspects of face which are important for identification. Fisherfaces are calculated from the initial face image set. New faces are projected onto the space expanded by fisherfaces and represented by weighted sum of the fisherfaces[6]. The matching in this case is done using both the techniques mentioned above. These are as follows

- Minimum Euclidean Distance
- Feedforward Neural Network

The series of steps performed in feature extraction using PCA and FLDA are similar, the difference in the two techniques lies in

- Internal Computation
- Accuracy Rate
- Execution Time
- Space Occupied

IV. RESULTS AND DISCUSSION

The entire implementation is divided into two parts first it is implemented in Matlab R2009a on a small database and later on a larger database. The comparisons are made on the basis of accuracy and execution time. These results are tabulated and presented graphically in this section.

A. Results for small database containing 20 images

TABLE I
COMPARISON FOR SMALLTRAINING DATABASE

Methodologies	**Accuracy(%)**	**Execution Time(sec)**
PCA+ Minimum Euclidean Distance	100	.124296
PCA+ ANN	66.66	.51114
FLDA+ Minimum Euclidean Distance	80	.04579
FLDA+ ANN	56.66	.64037

Graphical representations of the above table are as follows

1) Combined Accuracy results:

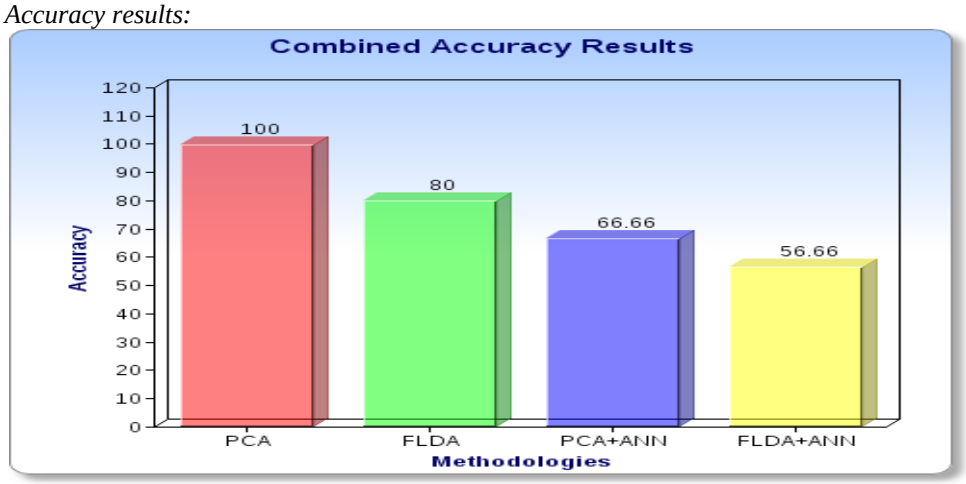

Fig. 1 : Graphical Representation of Combined Accuracy Results for Small Database

2) Combined Execution Time results:

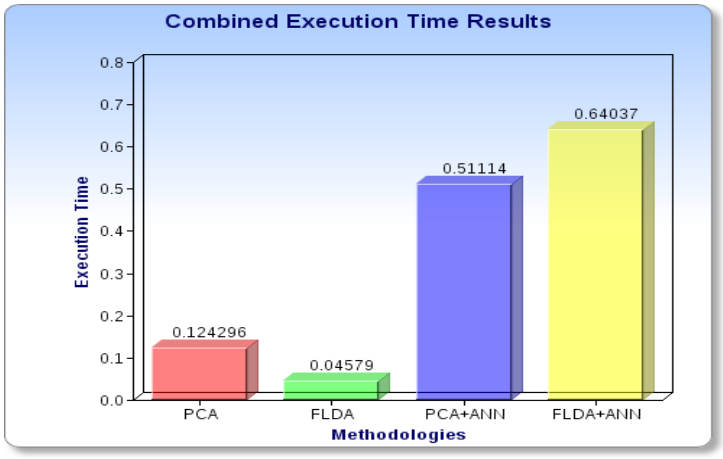

Fig. 3 : Graphical Representation of Combined Execution Time Results for Small Database

B. Results for small database containing 80 images

TABLE 2
COMPARISON FOR LARGE TRAINING DATABASE

Methodologies	**Accuracy(%)**	**Execution Time(sec)**
PCA+ Minimum Euclidean Distance	100	.53531
PCA+ ANN	87	2.57155
FLDA+ Minimum Euclidean Distance	90	.12643
FLDA+ ANN	76.66	1.74055

Graphical representations of the above table are as follows

1) Combined Accuracy results:

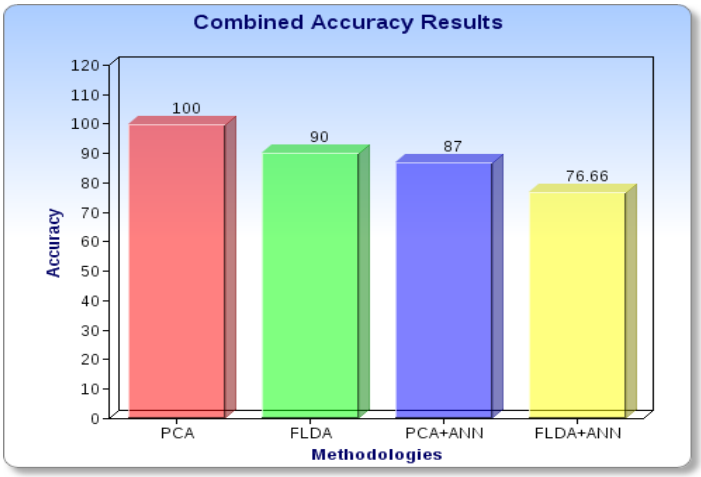

Fig. 4 : Graphical Representation of Combined Accuracy Results for Large Database

2) Combined Execution Time results:

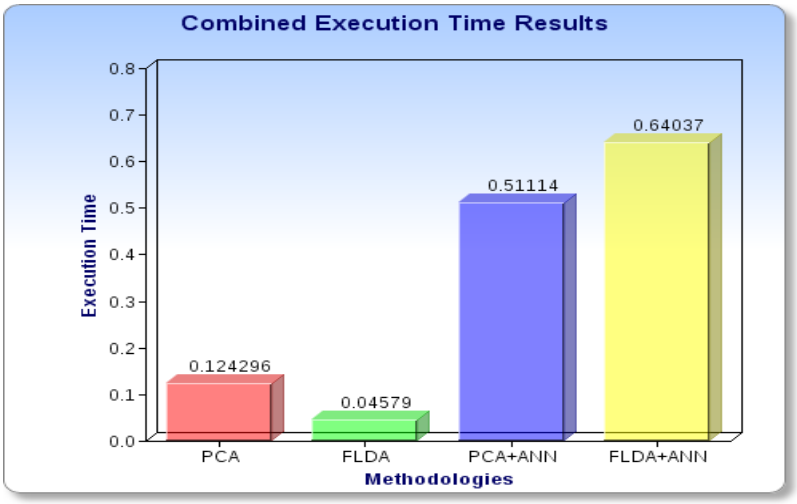

Fig. 5 : Graphical Representation of Combined Execution Time Results for Large Database

V. CONCLUSIONS

From the entire study and implementation of all the four methodologies in the project the following conclusions are drawn.

1. If we take accuracy into consideration, then "Principal Component Analysis" is considered as the best algorithm.
2. If time for recognition is the considered parameter, then "Fishers Linear Discriminant Analysis" approach is the best.

3. If both the parameters are in the focus of consideration, then we can say that "Principal Component Analysis" is the best approach of face recognition for both small and large databases.
4. Principal Component analysis combined with Artificial Neural Networks is always stated to be a better approach but this is only when the training database is large almost containing 300 to 400 images. Otherwise PCA alone is very efficient in recognizing faces.

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