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Human Face Recognition Using PCA with BPNN

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Abstract: ***In this research paper we have developed a human face recognition system using principal component analysis (PCA) with back propagation neural network (BPNN). There are many techniques have been used since now for this purpose but here in this research paper our approach has concluded that principal component analysis with back propagation neural network worked even better than the individual principal component analysis. Thus we have developed a face recognition system for human beings using both above techniques.***

Keywords: Biometrics, Face detection and recognition, Principal Component Analysis, Euclidean distance, Eigen faces, Back Propagation Neural Network, MATLAB

1. Introduction

Face recognition is an important research topic in the field of computer vision and pattern recognition and has become a very active research in recent decades. It covers the content of many disciplines, and has a wide value of usage, particularly has extensive and specific purposes in an important area of social security institution. Because of its convenience in sampling and its recognition without contacting with the target it can be a very good use. However, human face is non-rigid, as time changes, in different light illumination, the face image is changed, and this which makes Face recognition extremely difficult. In short, the face recognition is still a challenging issue. It needs further research to find a suitable algorithm.

During the past decades, face recognition has received increased attention and has advanced technically. Many commercial systems for still face recognition are now available. Recently, significant research efforts have been focused on video-based face modeling/tracking, recognition and system integration. New databases have been created and evaluations of recognition techniques using these databases have been carried out. Now, the face recognition has become one of the most active applications of pattern recognition, image analysis and understanding.

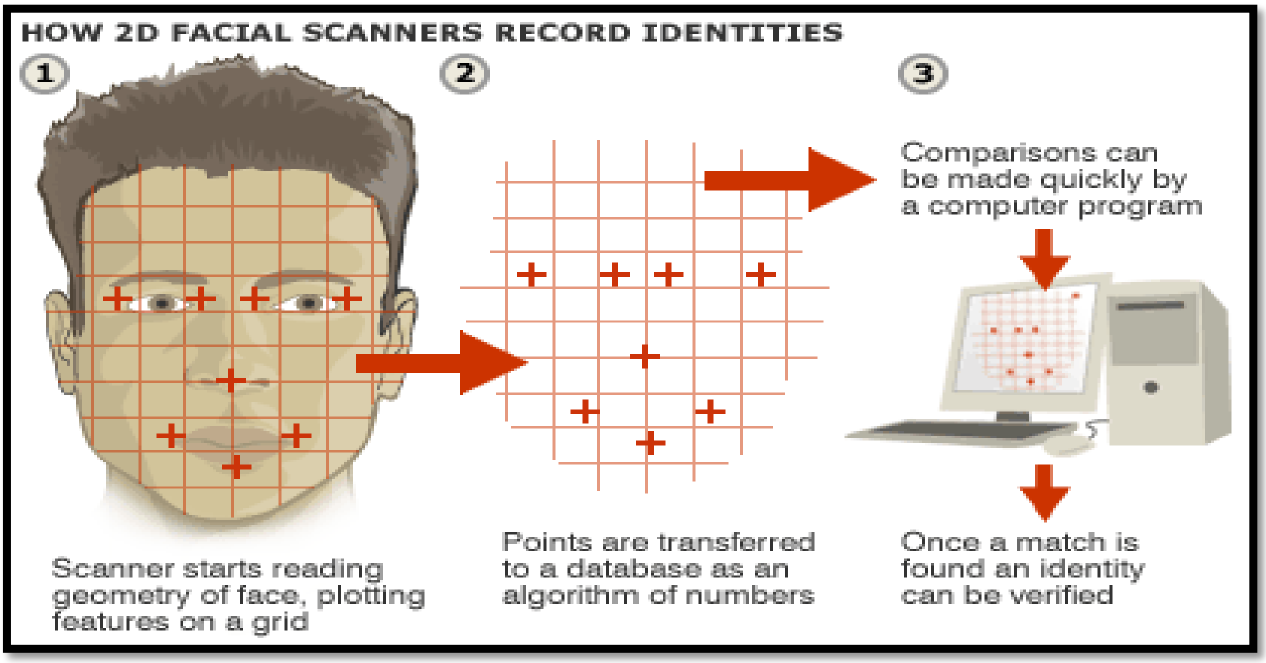


Figure 1: Showing general process for 2 dimension face recognition [10]

As shown in the above figure 1 similarly, we have developed a 2D face recognition system. As we all know that previously security features were not so much strong as required. So in that case intruders and heckars were easily gets involved in bleaching our security phenomenon. But now human face recognition strongly finishes such kind of gaps which are essential for a secure system.

2. Biometrics

Biometrics is used in the process of authentication of a person by verifying or identifying that a user requesting a network resource is who he, she, or it claims to be, and vice versa. It uses the property that a human trait associated with a person itself like structure of finger, face details etc. By comparing the existing data with the incoming data we can verify the identity of a particular person [1].

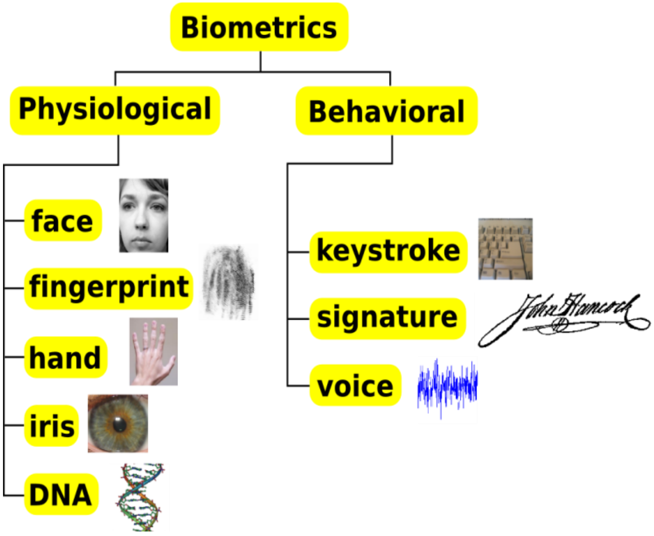


Figure 2: Types of Biometrics [11]

There are many types of biometric system like fingerprint recognition, face detection and recognition, iris recognition etc., these traits are used for human identification in surveillance system, criminal identification. Advantages of using these traits for identification are that they cannot be forgotten or lost. These are unique features of a human being which is being used widely [2].

3. Working Model

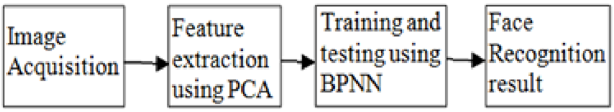


Figure 3: Block diagram of face recognition system [12]

The issues of the design and implementation of the Face Recognition System (FRS) can be subdivided into two main parts. The first part is image processing and the second part is recognition techniques. The image processing part consists of Face image acquisition techniques and the second part consists of the artificial intelligence which is composed by PCA and Back Propagation Neural Network. Face image acquired in the first step by web cam, digital camera or using scanner is fed as an input to PCA, which converts the input image to low dimensional image and calculates its Euclidian distance. This Euclidian distance is then fed as an input to Back-propagation Neural Network.

4. Principal Component Analysis (PCA)

PCA also known as Karhunen-Loeve method is one of the popular methods for feature selection and dimension reduction. Recognition of human faces using PCA was first done by Turk and Pentland [8] and reconstruction of human faces was done by Kirby and Sirovich [9]. The recognition method, known as eigenface method defines a feature space which reduces the dimensionality of the original data space. This reduced data space is used for recognition.

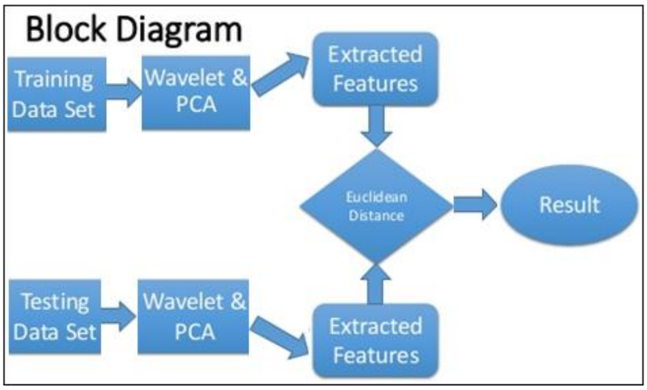


Figure 4.1: Block diagram of Principal component analysis (PCA) [13]

1. Compute the mean feature vector

   $\mu = \frac{1}{p}\sum_{k=1}^{p} x_k$, where, x_k is a pattern (k = 1 to p), p = number of patterns, x is the feature matrix

2. Find the covariance matrix

   $C = \frac{1}{p}\sum_{k=1}^{p}\{x_k - \mu\}\{x_k - \mu\}^T$ where, T represents matrix transposition

3. Compute Eigen values λ_i and Eigen vectors v_i of covariance matrix

   $Cv_i = \lambda_i v_i$ $\quad$ (i = 1, 2, 3,....q), q = number of features

4. Estimating high-valued Eigen vectors

   (i) Arrange all the Eigen values (λ_i) in descending order

   (ii) Choose a threshold value, θ

   (iii) Number of high-valued λ_i can be chosen so as to satisfy the relationship

   $\left(\sum_{i=1}^{s}\lambda_i\right)\left(\sum_{i=1}^{q}\lambda_i\right)^{-1} \geq \theta$, where, s = number of high valued λ_i chosen

   (iv) Select Eigen vectors corresponding to selected high valued λ_i

5. Extract low dimensional feature vectors (principal components) from raw feature matrix.

   $P = V^T x$, where, V is the matrix of principal components and x is the feature matrix

Figure 4.2: Showing the PCA algorithm [14]

PCA technique is a mathematical procedure which include the calculation of covariance matrix, eigen values and eigen vectors. PCA is a dimension reduction tool that can be used to reduce a large set of variables to a small set that still contains most of the information in the large set. In other words PCA is the mathematical Procedure that transforms a number of (possibly) correlated variables into a (smaller) number of uncorrelated variables called Principal Components.PCA is a technique for feature extraction of an image.

The major advantage of PCA is using it in Eigen-face approach which helps in reducing the size of the database for recognition of a test images. The images are stored as their feature vectors in the database which are found out projecting each and every trained image to the set of Eigen faces obtained. PCA is applied on Eigen face approach to reduce the dimensionality of a large data set.

5. Euclidean distance

The Euclidean distance between two points in either the plane or 3-dimensional space measures the length of a segment connecting the two points. It is the most obvious way of representing distance between two points.

The Pythagorean Theorem can be used to calculate the distance between two points, as shown in the figure below. If the points (x1, y1) and (x2, y2) are in 2 dimensional space then the Euclidean distance between them is given by equation:-

$$\sqrt{(X2 - X1)^2} + \sqrt{(Y2 - Y1)^2}$$

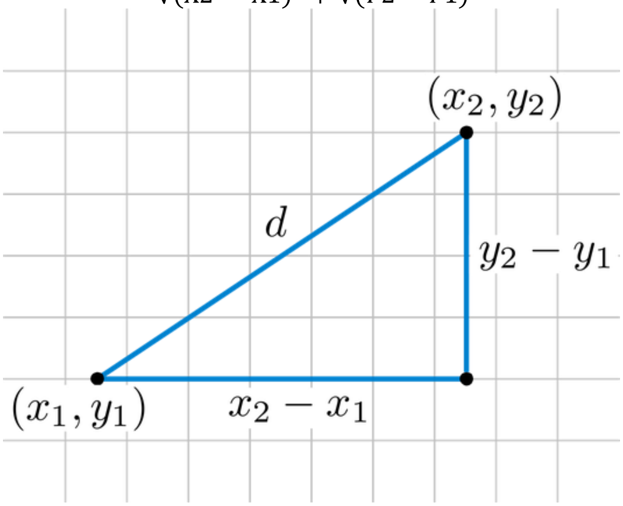


Figure 5: Illustration of calculation of Euclidean distance [15].

6. Back Propagation Neural Network

BPNN is an Artificial Neural Network (ANN) based powerful technique which is used for detection of the intrusion activity. Basic component of the BPNN is a neuron, which stores and processes the information.

BPNN which is used for linear as well as non linear classification is a supervised learning algorithm in which error difference between the desired output and calculated output is back propagated. The procedure is repeated during learning to minimize the error by adjusting the weights thought the back propagation of error. As a result of weight adjustments, hidden units set their weights to represent important features of the task domain.

BPNN consists of three layers: 1) Input Layer 2) Hidden Layer and 3) Output Layer. Number of the hidden layers, and number of hidden units in each hidden layers depend upon the complexity of the problem. Learning in BPNN is a two step processes [2].

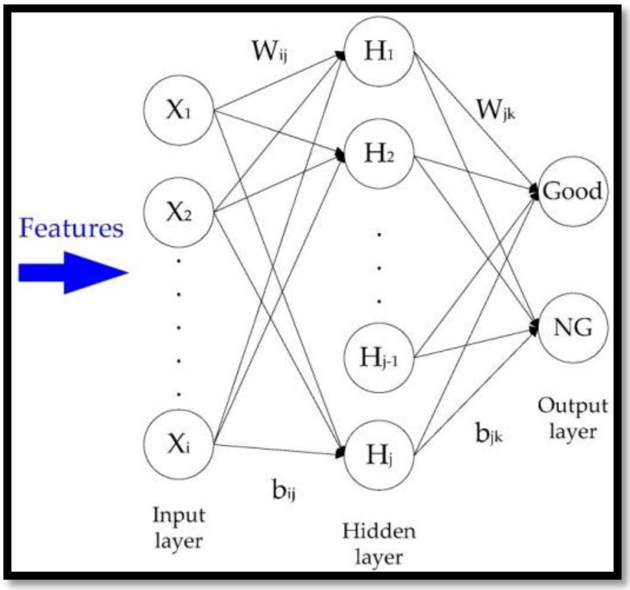


Figure 6: Multilayered Neural Network [16]

The back propagation algorithm is a multi-layer network using a weight adjustment based on the sigmoid function, like the delta rule. According to the back-propagation Network (BPN) algorithm, is a fully feed forward network connection. The activation travels in a direction from input layer to the output layer and the units in one layer are all connected to every unit in the next layer.

Basically, back-propagation algorithm consists of two sweeps of the network which are the forward sweep and the backward sweeps. Forward sweep defines the network from the input layer to the output layer, in which it propagates the input vectors through the network to provide outputs at the output layer in the end. During the forward sweep, the weights of the networks are all fixed.

The backward sweep hence defines network from the output layer to the input layer, where it is similar to forward sweep except that the error values are propagated back through the network. This is done in order to determine how the weights are to be changed during the training, in which the weights are all adjusted in accordance of an error correction rule where the actual response of the network is subtracted from the target response to produce an error signal [10].

In fig.6, the hidden units send activation to each output units and thus during backward sweep, this hidden unit will received an error signals from the output units. Basically, the number of processing elements in each layer will vary according to the applications verified.

7. BPNN algorithm

Backpropagation Algorithm

Input: Data set D, learning rate l, network **Output:** Trained Neural Network

Initialize all weights and biases in *network*;
while terminating condition is not satisfied {
  for each training tuple X in D {
    // Propagate the inputs forward:
    for each input layer unit j {
      $O_j = I_j$; // output of an input unit is its actual input value
    for each hidden or output layer unit j {
      $I_j = \sum_i w_{ij} O_i + \theta_j$; //compute the net input of unit j with respect to the previous layer, i
      $O_j = \frac{1}{1+e^{-I_j}}$; } // compute the output of each unit j
    // Backpropagate the errors:
    for each unit j in the output layer
      $Err_j = O_j(1-O_j)(T_j - O_j)$; // compute the error
    for each unit j in the hidden layers, from the last to the first hidden layer
      $Err_j = O_j(1-O_j)\sum_k Err_k w_{jk}$; // compute the error with respect to the next higher layer, k
    for each weight w_{ij} in *network* {
      $\Delta w_{ij} = (l) Err_j O_i$; // weight increment
      $w_{ij} = w_{ij} + \Delta w_{ij}$; } // weight update
    for each bias θ_j in *network* {
      $\Delta \theta_j = (l) Err_j$; // bias increment
      $\theta_j = \theta_j + \Delta \theta_j$; } // bias update
    } }

Training Algorithm

The training algorithm of back propagation involves four stages.

- **Initialization of weights-** some small random values are assigned.
- **Feed forward-** each input unit (X) receives an input signal and transmits this signal to each of the hidden units $Z_1, Z_2, \ldots\ldots Z_n$. Each hidden unit then calculates the activation function and sends its signal Z_i to each output unit. The output unit calculates the activation function to form the response of the given input pattern.
- **Back propagation of errors-** each output unit compares activation Y_k with its target value T_K to determine the associated error for that unit. Based on the error, the factor $\delta_K(k=1,\ldots\ldots,m)$ is computed and is used to distribute the error at output unit Y_k back to all units in the previous layer. Similarly, the factor $\delta_j(j=1,\ldots.,p)$ is compared for each hidden unit Z_j.
- **Updation of the weights and biases.**

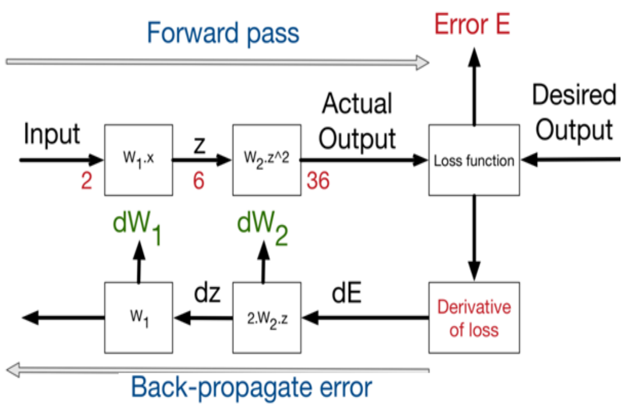


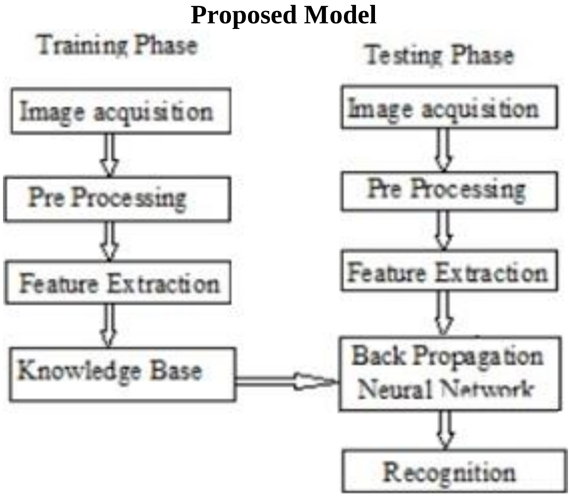
Figure: 7: Illustration of the forward pass & back propagation error [17]

Testing using Trained BPNN

In testing, input image from testing set is selected and its features are extracted and given them to the trained model. The trained BPNN model classifies given sample and produces output as type of signature and corresponding pattern

$$\text{Classification Accuracy} = \frac{\text{Number of recognized signatures}}{\text{Total number of testing signatures}}$$

Proposed Model



Block diagram of signature recognition [22]

Figure 7.2: Block diagram of proposed model of signature recognition [22]

8. Experimentation flow chart

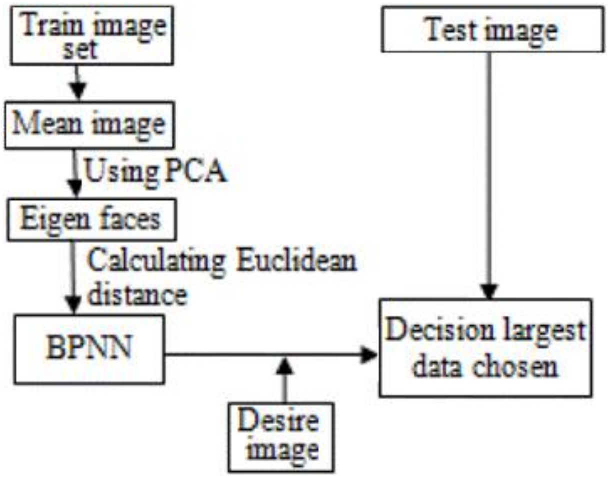


Figure 8.1: Block diagram of complete process of PCA & BPNN face recognition system[12]

Figure 8.2: Mean face of a person [18]

As shown in this above block diagram I had described about the calculation of Euclidean distance previously but for now I will also be going to illustrate the diagrams of mean image/face and the Eigen faces using the PCA method.

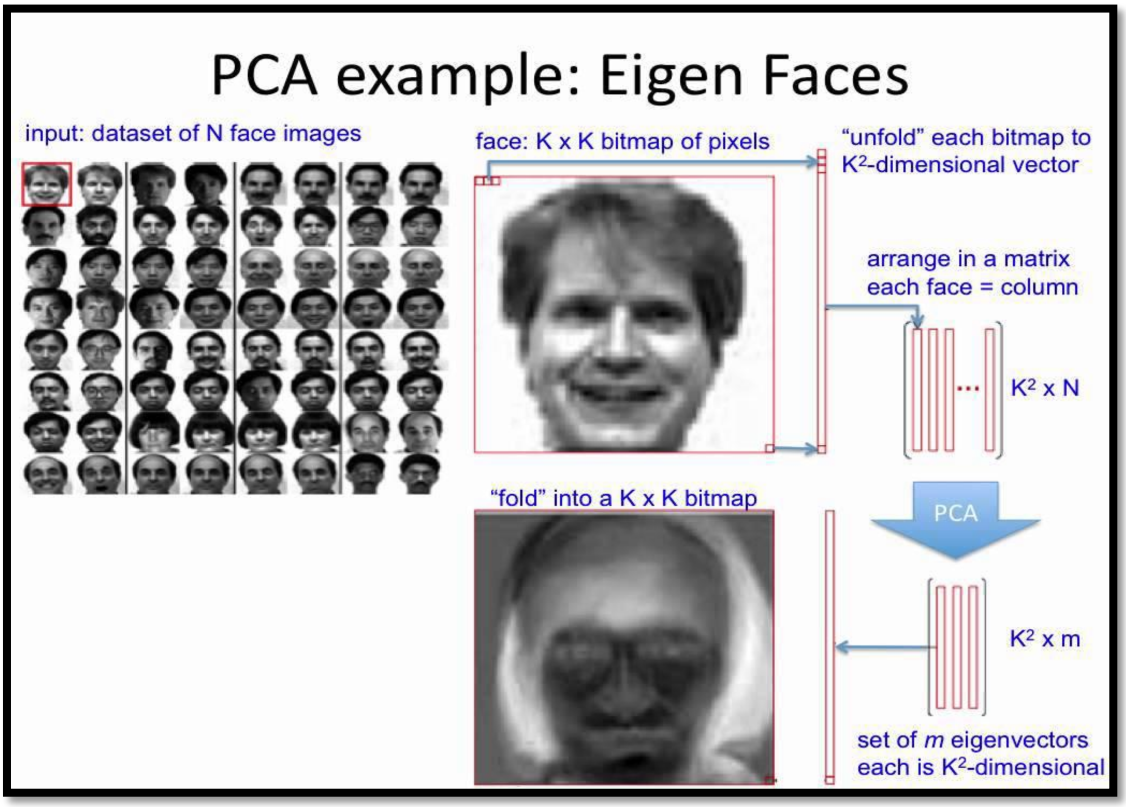


Figure 8.3: Illustration of an Eigen face [19]

9. Simulation Results

Test Results of Face Recognition using PCA and BPNN

The simulation of the proposed approach was performed on MATLAB. The proposed method is tested on ORL face database. This database has more than one image of the individual's face with different conditions. The database is divided into two sets, which are, training database and the testing database. The network is trained on the training database and then one of the images from the testing database is fed as an input to test the network.

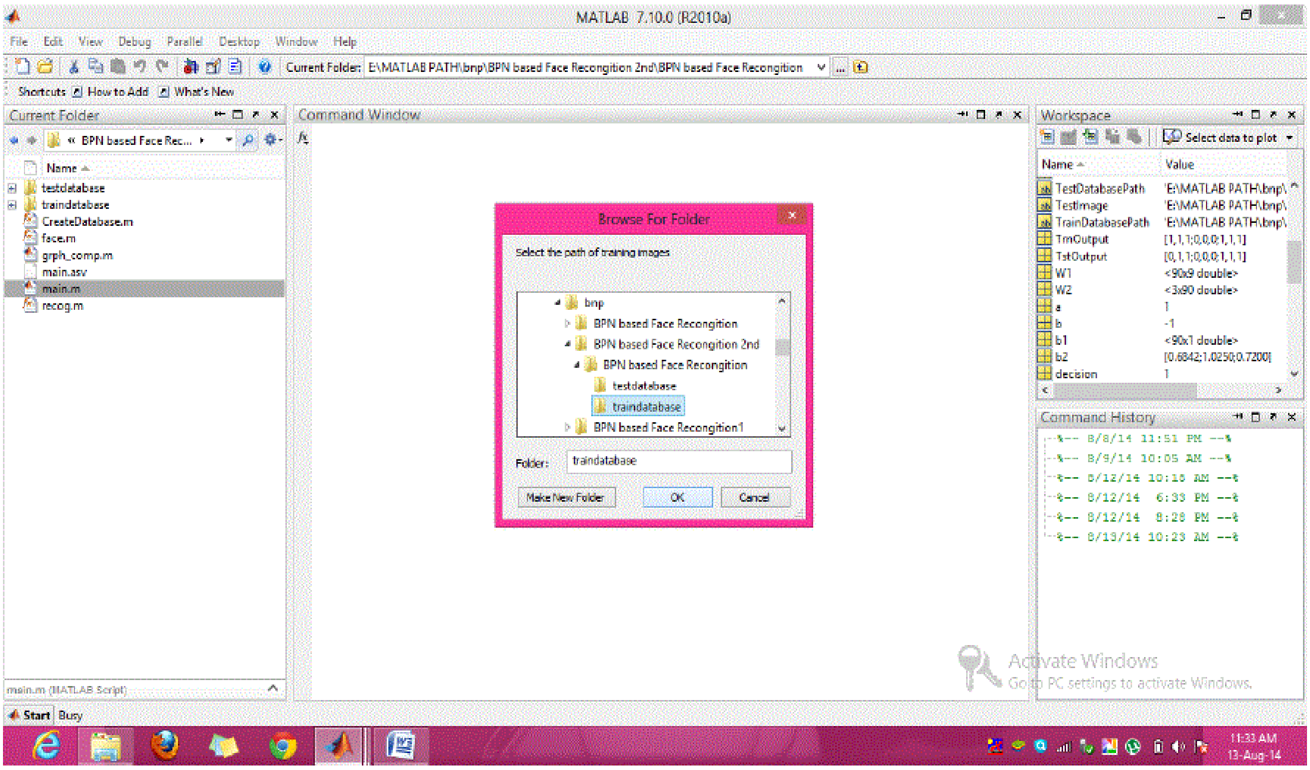


Figure 9.1: Training of Database Images [12]

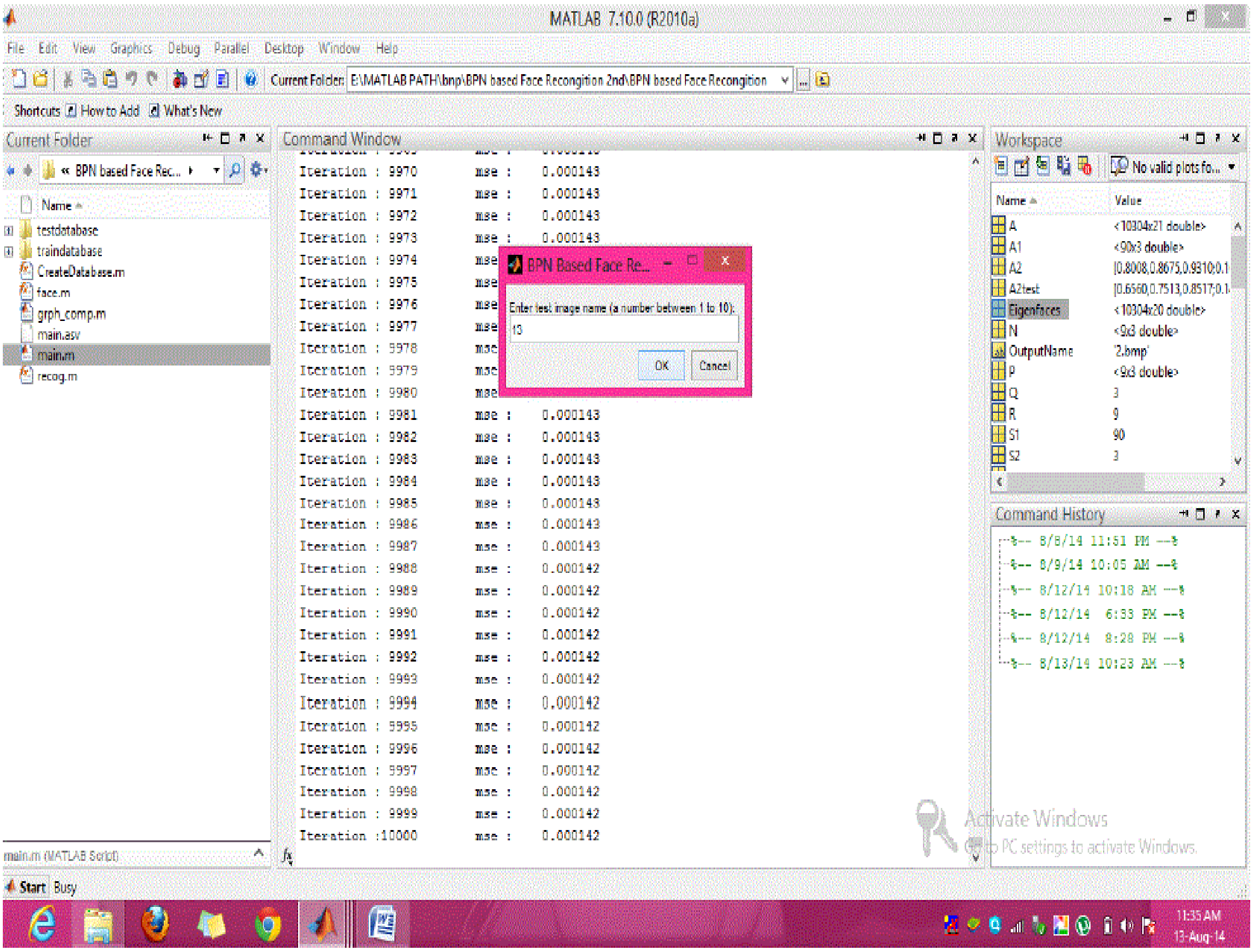


Figure 9.2: Test image selected [12]

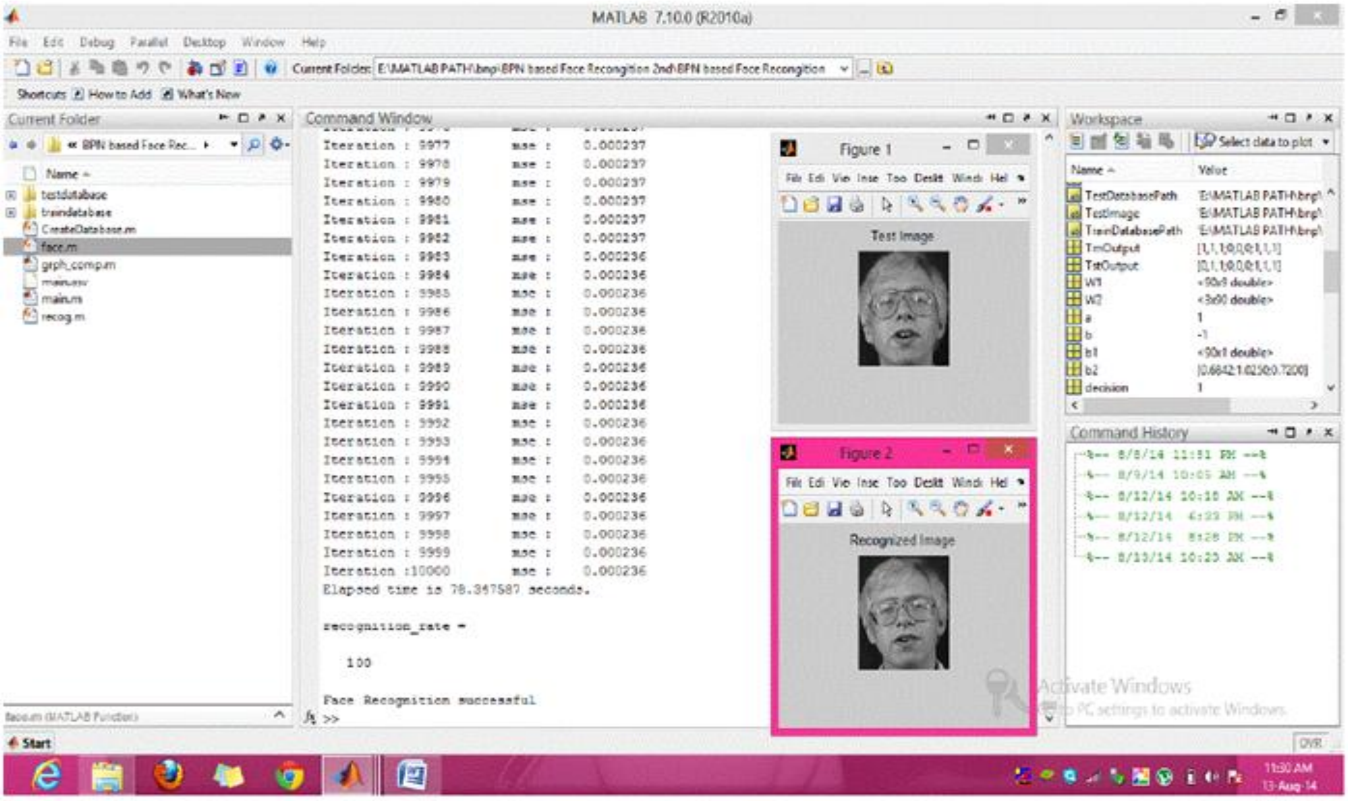


Figure 9.3: Output result with image recognized from the database [12]

10. Experimental Result & Analysis

Table 10: Comparison between PCA and PCA with BPNN methods [20]

No. of Images	Acceptance Ratio (%)		Execution Time (Seconds)	
	PCA	PCA with BPNN	PCA	PCA with BPNN
40	92.4	96.5	38	36
80	90.6	94.3	46	43
120	87.9	92.8	55	50
160	85.7	90.2	67	58
200	83.5	87.1	74	67

Table 10.2: Comparison of BPNN with other algorithms [21]

Algorithm Name	Accuracy
Bayesian Network	0.803047372
Naïve Bayes	0.80386569
Support Vector Machine	0.815737546
BPNN GA	0.9222595

11. Conclusion

In the above project research paper of "Human face recognition system using PCA with BPNN" I have concluded that the system easily recognizes human faces in PCA with BPNN as compare to the individual PCA. Thus PCA with BPNN works better than the individual PCA on both conditions those are accuracy and execution time.

PCA with BPNN was an example of a hybrid method. As future work my aim is that we can apply our more new tools and techniques of different types of hybrid methods to get more high efficiency in this field of image processing and pattern recognization.

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