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RESEARCH ARTICLE

An Efficient Back Propagation Neural Network Based Face Recognition System Using Haar Wavelet Transform and PCA

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Abstract— With fast evolving technology, it is necessary to design an efficient security system which can detect unauthorized access on any system. The need of the time is to implement an extremely secure, economic and perfect system for face recognition that can protect our system from unauthorized access. So, in this paper, a robust face recognition system approach is proposed for image decomposition using Haar Wavelet Transform, feature extraction of eigen values using Principal component Analysis (PCA) and then classification using Back Propagation Neural Network (BPNN). Also comparison with the traditional face recognition algorithms is done to show the effectiveness of the proposed algorithm.

Key Terms: - Principal Component Analysis (PCA); Back Propagation Neural Network (BPNN); Haar wavelet transform; Face recognition; Eigen faces

I. INTRODUCTION

Human beings have good recognition capabilities of faces and complex patterns and anything cannot affect this capability. This ability is quite robust, in spite of great changes in the visual stimulus due to facial expression, masking conditions, aging, and mismanagements such as whiskers, changes in hairdo or spectacles. The main reason for this is the high degree of interconnectivity, acquisition skills, adaptive quality, and abstraction capabilities of the human nervous system. There are various highly correlated biological neurons in human brain which can outperform super computers in certain specific tasks.

Even a small child can perfectly and completely identify a human face, but it is a difficult task for the computer. Therefore, the main objective is to design such systems which can compete with what a small child does and thus making computers as lively as humans can.

Face image is a biometrics physical feature which is used to verify the identity of people. The main components involved in the face image space include mouth, nose and eyes. Among various biometrics characteristics face is the most natural means of identify people. Face identification [1] can be done significantly by capturing devices using digital cameras.

A. Haar Wavelet Transform

A wavelet transform (WT) is based on wavelets. It is used to analyze a signal or an image into different frequency components at different resolution scales. It allows acknowledging image's frequency attributes and spatial attributes simultaneously.

Haar wavelet transform [2] is used to break down original greyscale image into four regions. These are horizontal high frequencies, vertical high frequencies, diagonal high frequencies and approximate region. The approximation region contains the minimum frequencies feature. Now at the next decomposition level, image's upper left corner approximation region is further festered into four smaller regions. Hence at this second level of decomposition there are seven sub-image bands. Along with this the sum of sizes of all sub-image bands comes out to be equal to the size of the original image. Further decomposition or a more efficient approach can be used to extract extended features from the sub-image band.

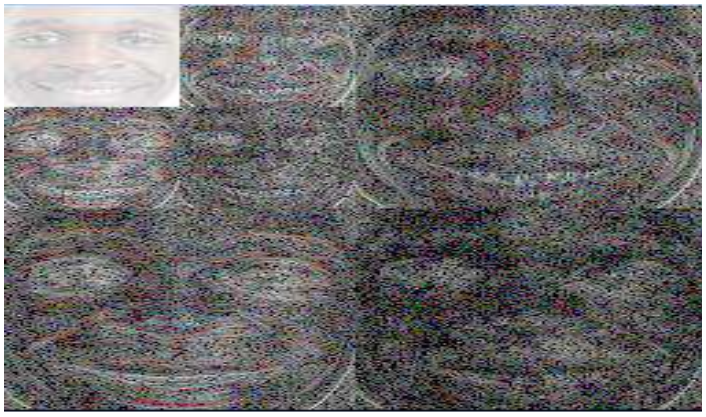

Fig. 1 2–level Haar Wavelet Transform

B. Principal Component Analysis

The basic concept of PCA is to find meaningful patterns or features in the input data without an external assistance. For this, a set of local nature rules are provided that allows it to learn and to compute an input-output mapping with explicit desirable properties. The local nature of rules means that the changes applied to the synaptic weight of a neuron is limited to the immediate neighbourhood of that neuron.

PCA intends images into a subspace so that the first orthogonal dimension of the subspace acquires the largest measure of variance among the images and the last dimension of subspace acquires the minimum measure of variance among the images. The main objective of PCA is the dimensionality reduction. Hence the eigenvectors of the covariance matrix must be obtained to reach the solution. The eigenvectors of the matrix resembles the directions of the principal components of the original data; their analytical implication is given by their corresponding eigenvalues.

C. Back Propagation Neural Network Face Recognition

Back Propagation Neural Network (BPNN) is a multilayered and feed forward Neural Network. BPNN contains input layer, with one or many hidden layers that are being followed by the output layer. The layers contain identical computing neurons associated such that the input of every neuron in the next layer receives the signal from the output neuron in the previous layer. The input layer of the network serves as the signal receptor whereas the output layer passes the result out from the network.

II. RELATED WORKS

The security of various existing systems is related to the efficiently designed systems to control unauthorized accesses. So, building of efficient face recognition systems is very necessary for this. Mayank Agarwal et al. [3] proposed a system in which they presented a technique for face recognition based on information theory approach of coding and decoding the face image. The proposed method involved two phases– Firstly the facial feature extraction using principle component analysis and next was the face recognition using the feed forward back propagation Neural Network. The paper introduced face recognition system using PCA and BPNN techniques. The efficiency of the proposed system was compared with K-means, Fuzzy Ant with fuzzy C-means and better recognition rate was obtained compared to the other two techniques.

In [4] Raman Bhati et al. used Eigen faces to represent the feature vectors. The paper introduced an approach for selecting the learning rate for single layer feed forward neural network and BPNN also. This modern approach generated more proficient results in all aspects including mean square error, recognition rate and training time. They presented that single layer neural network can give 100% recognition accuracy if correct learning rate is assigned to it. They also proposed that BPNN is more sensitive to hidden neurons and learning rate. Hence when wavelets were used for feature extraction both neural networks showed improved results.

A recognition method was suggested by Jong-Min Kim et al. [5], to improve the recognition rate that combines the multi-layer neural network with the method that computes the small number of eigenface feature vector through PCA. The proposed method showed the improved functioning with variations in illumination and noise so that it could minimize the recognition error. In the paper, the proposed face recognition system algorithm used the rectangular feature technique to extract the face from the background image and after that it performed the face recognition by reducing image size and removing noise from the image, then calculated the proper vector through PCA and finally applied the multi-layer neural network on the resultant image. Thus the performance of existing PCA matching method was compared with the combinational approach of PCA and MLNN.

The recognition system of face detection proposed by Amir Benzaoui et al. [6] involved two stages: learning and detection. In first phase, all face and non-face pictures were converted into gray level pictures and then were filtered by median filter to reduce noise. After that, feature extraction was done by choosing appropriate information from each picture to prepare the data for classifier learning. Then the system used Discrete Cosine Transform (DCT), to extract a vector of appropriate coefficient that symbolizes necessary parameters for modelling the original picture.

Further there were problems regarding variations in the different postures on an individual's image, so Pushpaja V. Saudagare et al. [7] proposed a system which involves inhibiting the consequences of changing illumination and pose. In their paper they proposed a 2-level Haar wavelet transform system that was used to partition the facade image into seven sub-image bands. Then from these sub–image bands, eigenfaces features were extracted and these features were further used as input to back propagation neural network based classification algorithm.

Face detection required that firstly noise should be reduced from the image so that better and more accurate results can be achieved. So, S.Adebayo Daramola et al. [8] proposed a system with four stages: face detection, pre-processing, principle component analysis (PCA) and classification. Firstly, database with images in different poses was made, then image was normalized and noise was removed from the image. After that, the eigenfaces were calculated from the training set. Then Eigen values were calculated using the PCA approach and then largest eigenvalues were found comparing training set images and eigenfaces. At last ANN approach was used in which the face descriptors were used as an input to provide training to the network.

The problems associated with the non-linearity of the images were out looked by Mohammod Abul Kashem et al. [9]. They proposed a computational model of face detection and recognition, which was accurate, simple and fast in forced environments. Face recognition system proposed in this paper used Eigen faces for accuracy and fast computation. Whereas when both the PCA and BPNN techniques were combined, non-linear face images were able to be easily distinguished. In [10], Face recognition using Eigen faces was shown to be accurate and fast. When both BPNN and PCA techniques were combined in the proposed system, non-linear face images were easily distinguished. Hence it was concluded that this method had execution time of only few seconds and its acceptance ratio was more than 90 %.

In [11], Ki-Chung Chung et al. referred to a new face recognition method based on Principal Component Analysis (PCA) and Gabor filter responses. First method, Gabor filtering was applied on predefined fiducial points to match robust facial features from the original face image. Second method involved transformation of the facial features into Eigen space by PCA, for optimal classification of individual facial representations.

III. PROBLEM DEFINITION

In today's world, computer plays a crucial role in every scenario of today's life and in the society. With the enhancing technology, human being becomes more and more affected with computers as the leader of this technological age. Technological revolution has taken place all over the world based on this enhancement. Computer vision plays a vital role in our life for the purpose of security of the systems. Major goal of computer vision is to acquire the ability of visual recognition like that of human. The face recognition has got extreme

importance nowadays in computer vision. Major things in face recognition involve the development of executable technologies to support the development of face recognition.

Main fields of commercial interest include biometrics, smart cards, access control and law control and investigation. It also includes fingerprint analysis and iris scans. Among all these, face recognition is a most user friendly and non- interfering. Face recognition has got significant attention from inquiries in biometrics, pattern recognition areas and computer vision communities. The importance of face recognition [12] comes out from the concept that a face recognition system does not need the involvement of the individual while the other existing systems require such participation like the iris recognition system.

Face recognition can be applied for identification at front door for home security, video investigation for security, Security measure at Air ports, Visa processing, Passport verification, Criminals list verification in police department, Verification of Electoral identification, in alignment with a smart card for authentication or recognition at ATM. Thus, we need to design such a robust system that can make our surrounding 100% secure from the intruders and all the problems related to identification, recognition and verification of face images can be solved.

For this we design a system that contains three stages. Firstly we decompose a face image into seven sub-image bands using the 2-level Haar wavelet transform. Then the eigenface features are extracted from those bands using the PCA technique. And after that these extracted features were inputted to the Back Propagation Neural Network (BPNN) based classification algorithm.

IV. PROPOSED METHODOLOGY

A. Image decomposition using 2-Level Haar Wavelet Transforms

The Discrete Wavelet transform includes a technique Haar wavelet transform which is used to decompose an original greyscale image into four regions. It includes 4 different regions namely, horizontal high frequencies, vertical high frequencies, diagonal high frequencies and approximate region.

Algorithm:

1. First of all we select an input image.
2. Then we define the number of decompositions and calculate values of the Approximation coefficient storage, the Horizontal detail coefficient storage, the Vertical detail coefficient storage and the Diagonal detail coefficient storage.
3. Now we have applied 2-level decompositions.
4. After that we rescale an input matrix to a specified range for display.
5. Then we convert to the above outcome into unsigned 8-bit integer to display..

The 2×2 Haar matrix that is associated with the Haar wavelet is

$$H_2 = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$$

Using discrete wavelet transform, we transform a sequence of vectors (t_0, t_1, …, t_{2n},t_{2n+1}) of even length into a sequence of two-component-vectors ((t_0, t_1), …,(t_{2n},t_{2n+1})).

If we have a sequence of length of multiple of four, we can build blocks of 4 elements and transform them in similar manner with the 4×4 Haar matrix.

$$H_4 = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & 0 & 0 \\ 0 & 0 & 1 & -1 \end{bmatrix}$$

B. Feature extraction using Principal Component Analysis

PCA-based technique operates on vectors. In this technique, the image vectors mostly contribute to a high dimensional space. For this we have to crop the image into 180 X 180 sizes because the database can store images o a limited size [11].

Algorithm:

Step 1: Creation of Database

1. We coordinate a set of face images (the training set T1, T2, ..., TM).
2. Then we reshape the 2D images of the training database into 1D column vectors. Then, we put these 1D column vectors in a row to construct 2D matrix 'T'.
3. We allocate numbers to all the images in the training database.
4. Now we construct a 2D matrix from 1D image vectors
5. Then we choose the name of each image in databases as a corresponding number.
6. Now we reshape the 2D images into 1D image vectors and the 2D matrix 'T' grows after each turn.

Step 2: Eigenvalues Calculation

1. We use PCA to determine the most discriminating features between images of faces.
2. We define a 2D matrix that contains all the training image vectors and gives 3 outputs which are extracted from training database.
3. We compute mean of face images of training database image as m = (1/P)*sum (Tj's). We calculate the deviation of each image from mean image by computing the difference image for each image in the training set Ai = Ti – m and then merge all the centred images where T is the 2-D matrix, P is the count to calculate mean m, Ai is difference between actual value and mean.
4. We calculate the eigenvectors of the covariance matrix of the training database and then we find matrix of centred image vectors

Step 3: Recognition of Image

At this level we compare the two faces by projecting the images into facespace and measuring the Euclidean distance between them:

1. We first project the centred images into facespace and extract PCA features from the test image.
2. Then we calculate Euclidean distances between the projected test image and the projection of all centred training images.

C. Face Recognition using Back Propagation Neural Networks

BPNN is a multilayered feed forward Neural Network [12]. During its training process, BPNN learning algorithm adjusts the weights and bias of each of the neurons so that Mean Square Error (MSE) between the targets can be minimized and it correctly predicts the desired output.

1. Firstly we set the value of all weights to random value range from -1.0 to 1.0.
2. Then we set an input binary values pattern into the neurons of the net's input layer.
3. At this step, we activate each and every neuron of the following layer:

i) We multiply weight values of the connections leading to this neuron with the output values of the preceding neurons, and we summarize these values.

ii) After that we pass the result to an activation function, which calculates the output value of this neuron.

4. Now we repeat all this procedure until the final output layer is achieved.
5. Next we compare the computed output approach pattern to the desired objected pattern and calculate value of square error.
6. Now we change the values of all weights of each weight using the formula:

Weight (old) + Learning Rate * Output Error * Output (Neuron i) * Output (Neuron i + 1) * (1 – Output

(Neuron i + 1)) where Weight(old) is previous layer weight, Learning Rate defines the rate at which database is being trained, Output Error is the error in previous steps.

7. After this go to the step 1.
8. Finally if all output patterns are matched with their desired outcomes the algorithm ends.

V. ARCHITECTURAL SUMMARY OF THE PROPOSED APPROACH USING FLOW CHART DIAGRAM

A. ER Diagrams of the proposed work

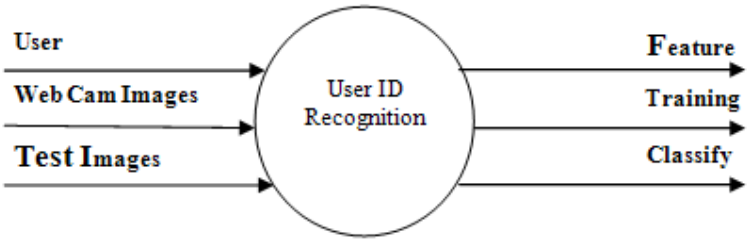

Fig. 2 Level 0 Data Flow Diagram

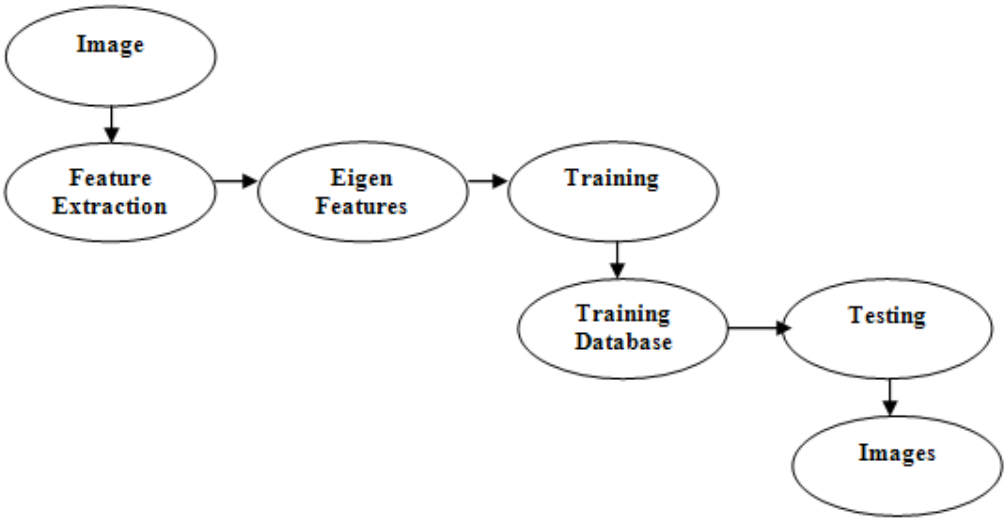

Fig. 3 Level 1 Data Flow Diagram

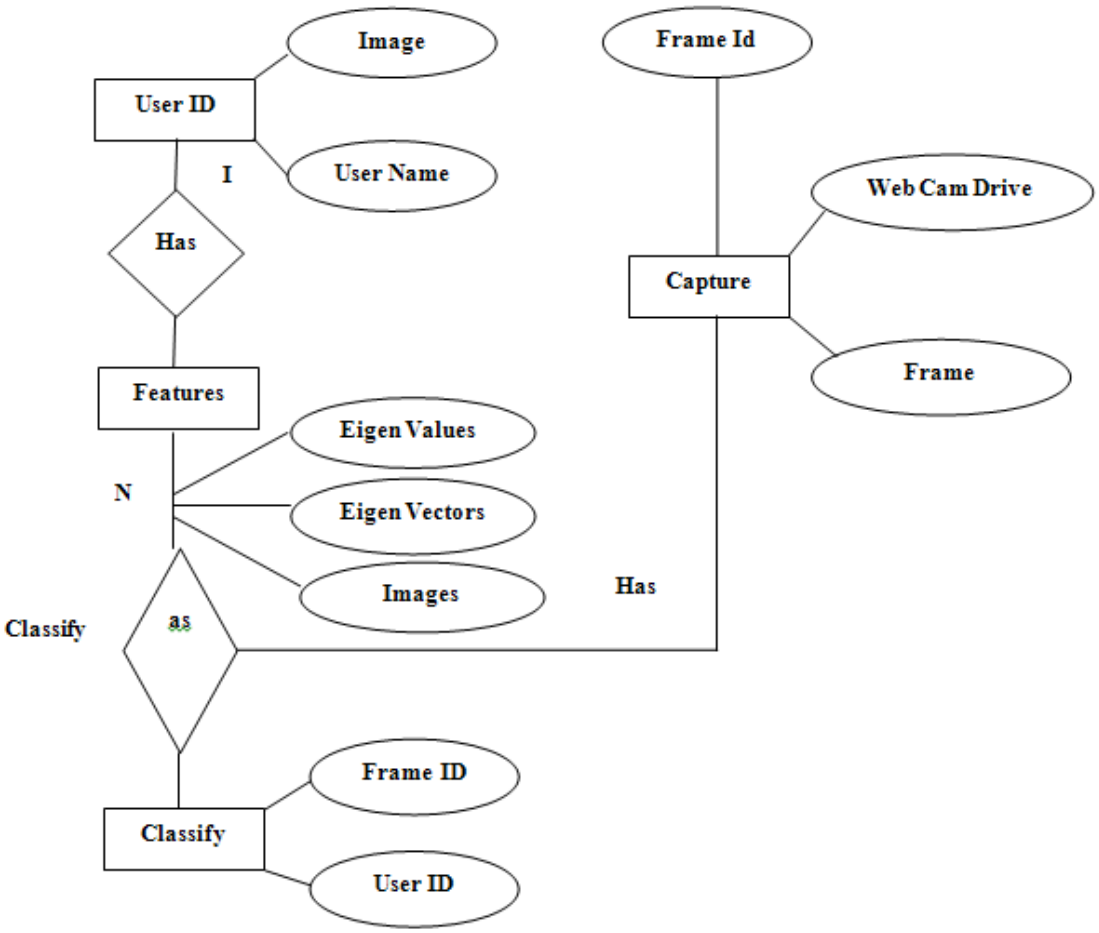

Fig. 4 ER Diagram to represent Eigen values

B. Flowchart for complete work

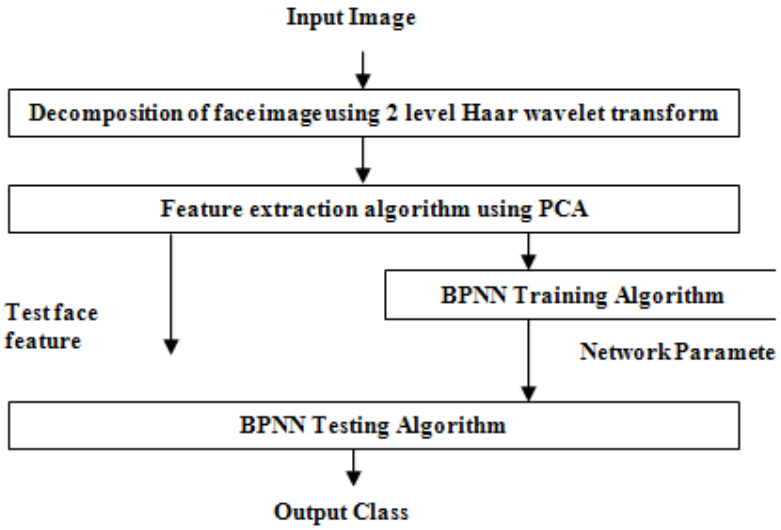

Fig. 6 Flow diagram of Proposed Face Recognition System

VI. SIMULATED RESULTS AND DISCUSSIONS

The simulation of the proposed approach was performed on MATLAB version 7.8.0.347 to affirm the effectiveness of the proposed algorithm. The size of the input image was assumed to be m * n.

We take an image and apply Haar wavelet transform on it. The output of the MATLAB code written and tested for the proposed approach is shown below-

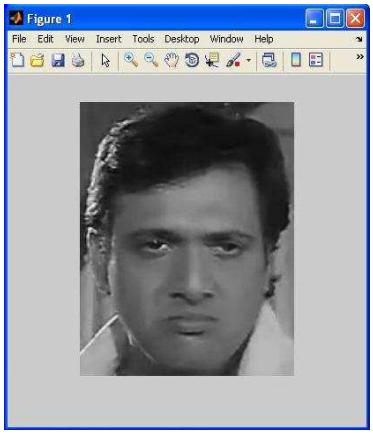

Fig. 7 Input Image

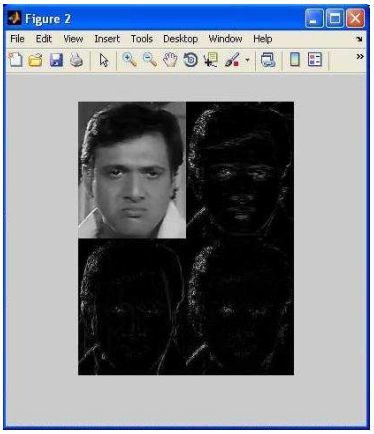

Fig. 8 Decomposed Image using Haar Wavelet Transform

Now moving forward to feature extraction, PCA is used to compare images from the test database and determine whether or not these images exist in the train database.

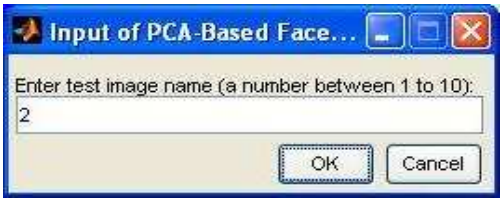

Fig. 9 Enter the no. of the image to be tested

We calculate the mean of the distances between two images of same individual and matches it with the images in test database.

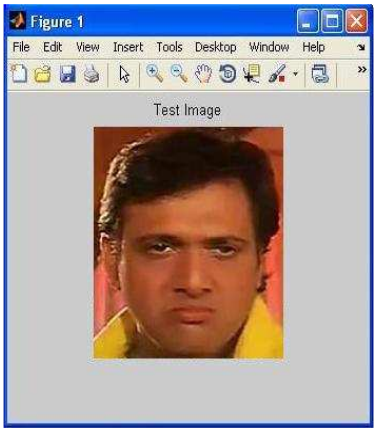

Fig. 10 Image whose no. was selected

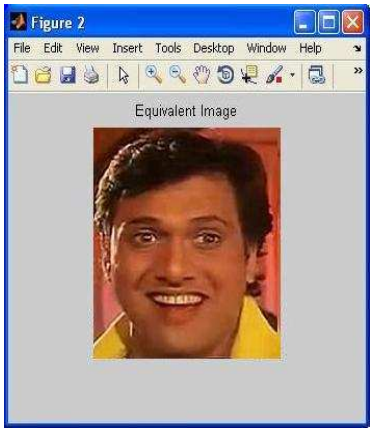

Fig. 11 Equivalent image from the test database

After this we use BPNN technique to classify the features of face images.

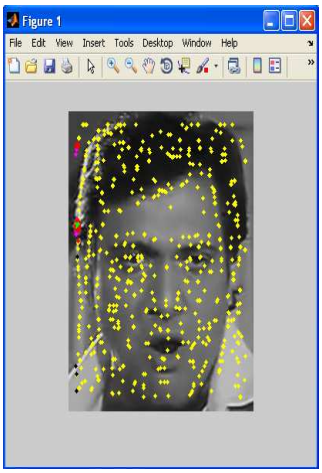

Fig. 12 Gabor features extracted

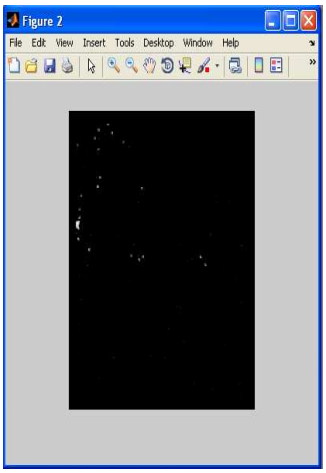

Fig 13. Features classified

Fig. 14 Image is tested with features extracted

VII. CONCLUSION

In this paper, we have presented a technique for designing fast, secure and robust face recognition system. Our applied technique reduces the time required to recognize an image from the database. Haar wavelet transform has been applied over an image to decompose it into 2-level sub images bands. Then we apply PCA for extracting Eigen values from these bands. And finally BPNN is used for image classification and recognition. So, this combined approach develops a more accurate approach compared to the existing techniques. It reduces execution time of recognizing an image from the test database and thus increases the acceptance ratio while traversing images from the database and makes the system more secure and reliable.

VIII. FUTURE DIRECTIONS

In future, two or more functionalities can be added to the proposed approach which will allow performing many more operations and thus more securing the biometric system while it is being used for detecting and recognising human faces. One of the outlooks for this thesis future work will be to learn the system with other prominent databases that poses great variations in the lighting conditions and the positioning of the head. It is necessary to study more on the optimization process for pre-processing and parameters of neural network in the future. So we will need to acknowledge people in real-time and in much less restrained situations. The fast and accurate classification and discrimination method are also areas of research in future work.

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