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Face Recognition Using Principal Component Analysis and Artificial Neural Network of Facial Images Datasets in Soft Computing

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Abstract

Face Recognition is one of biometric techniques, to recognize given face image using significant features of face. The paper present a face recognition using Principal Component Analysis and Two-Layer Feed Forward Neural Network techniques used to recognition frontal and poses variation images. The dimension of face image is reduced by the Principal Component Analysis and gives feature vector of images. The training and recognition is done by the Two-Layer Feed-Forward Neural Network. The study highlights the performance of neural network. The Two layer feed forward NN applied on face 95 as a standard dataset and Local Images taken by the variations of poses.The performance of neural network is satisfactory and the accuracy of recognition is 100%.

Keyword – Biometric, Face Recognition, Principal Component Analysis, Eigenface, Artificial Neural Network, Soft Computing.

I. INTRODUCTION

Face recognition is hugely used in biometric systems. Face recognition has been conducted now for 50 years. It is also useful in human computer communication, computer-operated reality, database retrieval, multimedia, computer entertainment, information security - operating system, medical records, online banking. Biometric - personal identification - passports, driver licenses, automated identity verification – border controls, law enforcement - video surveillances, investigation, personal security – driver monitoring system, home video surveillance system. The first paper published over face recognition can be traced back to the 1954's in psychology [1]. The initial study is concern automatic face recognition was completed in 1970 by Kelly [2]. During the 1980's work on face recognition had no progress, but the interest grew rapidly again from the beginning of the 1990's due to these reasons the research interest increased: real-time hardware became more available, and the importance of surveillance-related applications increased. There are different kinds of approaches-holistic approach that is appearance-based approach, feature-based approach and hybrid approach. In holistic approach the whole face region is taken into account as input data into face detection system. One of the best example of holistic methods are eigen faces[4], most widely used system for face recognition, In this methods common features such as eyes, nose and mouth are first extracted and their locations and local statistics (geometric and/or appearance) are fed into a structural classifier. It is a huge challenge for feature extraction methods in feature "restoration", this is when the system tries to recover features that are invisible due to large variations, e.g. head pose when we are comparing a frontal image with a profile image[3],[20].There are innumerable extraction methods, the first is generic methods based on edges, lines, and curves, the second is feature-template-based methods[5] and the third is structural matching methods that taken into consideration geometrical constraints on the features. Hybrid approach uses a combination of both holistic and feature-based approaches. Hybrid approach is used in a system developed by Huang [6].

II. RELATED WORK

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. In [7] the basic ideas underlying soft computing and its relation to fuzzy logic, neural network theory, and probabilistic reasoning. The principal aim of soft computing is to achieve tractability, robustness, low solution cost, and high Machine Intelligence Quotient (MIQ) through the exploitation of the tolerance for imprecision and uncertainty. Face recognition problem by combining Eigenfaces and Neural Network. Eigenfaces are applied to extract the relevant information in a face image, which are important for identification. Using this we can represent face pictures with several coefficients (about twenty) instead of having

to use the whole picture. Neural networks are used to recognize the face through learning correct classification of the coefficients calculated by the Eigenfaces algorithm. The network is being trained on the pictures from the face database first, and then it is ready to identify face pictures given to it. Eight subjects (persons) were used in a database of 80 face images. A recognition accuracy of 95.4% was achieved with vertically oriented frontal views of human face [8].In paper [9] initially provides the overview of the proposed face recognition system, and explains the methodology used. It then evaluates the performance of the system by applying two photometric normalization techniques: histogram equalization and homomorphic filtering, and comparing with Euclidean Distance, and Normalized Correlation classifiers. The system produces promising results for face verification and face recognition.

Face recognition using Eigen faces has been shown to be accurate and fast. When BPNN technique is combined with PCA, non-linear face images can be recognized easily. Hence it is concluded that this method has the acceptance ratio is more than 90 % and execution time of only few seconds [10]. By combining the PCA, MLNN algorithms that were used for face recognition individually the performance was compared with the existing PCA matching method. As a result, the method suggested by comparing with the existing method showed the improvement in the recognition rate as 95.3% [11]. A new approach to select the learning rate for back propagation neural network as well as single layer feed forward neural network. The new approach gave better results in all aspects including recognition rate, training time and mean square error [12]. Face recognition approach using PCA and Neural Network techniques. The result is compared with K-means, Fuzzy Ant with fuzzy C-means and proposed technique gives a better recognition rate then the other two [13].Facial recognition using back propagating neural networks. The recognition rate of BPNN system was found to be 99.25%. The identification result obtained using the neural network approach illustrates the success of its efficient use in face recognition. The BPNN algorithm is preferred over other neural network algorithms because of its unique ability to minimize errors [14].Neural network based face detection algorithm from the photographs as well as if any test data appears it check from the online scanned training dataset. Experimental result shows that the algorithm detected up to 95% accuracy for any image [15].

A new face localization technique is proposed and a new feature extraction algorithm is developed for human face recognition. The neural network model is used for recognizing the frontal or nearly frontal faces and the results are tabulated. A new neural network model combined with BPN and RBF networks is developed and the network is trained and tested. From these results, it can be concluded that, recognition accuracy achieved by this method is very high. This method can be suitably extended for moving images and the images with varying background [16].

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 [17].

III. PRINCIPAL COMPONENT ANALYSIS

Principal component analysis (PCA) is a dimensionality reduction technique which is used for compression and face identification and recognition problems. It is also known as eigenspace projection or Karhunen-Loeve transformation. PCA calculates the eigen vectors of the covariance matrix, and projects the original data onto a lower dimensional feature space, which is defined by eigen vectors with huge eigen values. PCA has been used in face representation and recognition where the eigen vectors calculated are referred to as eigen faces. PCA is a useful statistical technique that has found application in fields such as face recognition and image compression, and is a common technique for searching patterns in data of high dimension. It is one of the most successful techniques of face recognition [19].The benefit of PCA is to reduce the dimension of the data. No data redundancy is found as components are orthogonal. With help of PCA, complexity of grouping the images can be reduced. **The steps in the Principal Components Analysis can be brief as follows [21]:**

- Given a set of M sample images x_1, x_2, x_3.. . . . . x_M.

  Let us image column data matrix

$$X = \{x_1, x_2, x_3 \ldots\ldots x_M\} \quad (1)$$

  Where, M is number of images.
- The mean image ψ is the average information of all sample images representing the mean value of every pixel in N-dimensional vector.

$$\psi = \frac{1}{M}\sum_{i=1}^{M} Xi \quad (2)$$

- Calculate the covariance matrix.

$$C = \frac{1}{M}\sum_{i=1}^{M} \Phi_i \Phi_i^T = AA^T \quad (3)$$

Where A = (Φ_1, $\Phi 2$, $\Phi 3$ ..... Φ_M) is of dimension N X M matrix.

- Determine eigenvalues and eigenvectors of the matrix C.

- Choosing components and forming a feature vector: Once eigenvectors are found from the covariance matrix, the next step is to order them by eigenvalue, highest to lowest. This gives the components in order of significance. The eigenvector with the highest eigenvalue is the principle component of the data set. Choose the highest eigenvalue and forming a feature vector.
- Deriving the new datasets: Once chosen the components (eigenvectors) that wish to keep in the data and formed a feature vector, imply take the transpose of the vector and multiply it on the left of the original data set, transposed.

final data = row feature vector * row data adjust

The above formula getting the features of images, the Euclidean distance is calculated between the mean adjusted input image and the projection onto face space. The low values indicate that there is a face and display the face.

IV. Artificial neural Network

Artificial Neural Network thus is an information-processing system [22]. In this Information-processing system, the elements called as neurons, process the information. The signals are transmitted by means of connection links. The links possess an associated weight, which is multiplied along with the incoming signal (net input) for any typical neural network. The output signal is obtained by applying activations to the net input.

An artificial neuron is characterized by:

1. Architecture (Connection between neurons)
2. Training or learning (determining weights on the connections)
3. Activation function

The structure of simple Artificial Neural Network is shown in figure 1.

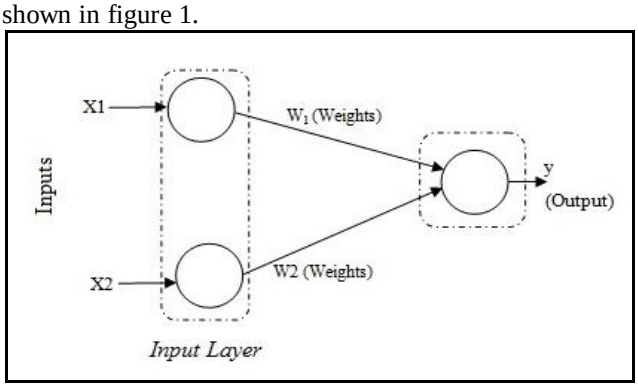

Figure 1 Simple Artificial Neural Network

Figure 1 shows a simple Artificial Neural Network with two input neurons(x1,x2) and one output neuron(y).The inter connected weights are given by w1 and w2. An artificial neuron is a p-input signal-output signal-processing element, which can be thought of as a simple model of a non-branching biological neuron. In figure 1 various inputs to the network are represented by the mathematical symbol, x(n). Each of these inputs is multiplied by a connection weight. These weights are represented by w(n). In the simplest case, these products are simply summed, fed through a transfer function to generate a result, and then delivered as output. The figure 2 shows the diagram of Two-Layer Feed Forward Neural Network. The Neural Network is created by using MATLAB (R2010a). The Neural Network is a Two Layer Feed Forward Back Propagation Network with both the layers consisting of 20 neurons each. In the figure 2, Input p1 is a feature vector of sample images. IW is initial weight matrix and LW is learning weight matrix. b1 and b2 is bias vector of both layers and the input to bias vector is fix to one. The first layer selected tan sigmoid transfer function that is tansig and second layer selected liner transfer function that is purelin. The a1 is output of first layer and a2 is output of neural network are given in equation (4) and (5).

$$a1 = \text{tansig}(IW * p1 + b1) \quad (4)$$

$$a2 = \text{purelin}(LW * a1 + b2) \quad (5)$$

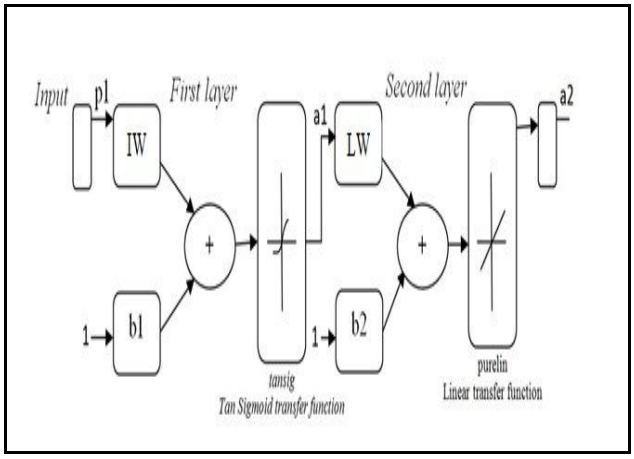

Figure 2 Two Layer Feed Forward Neural Network

The traingdx is a network training function that updates weight and bias values according to gradient descent momentum and an adaptive learning rate. The initial set training parameters of the Feed-Forward Neural Network is gradient descent backpropagation with adaptive learning rate. The performance function is used mean squared error. The maximum number of epochs to train the neural network is 700 and momentum factor is 0.50. The goal of mean of squared error is 0.1, the network is initialized then we need to train the network. In Training, first of all we have to prepare a set of training data, for this we take projection of centered images into facespace using eigenface space and the weight of the input image with respect to our eigenfaces. The network is trained for 700 epochs. Once we have trained the training data, our neural network is prepared for recognition and the performance and recognition is 100%. The performance of two layer neural network is much better than a single layer neural network.

V. EXPERIMENT AND RESULTS

The Neural Network is applied on standard face database face95 and Local images taken by the variation of poses. The images were obtained from Libor Spacek Collection of facial images[18]. This database includes 7900 colored images of faces of 395 individuals. Each individual has 20 image samples in the database. The database consisits of

male and female images of various racial origins. The images are mainly of first year under graduate students, so the majority of individuals are between 18-20 year sold but some under individuals are also present. Some of the individuals has glasses and some of the male individuals have beards. The image format is 24-bit color jpeg in other words 200 x 180 array of pixels and each pixel is represented by 24 bits of RGB color values. The Local Images taken by the variations of poses is created by Sony Digital Camera. The dimension of these images 320 X 240 array of pixels.

The 71 images were selected from face95 standard database and 5 images of Local Images taken by the variations of poses. The 71 and 5 face images in the database were tested using PCA. The threshold value of a database is change. The success rate of recognition using PCA is 100%. The figure 3 shows the sample images of face95 database. The figure 4 shows the eigenfaces of face95 database. The figure 5 shows the mean face of all sample images. The figure 6 gives the query and output image of face95 database. The figure 7 shows the training of neural network of face95 database in which the performance is 0.087516 with 337 epochs. The figure 8 shows the sample local images by pose variations. The figure 9 shows the eigenfaces of local images. The figure 10 shows the mean face of all local images. The figure 11 gives the query and output image of local images.The figure 12 shows the Performance of Neural Network applied on Local Images in which the performance is 0.029753 with 127 epochs. The execution time of face95 and Local Images is only few seconds and the recognition accuracy is 100%.The Table 1 shows the result of Neural Network

Table 1: Results of Neural Network

Database	Total Images	Epochs	Execution Time (Seconds)	Recognition
Face 95	**71**	**337**	**3.4**	**100%**
Local Images	**5**	**127**	**2.2**	**100%**

Figure 3 Sample Images of Face 95 Database

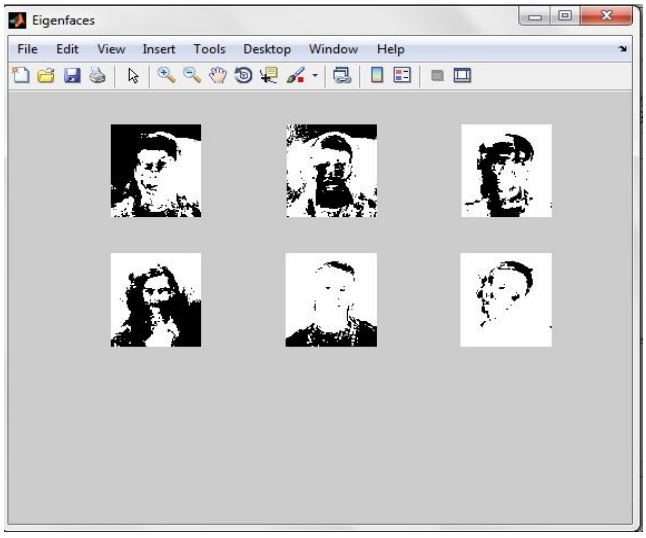

Figure 4 Eigenfaces of Face 95 Database

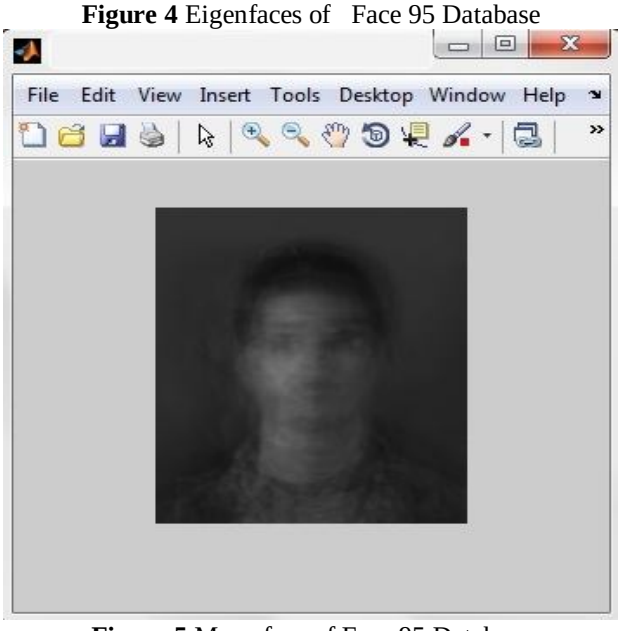

Figure 5 Mean face of Face 95 Database

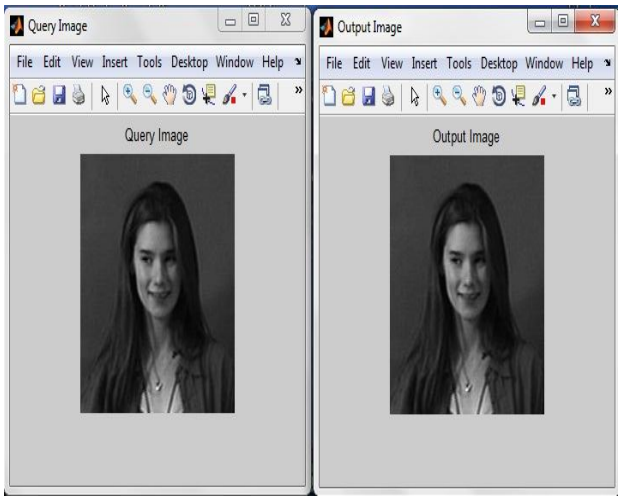

Figure 6 Query and Output Image of Face 95 Database

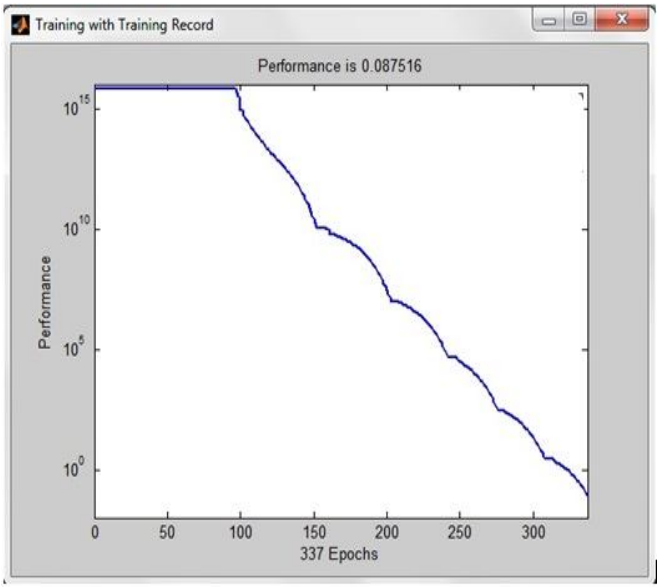

Figure 7 Training of Neural Network of Face 95 Database

Figure 8 Sample Local Images by Pose Variations

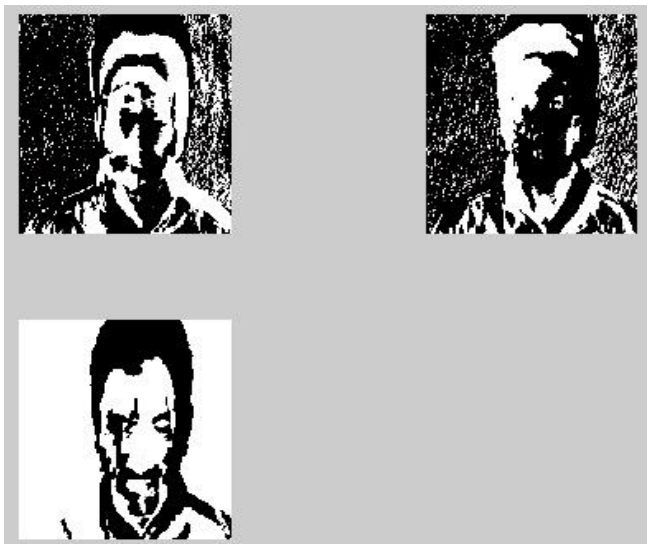

Figure 9 Eigenfaces of Local Images

Figure 10 Mean face of Local Images

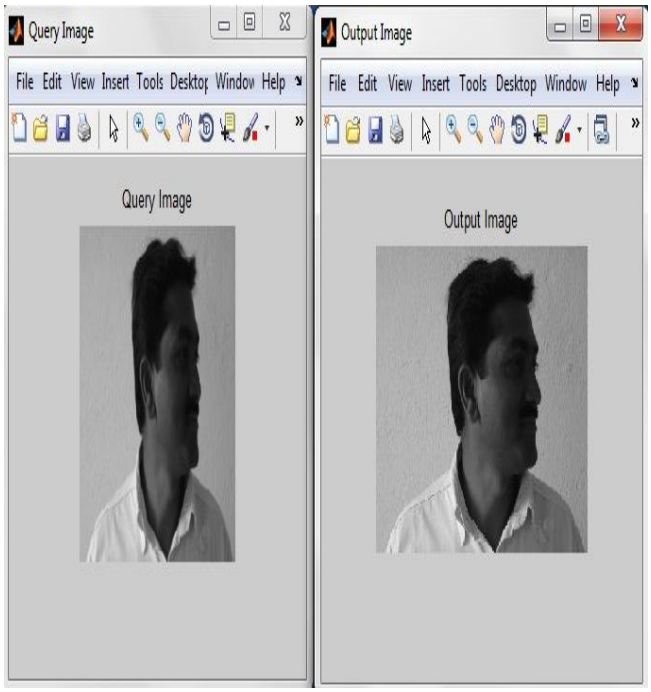

Figure 11 Query and Output Image of Local Images

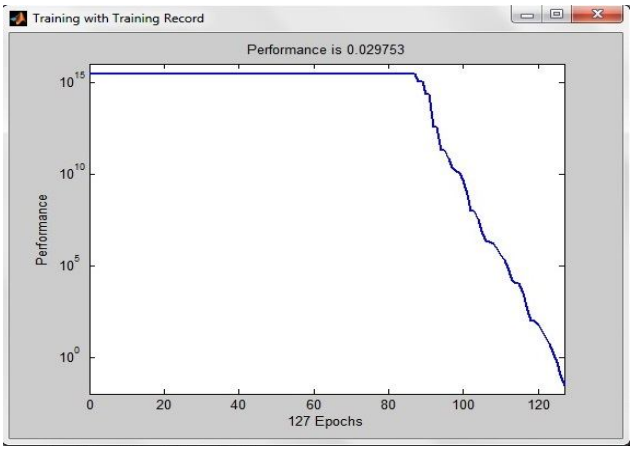

Figure 12 Performance of Neural Network applied on Local Images

VI.Conclusion

It is observed that a lot of researchers give up working in the face recognition problem due to the inefficiencies of the technique used to represent faces. The paper present a face recognition using Principal Component Analysis and Two-Layer Feed-Forward Neural Network techniques used to recognition frontal and Local Images taken by the variations of poses.The dimension of face image is reduced by the Principal Component Analysis and gives feature vector of images. The training and recognition is done by the Feed-Forward Neural Network. The performance of Neural Network for face95 database is 0.087516.The performance of Neural Network applied on local images is 0.029753. Entirely Performance is satisfactory. The execution time is in few seconds and the recognition accuracy is 100%.

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