Face Recognition Using PCA and ANN Algorithm

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Abstract: **This paper is focused on comparative study of two algorithms for face recognition: Principle Component Analysis (PCA) and Artificial Neural Network (ANN). Simulation results show that principle component analysis where eigenface algorithm is used as essentially a minimum distance classifier, works well when illumination variation is small. Here, recognition is done by putting a test image onto the face space spanned by the eigen faces and by measuring minimum Euclidean distance. In ANN algorithm, learning process of neurons is used to train the input face to minimize the error. Face recognition using ANN algorithm shows good accuracy and success rate even for different illumination condition.**

Index Terms **- Face Recognition, PCA, Artificial Neural Network, Eigen Faces, Neurons**

I. INTRODUCTION

Face recognition system is a digital technology and a popular area of research in computer vision and one of the most successful applications of image analysis and understanding. The purpose is to implement the system to identify a particular face from a large number of faces with some real time variations as well. This algorithm can also be extended to recognize the gender of a person or to detect the facial expression of a person. The face recognition system has various applications like security systems, authentication, searching of persons, pattern recognition, computer vision, entertainment etc. The purpose of this research work is to study and develop an efficient MATLAB program for face recognition using PCA and ANN algorithm. In face recognition system the input of an arbitrary image will search in database to output people's identification in the input image. Face recognition process generally consists of four modules: face detection, alignment, feature extraction and matching. Face components such as eyes, nose, mouth and facial outline, based on the location points, the input face image is normalized with respect to geometrical properties, such as size and pose, using geometrical transforms. The face is again normalized with photometrical properties such as illumination and gray scale. After a face is normalized geometrically and photo metrically, feature extraction is performed to provide detail information which is useful. This information is compared against the training set or image database then the face can be classified as known or unknown face.

II. RELATED WORKS

Feature extraction of the human faces by PCA based eigenface process reduces the high dimensional space into very low dimensions [2]. In past decades, various methodologies for face recognition have been reported by researchers in literature. In 2012, Liton Chandra Paul and Abdulla Al Sumam [7] have shown that the face images can be represented in terms of a best coordinate system termed as "eigenfaces". These are the eigen functions of the average covariance of the ensemble of faces. They also proposed that even for large number of faces, the small number of eigenfaces are needed for face recognition. In 2008, RajibSaha and Debotosh Bhattacharjee [8] proposed a face recognition method based on the eigenfaces representation of faces. Various feature extraction methods for face images are also present like Linear Discriminant Analysis (LDA) [2], Kernel methods, Evolutionary Pursuit (EP) Support Vector Machine (SVM) and Artificial Neural Networks(ANN)[1][2]. Linear Discriminant Analysis is a supervised learning algorithm. LDP features are extracted by calculating the edge response values in all eight directions at each pixel position. All projected samples will create the maximum between class scatter and the minimum within class scatter simultaneously in the projective feature space. Each face is represented as a collection of LDP codes for face recognition process.

Evolutionary Pursuit (EP) is a genetic algorithm which resolves the problem of the dimension of the solution space. It is an eigenspace based adaptive approach that searches for the best set of projection in order to maximize a fitness function, measuring at the same time the classification accuracy and generalization ability of the system. Artificial neural networks [1] is a very robust and powerful classification technique that has been used to approximate real-valued, discrete-valued and vector-valued functions from various examples. In 2010, Jong-Min Kim and Myung-A Kang train the system by back propagation using nonlinear units [4]. Learning ability of neurons is used to analyze the different face distances and the parts of backgrounds by training the neural network. This proposed work demonstrates a complete face recognition system by using the principal components analysis [6] based feature extraction in combination with artificial neural networks [3], [13] based detection system for improving the success rate and defining the rejection rate. The work is shown using face images database with MATLAB simulation.

III. ALGORITHMS FOR FACE RECOGNITION

3.1.1 Principal Component Analysis (PCA)

PCA is a mathematical method that performs a dimensionality reduction by extracting the principal components of the multi-dimensional data. The first principal component is the linear combination of the original dimensions that has the highest variability. The n-th principal component is the linear combination with the maximum variability, being orthogonal to the n-1 first principal components.

The process is based on an information theory that decomposes face images into a small set of characteristic feature images called 'Eigen faces', which are actually the important components of the initial training set of face images. An important characteristic of PCA is that one can reconstruct any original image from the training set by combining the Eigen faces. The technique used in creating Eigen faces and using them for recognition is also used outside of facial recognition. This technique is also used for handwriting analysis, lip reading, voice recognition, sign language interpretation and medical imaging analysis. In training phase, each face image is represented as a column vector, with each entry corresponding to an image pixel, these face image vectors are then normalized with respect to the average face. Next, the algorithm calculates the eigenvectors of the covariance matrix of normalized faces by using a speedup technique that reduces the number of multiplications to be performed. This eigenvector matrix is then multiplied by each of face vectors to obtain their corresponding face space projections.

Finally, the recognition threshold is calculated by using the maximum distance between any two face projections. In the recognition phase, a subject face is normalized with respect to the average face and then projected onto face space using the eigenvector matrix. Next, the Euclidean distance is calculated between this projection and all known projections. The minimum value of these comparisons is considered and compared with the threshold value calculated during the training phase. Based on this, if the value is greater than the threshold value, the face is new. Otherwise, it is a known face.

3.1.2 Algorithm

Step 1: Creation of Database

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

Step 2: Eigenvalues Calculation

1. PCA algorithm is used to determine the most discriminating features between images of faces.
2. Next define a 2D matrix that contains all the training image vectors and gives 3 outputs which are extracted from training database.
3. Then compute mean of face images of training database image as m = (1/P)*sum (Tj's). 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. Now calculate the eigenvectors of the covariance matrix of the training database and then find matrix of centred image vectors

Step 3: Recognition of Image At this level we compare the two faces by projecting the images into face space and measuring the Euclidean distance between them:

1. First project the centred images into face space and extract PCA features from the test image.
2. Then calculate Euclidean distances between the projected test image and the projection of all centred training images

3.1.3 Face space

A two dimensional image $\Gamma(x,y)$ of size m-by-n pixels can be viewed as a vector in high dimensional space. The easiest process to create a vector from an array is to concatenate its columns, thus getting a vector $X=[x_1...x_N]^T$, where N= mXn. Then each pixel of the image then corresponds to a coordinate in N-dimensional space. This N-dimensional space is referred as image space. This space has huge dimensionality ($\Re^N$) and recognition there would be computationally inefficient.

However, if an image of an object is a point in image space, a collection of M images of the same sort of an object represents a set of points in the same subspace of the original image space. These points may be considered as samples of probability distribution. All possible images of one particular object define a lower dimensional manifold, embedded within the high-dimensional image space. For face recognition purposes it is referred as face space. Its intrinsic dimensionality is determined by the number of degrees of freedom within face space.

Generally, the goal of subspace analysis is to determine the intrinsic dimensionality and to extract the principal modes (basis functions) of the principal manifold. By this process a subspace, compression is achieved (computational efficiency), data samples are drawn from a normal distribution and, because data will be mean centered, Euclidian distance in subspace is inversely proportional to correlation between source images.

3.2.1 Artificial Neural Network [6]

The neural networks algorithm for face recognition is based on the functionality of neurons. The perceptron is the neural network equivalent of a neuron. Like a neuron sums the strengths of all its electric inputs, a perceptron performs a weighted sum on its numerical inputs.

Using these perceptrons, a neural network is formed for each person in the database. The neural networks usually consist of three or more layers. An input layer takes in a dimensionally reduced image from the database. An output layer produces a numerical value between 1 and -1. In between these two layers, there usually exist one or more hidden layers. For the purposes of face recognition, one hidden layer provides a good balance between complexity and accuracy. Including more than one hidden layer exponentially increases the training time, while not including any results in poor recognition rates. Once this neural network is formed for each person, it must be trained to recognize that person. The most common training method is the back-propagation algorithm.

Back propagation algorithm sets the weights of the connections between neurons such that the neural network exhibits high activity for inputs that belong to the person it represents and low activity for others. During the recognition process, a reduced image is placed at the input of each of these networks, and the network with the highest numerical output would represent the correct match.

The main issue with neural networks is that there is no clear method to find the initial network topologies. Since training takes a long time, experimenting with such topologies becomes a difficult task. Another problem that arises when neural network are used for face recognition is that of online training. Unlike PCA algorithm, where an individual may be added by computing a projection, a neural network must be trained to recognize an individual. This is a time-consuming process not well suited for real-time applications.

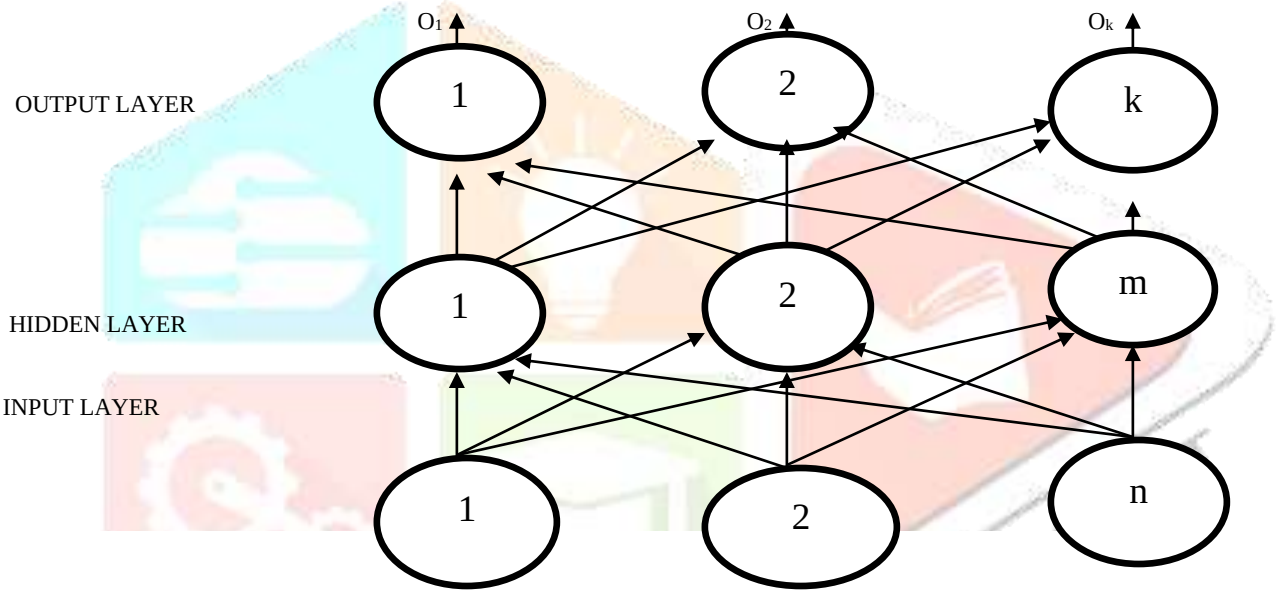

Fig. 1 Feed Forward Neural Network

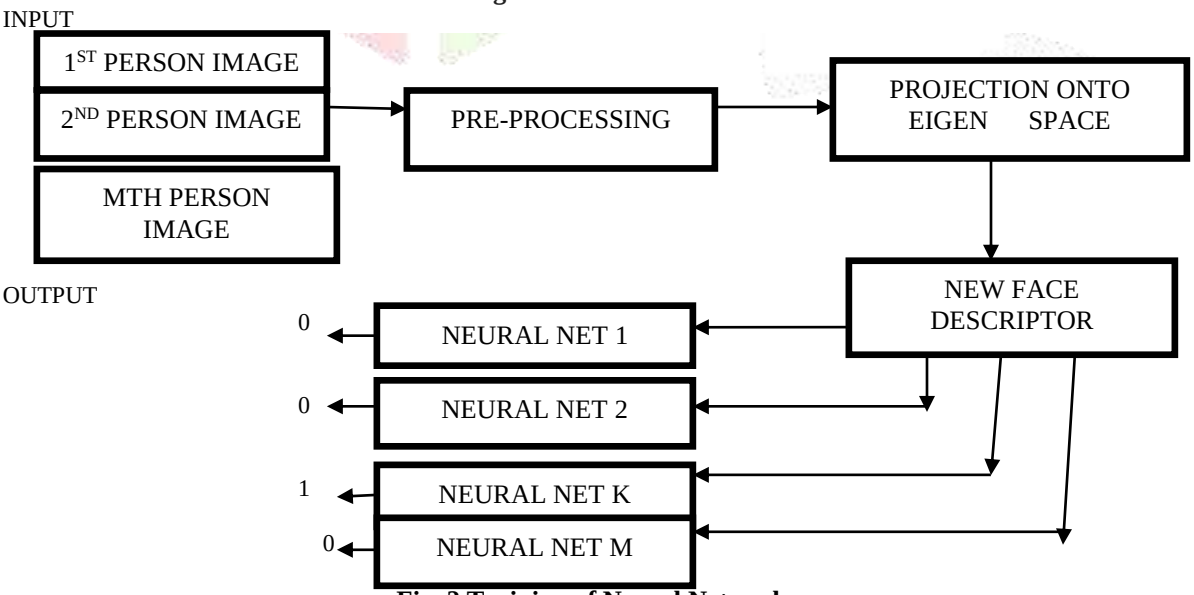

Fig. 2 Training of Neural Network

3.2.2 Algorithm

Back propagation neural network is a multilayered feed forward neural network. During its training process, back propagation 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. First set the value of all weights to random value range from -1.0 to 1.0.
2. Then set an input binary values pattern into the neurons of the net's input layer.
3. Next activate each and every neuron of the following layer:
   i) Multiply weight values of the connections leading to this neuron with the output values of the preceding neurons and summarize these values.
   ii) After that pass the result to an activation function, this calculates the output value of this neuron.
4. Now repeat all this procedure until the final output layer is achieved.
5. Then compare the computed output pattern to the desired objected pattern and calculate value of square error.
6. Now 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.

IV. SIMULATION RESULTS

4.1.1. Simulation of Face Recognition Using PCA Algorithm

The simulation of the proposed approach was performed on MATLAB version 2014a to affirm the effectiveness of the proposed algorithm. The size of the input image was assumed to be m * n.

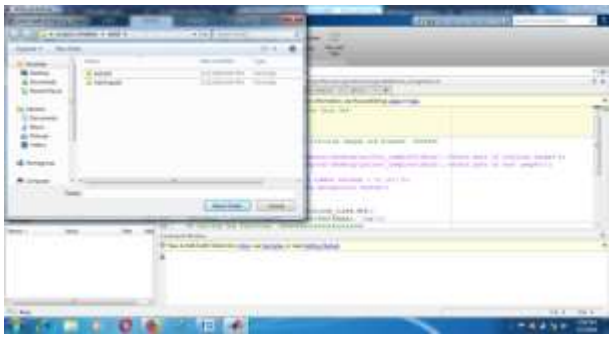

Fig .3 Database of face images

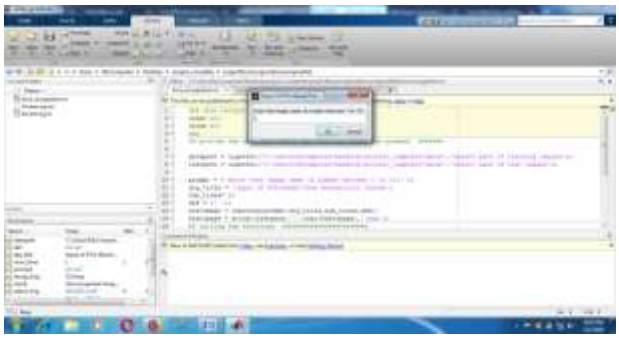

Fig .4 Choose a face image for recognition

Fig .5 Simulation result of PCA Algorithm

Figure 3 shows two folders which consist of database of the faces and named as test set and training set. Selection of one image from test set and compare with training set is shown in Fig. 4. Figure 5 shows the recognized image by using PCA algorithm.

4.2.2 SIMULATION OF FACE RECONITION USING ANN ALGORITHM

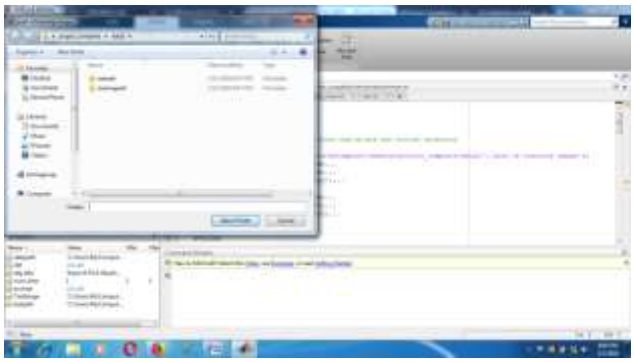

Fig .6 Database of face images

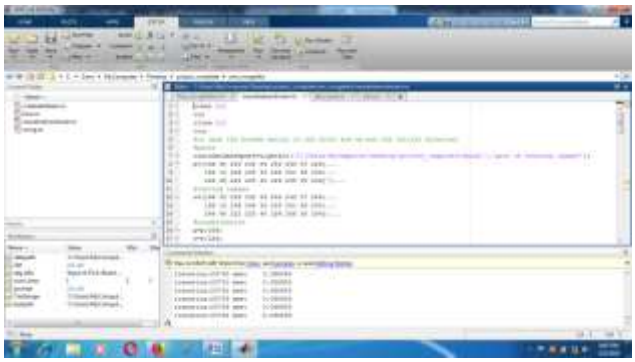

Fig .7 Simulation of ANN Algorithm

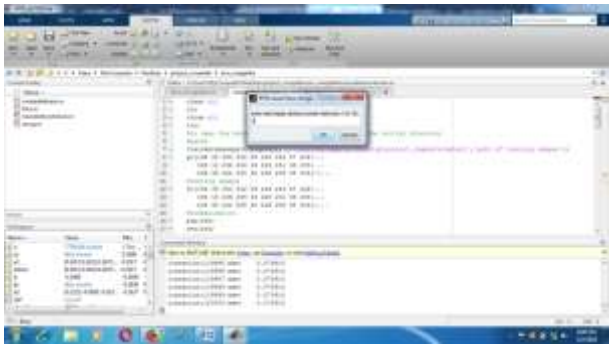

Fig .8 Choose a face image for recognition

Fig.9 Simulation result of ANN Algorithm

Figure 6 shows two folders which consist of database of the faces and named as test set and training set. Figure 7 illustrates the iteration and MSE of the neural network during training of the neural network. As shown in Fig .8, one image is to be selected from test set and compared with training set. Figure 5 shows the recognized image by using ANN algorithm. One artificial neural network is used for each person in the database in which face descriptors are used as inputs to train the networks. During training of the artificial neural network's, the faces descriptors that belong to same person are used as positive examples for the person's network that gives 1 as output and negative examples for the others network that gives 0 as output.

Simulation of ANN for Recognition

New test image is taken for recognition process. These new descriptors are given as an input to every network; further these networks are simulated. Compare the simulated results and if the maximum output exceeds the predefined threshold level, then it is confirmed that this new face belongs to the recognized person with the maximum output.

Table .1 Simulation Result

Number of face	Iteration	% of classification	MSE
20	234	87.5000	0.0573
	208	99.500	0.0160
	115	99.235	0.0101
30	97	34.5833	0.1287
	166	99.5833	0.0214
	246	87.9167	0.0613
40	147	79.1667	0.0742
	140	97.0833	0.0301
	119	99.1667	0.0224

50	74	29.1667	0.1336
	196	97.0833	0.0322
	148	99.1667	0.0248
60	85	24.1667	0.1387
	95	93.7500	0.0460
	150	97.9167	0.0325
70	92	34.5833	0.1306
	162	92.0833	0.0470
	162	96.6667	0.0352
80	117	86.6667	0.0612
	120	83.333	0.0675
	155	96.6667	0.0319
90	117	81.6667	0.0686
	96	87.0833	0.0583
	135	96.6667	0.0338
100	67	41.6667	0.1213
	122	98.333	0.0269
	139	93.7500	0.0435

In classification module, with the help of a pattern classifier, extracted features of the face image is compared with the ones stored in a face library (or face database).After this comparison, face image is classified as either known or unknown. From the above Table 1 we observe that classification process depends on the number of iteration of a neural network and mean square error. When mean square error increases then the rate of classification decreases and vice versa.

V. COMPARISION BETWEEN PCA AND ANN

Face Recognition using principal component analysis

Strength

1. Recognition is simple and efficient compared to other Matching approaches.
2. Data compression is achieved by the low dimensional subspace representation.
3. Raw intensity data are used directly for learning and recognition without any significant low-level or mid-level processing.
4. No knowledge of geometry and reflectance of faces is Required.

Weakness

1. The method is very sensitive to scale, therefore, a low- level pre-processing is still necessary for scale normalization.
2. The Eigen face representation is, in a least squared sense, faithful to the original images, its recognition rate decreases for recognition under varying pose and illumination.
3. These experiments were made only with frontal views. The problem can be far more difficult when there exists extreme change in pose as well as in expression and disguise.

Face Recognition artificial neural network

Strength

1. This method indicates that the high speed recognition over PCA based method which is widely used for feature extraction.
2. Artificial Neural Network acts as a reliable classifier
3. The combination of Wavelet and ANN exhibits the most favourable performance, it has the lowest overall training time, the lowest redundant data, and the highest recognition rates

Weakness

1. The direct use of wavelet coefficients may not extract the most discriminative features.
2. There is much redundant or irrelevant information contained in wavelet coefficients.
3. It cannot recover new meaning underlying features which has more discriminative power.

VI. CONCLUSION

In this paper we have compared two different techniques for face recognition with their strengths and weaknesses. The study shows that face recognition using PCA with ANN provides a high accuracy rate.ANN works better than the individual PCA. This method has an acceptance ratio of more than 90% and the execution time of only a few seconds. Finally, the ANN exhibits the most favourable performance, it has the lowest overall training time, the lowest redundant data, and the highest recognition rates when compared to similar so-far-introduced methods. Hence, it is concluded that face recognition using artificial neural network is the best one for recognizing face and it is also possible to obtained high face recognition rate equal to 98% by using this technique.

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