Face Recognition using PCA & Neural Network

Hemant Singh Mittal, Harpreet Kaur

Abstract— The Face Recognition Scheme Based on Neural Network and PCA technique for the detection of the persons. I have used the PCA technique which involves a mathematical method that transforms a number of possibly correlated variables into a smaller number of uncorrelated variables called principal components. Pre-processing stage –In this stage the images are made zero-mean and unit- variance. Dimensionality Reduction stage: (PCA) - Input data is reduced to a lower dimension to facilitate classification. In this stage dimension are reduced. Classification stage - The reduced vectors output from PCA are applied to the BPNN classifier for the training of the data and used to obtain the recognized image. I got good results from this proposed algorithm, MATLAB platform is used on various images to detect.

Keywords — Program Component Analysis, Face detection, Eigen values, Back Propagation neural networks.

I. INTRODUCTION TO FACE RECOGNITION

The recognition of a person by their facial image can be done in a many different ways such as by taking an image of the face in the visible region using an inexpensive camera or by using the infrared patterns of facial heat emission. Facial recognition in visible light is the model key such as features from the central portion of a facial image. Using a wide assortment of cameras, the visible light system is used to extract the features from the images that do not change over time while avoiding superficial features such as expressions of face as mouth, nose eyes, lips, hair. Many approaches for the modeling of facial images in the visible spectrum are Principal Component Analysis, Local Feature Extraction, Neural Networks, Comparative Analysis, Automatic Gabor wavelet feature extraction method, and Radial basis function. Some difficulties in face recognition in the visible spectrum include reducing the impact of variable values and detects the mask or photograph. Some facial recognition systems may require a stationary or posed manner in order to take the image, though many systems use a real time process to detect a person's head and locate the face automatically. Main advantages of face recognition are that it is non-intrusive, continuous and accepted by approximate all the users.

Face detection is essential front end for a face recognition system. Face detection locates and segments face regions from cluttered images, either obtained from video or still image.

Manuscript received on April, 2013.

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It has numerous applications in areas like surveillance and security control systems, content based image retrieval, video conferencing and intelligent human computer interfaces. Most of the current face recognition systems presume that faces are readily available for processing.

Human communication has two main aspects: verbal (auditory) and non-verbal (visual), examples of the latter being facial expressions, body movements and physiological reactions. All of these provide significant information regards the state of the person:

(i) Affective state, which includes both emotions such as fear, surprise, anger, disgust, sadness, and more enduring moods such as euphoria or irritableness.

(ii) Cognitive activity, such as perplexity, boredom, or concentration, temperament and personality, including such traits as hostility, sociability or shyness.

(iii) Truthfulness, including the leakage of concealed emotions, and clues as to when the information provided in words about plans or actions is false.

(iv) Psychopathology, including not only diagnostic information relevant to depression, mania, schizophrenia, and other less severe disorders, but also information relevant to monitoring response to treatment.

II. PRINCIPAL COMPONENT ANALYSIS

Principal component analysis (PCA) involves a mathematical method that transforms a number of possibly correlated variables into a smaller number of uncorrelated variables called principal components. PCA is a very famous approach, which is used to calculate a set of features for face Recognition.

Any particular face can be

(i) Economically represented along the eigen pictures coordinate space, and.

(ii) Approximately constructed by the uses a small collection of Eigen pictures.

To do this ,When a face image is projected to several face templates called eigenfaces then the difference between the images will be calculated which can be considered as a set of features that are considered as the variation between face images. When a set of eigenfaces is calculated, then a face image can be approximately reconstructed using a weighted combination of the eigenfaces. The projected weights form a feature vector for face representation and recognition. When a new test image is given, the weights are calculated by projecting the image onto the eigen- face vectors. The classification between the images is then carried out by comparing the distances between the weighted vectors of the test image and the trained images from the input database. Conversely, we can reconstruct the original image from the eigen faces so that the input image must exactly match with the original image using all of the eigen faces extracted from the original images.

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PCA is a mathematical method that is based on a transformation of the variables namely orthogonal with which we can convert a set of correlated variables into a set of uncorrelated variables. The variables which are uncorrelated with each other are known as principal components. The number of principal components means the uncorrelated must be less than or equal to the number of original variables. In such type of transformation the first principal components will have the highest priority which shows the maximum variance . This will help us to calculate the variability in data. If the data set is distributed normally only in that case the principal components has surety to be independent from the other variables. The reduction in dimensions can cause information loss but it preserves as much information as possible. The best low dimensional space can be calculated by the best eigenvectors of the covariance matrix.

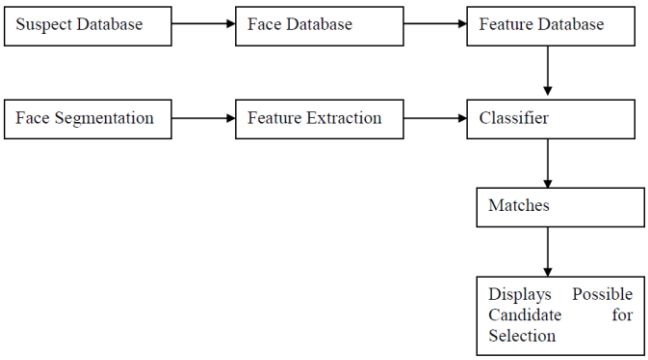

Fig. 1 Face Identification System

III. ALGORITHMS AND PROPOSED TECHNIQUE

Pre-processing stage –In this stage the images are made zero-mean and unit-variance Dimensionality Reduction stage: (PCA) - Input data is reduced to a lower dimension to facilitate classification. In this stage dimension are reduced.
Classification stage - The reduced vectors output from PCA are applied to the BPNN classifier for the training of the data and used to obtain the recognized image.
Face recognition is a biometric technique used for surveillance purposes such as search for wanted criminals, suspected terrorists, and missing children. The term face recognition refers to the identification of an unknown face image, by using computational algorithms. This operation can be done by comparing the unknown face with the faces stored in database.
Face recognition has three stages.
1. Face location detection
2. Feature extraction
3. Facial image classification.

IV. PCA ALGORITHM

Let the training set of images be $\Gamma_1\ \Gamma_2\ \Gamma_3\ \Gamma_4 \dots\dots\dots\dots \Gamma_M$.
The average face of the set is defined by

$$\Psi = \frac{1}{M}\sum_{n=1}^{M} \Gamma_n$$

Each individual face differs from the average face by the vector

$$\Phi_i = \Gamma_i - \Psi$$

The Co- Variance matrix is formed by vector

$$C = \frac{1}{M}\sum_{n=1}^{M} \Phi_n\ \Phi_n^T = AA^T$$

Where the Matrix

$$A = (\Phi_1\ \Phi_2\ \Phi_3 \dots\dots\dots\dots \Phi_M)$$

The set of large vectors is then subject to PCA , Which Seeks a set of M orthonormal vectors $U_1 \dots\dots U_M$
To obtain weight vector Ω of the facial image Γ.
The face is transformed into the Eigenface components projected onto the face space

$$W_k = U_k^T\ (\Gamma - \Psi)$$

For k= 1,…...M', Where M'≤M is the no. of eigenfaces used for the recognition.
The weights form vector

$$\Omega = (w_1, w_2, w_3, \dots\dots\dots w_M)$$

V. BACK PROPOGATION NEURAL NETWORKS ALGORITHMS

A typical back propagation network with Multi-layer, feed-forward supervised learning is as shown in the figure. Here learning process in Back propagation requires pairs of input and target vectors. The output vector 'o 'is compared with target vector't'. In case of difference of 'o' and't' vectors, the weights are adjusted to minimize the difference. Initially random weights and thresholds are assigned to the network. These weights are updated every iteration in order to minimize the mean square error between the output vector and the target vector.
Input for hidden layer is given by

$$net_m = \sum_{z=1}^{n} x_z\ w_{mz}$$

The units of output vector of hidden layer after passing through the activation function are given by

$$h_m = \frac{1}{1 + \exp(-net_m)}$$

In same manner, input for output layer is given by

$$net_k = \sum_{z=1}^{m} h_z\ w_{kz}$$

and the units of output vector of output layer are given by

$$o_k = \frac{1}{1 + \exp(-net_k)}$$

For updating the weights, we need to calculate the error. This can be done by

$$E = \frac{1}{2}\sum_{i=1}^{k} (o_i - t_i)^2$$

and represents the real output and target output at neuron *i* in the output layer respectively. If the error is minimum than a predefined limit, training process will stop; otherwise weights need to be updated. For weights between hidden layer and output layer, the change in weights is given by

$$\triangle w_{ij} = \alpha \delta_i h_j$$

Where a training rate coefficient that is restricted to the range [0.01,1.0], is the output of neuron *j* in the hidden layer, and can be obtained by

$$\delta_i = (t_i - o_i)\ o_i\ (1 - o_i)$$

Similarly, the change of the weights between hidden layer and output layer, is given by

$$\triangle w_{ij} = \beta \delta_{Hi} x_j$$

Where β is a training rate coefficient that is restricted to the range [0.01,1.0], is the output ofNeuron j in the input layer, and *can* be obtained by

$$\delta_{Hi} = x_i\ (1 - x_i) \sum_{j=1}^{k} \delta_j\ w_{ij}$$

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is the output at neuron i in the input layer, and summation term represents the weighted sum of all values corresponding to neurons in output layer that obtained in equation. After calculating the weight change in all layers, the weights can simply updated by

$$w_{ij}(new) = w_{ij}(old) + \triangle w_{ij}$$

This process is repeated, until the error reaches a minimum value

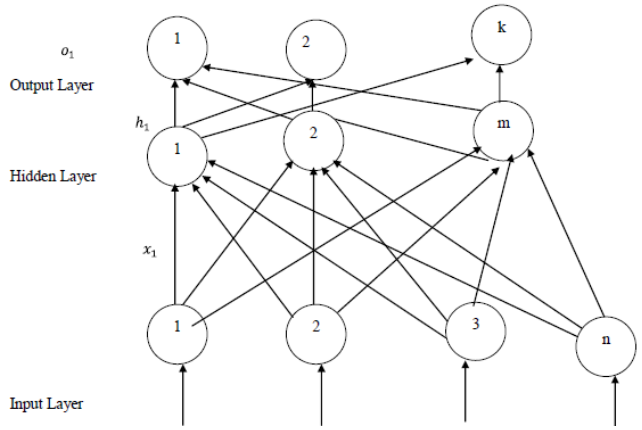

Fig 2 Basic Block Diagram of Back Propagation Neural Network

VI. RELATED WORK

Selection of Training Parameters

For the efficient operation of the back propagation network it is necessary for the appropriate selection of the parameters used for training.

Initial Weights

This initial weight will influence whether the net reaches a global or local minima of the error and if so how rapidly it converges. To get the best result the initial weights are set to random numbers between -1 and 1.

Training a Net

The motivation for applying back propagation net is to achieve a balance between memorization and generalization; it is not necessarily advantageous to continue training until the error reaches a minimum value. The weight adjustments are based on the training patterns. As long as error the for validation decreases training continues. Whenever the error begins to increase, the net is starting to memorize the training patterns. At this point training is terminated.

Number of Hidden Units

If the activation function can vary with the function, then it can be seen that a n-input, m output function requires at most 2n+1 hidden units. If more number of hidden layers are present, then the calculation for the values are repeated for each additional hidden layer present, summing all the values for units present in the previous layer that is fed into the current layer for which is being calculated.

Learning rate

In BPN, the weight change is in a direction that is a combination of current gradient and the previous gradient. A small learning rate is used to avoid major disruption of the direction of learning when very unusual pair of training patterns is presented.

Various parameters assumed for this algorithm are as follows.

No. of Input unit = 1 feature matrix
Accuracy = 0.001
Learning rate = 0.4
No. of epochs = 400
No. of hidden neurons = 70
No. of output unit = 1

Main advantage of this back propagation algorithm is that it can identify the given image as a face image or non face image and then recognizes the given input image .Thus the back propagation neural network classifies the input image as recognized image.

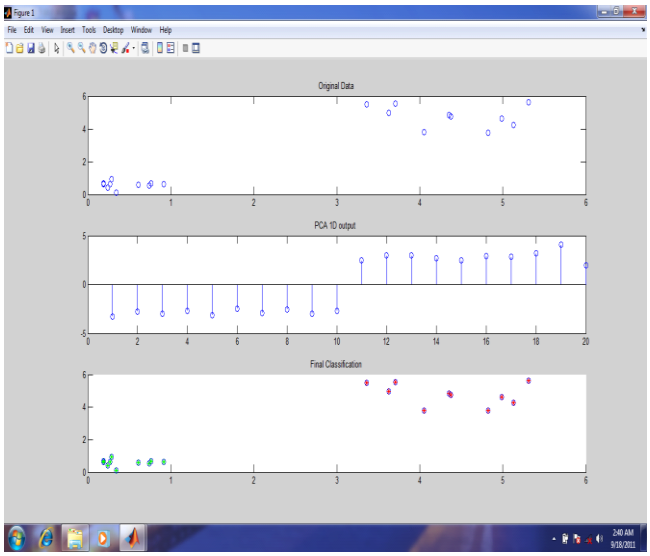

Fig 3 Representation of PCA

According to this graph firstly the original data is applied to PCA and then PCA pre processes the data and transforms the data into a proper curve known as transient curve as shown in the above figure. After that the data classified differently according to the face image and the different colors shows the classification.

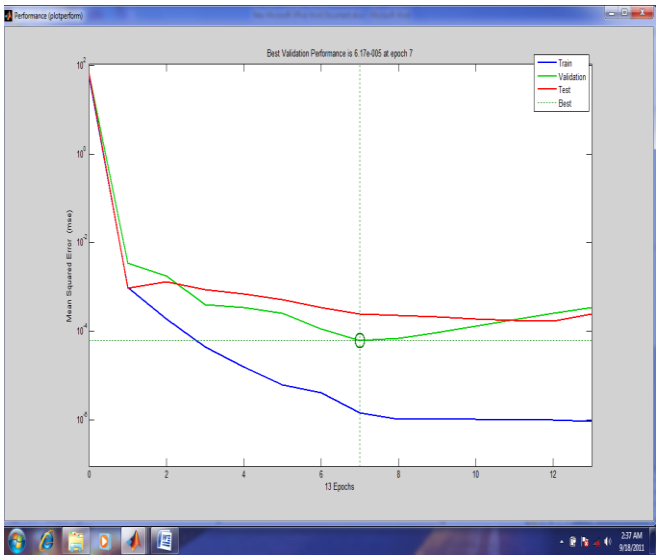

Fig 4 Output Performance Graph

This is termed as the Performance Graph. According to this graph there are three different curves of different colors different colors have different meanings as the blue line denotes the Training the data line and the green line denotes the Validation of the data and Red line denotes the Testing of the data. Generally we select the 70% of the data for training and 15% data for the Validation of the data and 15% for testing data.

And according to this graph the error rate is very small and the rate of detection is very high which is shown in the further Regression Graphs.

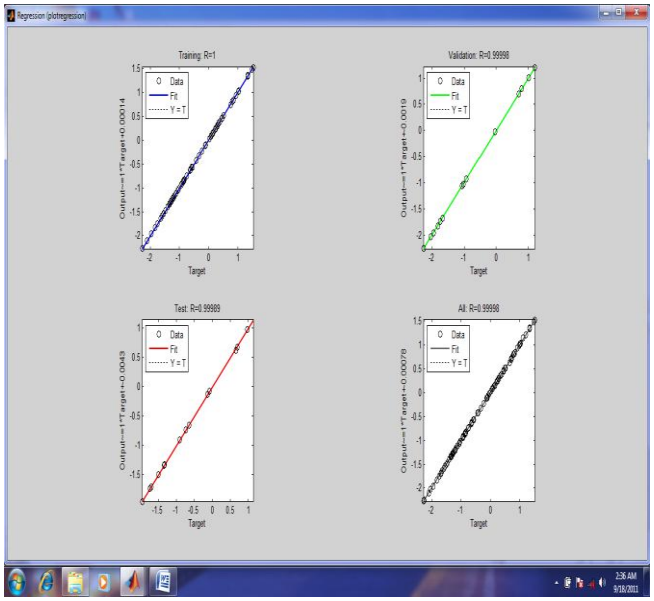

Fig 5 For Regression Values

The above graph is termed as Regression Plot. This graph is plotted to calculate the value of accuracy or to determine the detection rate or Recognition rate. According to this graph the accuracy or the recognition rate is very high approximately equal to 100% for the trained images and decreases to a very small extent for non-trained images. This is also shown in the above graph.

VII. CONCLUSION

Face detection has many applications including Security applications, until recently, much of the work in the field of computer vision has focused on face recognition, with very little research into face detection. Human face detection is often the first-step in the recognition process as detecting the location of a face in an image, prior to attempting recognition can focus computational resources on the face area of the image. Although a trivial task that can be performed by human effortlessly, the task of face detection is a complex problem in computer vision, due the great multitude of variation present across faces. Several techniques have been proposed to solve this problem, including Feature-Based approaches, and the more recent Image-Based approaches, Compression of the images. Both categories of approaches offer systems worthy of recognition with promising results. Feature-Based Approaches, often applied to real-time systems, are often reliant on a priori knowledge of the face, which is used explicitly to detect features. The more robust Image-Based approaches are too computationally expensive for real-time systems, although systems using a hybrid of both approaches are being developed with encouraging results.

By the use of PCA and BPNN the value of the recognition rate increases. So by dividing the Pre processed image into smaller subsets known as principal components are applied to the neural network approach. To improve the output accuracy back propagation neural network is used in the LM approach. And this neural network is used for the classification of the images and detects the image very accurately. Firstly the neural network is trained and then testing the images provides the image which matches with the actual image. And the detection rate of this system is approximately 100% for the trained images.

Results from Proposed Scheme:

When BPNN technique is combined with PCA, non linear face images can be recognized easily. One of the images is taken as the Input image. The Recognized Image by BPNN and reconstructed output image by PCA is as BPNN technique is combined with PCA, non linear face images can be recognized easily. Hence it is concluded that this method has the accuracy more than 99 % and execution time of only few seconds. Face recognition can be applied in Security measure at Air ports, Passport verification, Criminals list verification in police department, Visa processing , Verification of Electoral identification and Card Security measure at ATM's. Face recognition has received substantial attention from researches in biometrics, pattern recognition field and computer vision communities. In this dissertation we proposed a computational method of face detection and recognition, which is fast, reasonably simple, and accurate in constrained environments such as an office or a household

Table 1. Accuracy of Face Detection Using PCA and PCA with BPNN

IMAGES	PCA	PCA WITH BPNN
40	92.4	96.5
60	90.6	94.3
120	87.9	92.8
160	85.7	90.2
200	83.5	87.1

According to the above Table which was proposed earlier the Rate of recognition or detection of the face using only PCA is smaller But by using PCA and BPNN the detection of face images or the recognition rate increase so the accuracy as shown in the above table is as

Table 11. Accuracy of Face Detection Using PCA and PCA with BPNN

Images	PCA	PCA With BPNN
40	95.8	100
60	93.5	99.99
120	90.7	99.98
160	88.6	99.987

The Table Shown above consists of the values which are calculated and showing the improvement in the rate of detection by using PCA and BPNN. In this system the accuracy is up to 100% for the trained images. And the accuracy decreases to a small extent by the increase in the number of images.

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