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Development of Pose Invariant Face Recognition Method Based on Pca and Artificial Neural Network.

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ABSTRACT-

This paper considers human face for pose invariant face recognition as a biometric parameter. There are lots of methods proposed for the face recognition. Face recognition by Neural Network and PCA is common method used now days. But every time it is not possible that the situation or poses are same. Due to some reasons the conditions are change like wink position, blinking, left pose, right pose, etc. In such cases recognition goes difficult. This paper focused on pose invariant human face recognition system and as a result we focus on face recognition system using PCA with feed forward Neural (Multilayer) Networks for recognition of human face irrespective of pose of face in images. The Principal Components Analysis (PCA) is used as a feature extractor whereas Neural (Feed Forward) Network is used for classification. We refer Yale Face Database with 11 images for each subject in which is having poses like wink, open mouth, smile etc.

Keywords- PCA; Neural Network; Yale; Pose; Eigen Vector; Eigen Value;

1. INTRODUCTION-

Face recognition methodology uses computer algorithm to prefer out some specific, typical details about a human's face. Some of these details, such as distance between the eye's opening or shape of the chick and chin, are represented into a mathematical model and compared with the data on other faces composed in a face database.[6][11]

Face recognition is a methodology of recognizing or authenticating a subject's through an image of their face. Generally, this recognition is used to access an applications or systems or services. Facial appearance has more gestures or positions due to the face muscles above the skin on face. As per the controversial theory, the movement of muscles conveys the emotional state of a specific to viewers [11][17]. There are lot many from facial of poses as per the study: Happy, Sad, Angry, Fearful, Disgusted, Surprised, wink, Appalled, Hate, Impressed etc. Independent of the Poses, the face recognition is process perform by both human's eyes and brain system or by means of some algorithms, which has the steps as:

1. Face Locating in picture (detection of face),
2. Feature Extracting by means of some algorithm from above face (e.g., Eigen value calculation; this step is called as feature extraction for face recognition),
3. Analyzing face from the pose image with the extracted features and recognizing the face from above information by means of classifier and recognizing it as a subject.

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This paper proposes PCA for the process of extraction of feature from input images and Feed Forward Neural Network for the process of classification. The neural network is multilayer NN.[29[[36]

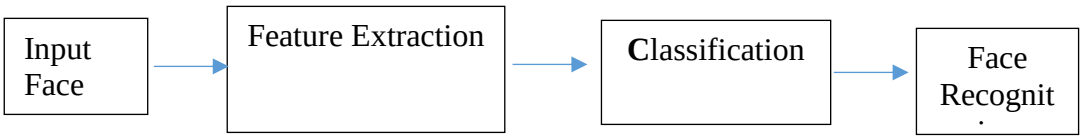

Figure 1: steps in designing the Pose invariant Face Recognition.

a. PCA (Principal Components Analysis): -

PCA (Principal Components Analysis)[29] is one of the used standard statistical methodologies recommended to facial features extraction. This transforms input dataset which is represented by a random Vector as

$f = [fo, f_l, f_2,...,f_{p-1}]^T$ (1)

$E[f] = 0$

As with Correlation Matrix $R_f = E[FF^T] = R^T_f$ to some sets of coefficient called principal component (PC).

$ki = U^T i\ F = F^T Ui$, I = 0, 1, 2, … … , .p-1 (2)

and represented by the vector $k = [ko, k_1, k_2, . \ . \ . , k_{p-1}]^T$.

Unit vectors $Ui = [u_{io}, u_{il}, u_{i,2}.. , u_{ip.i}]^T$ which forms matrix as $u = [u_0, u_1, u_2, \ … ., u_{p-l}]$, then have the Eigen vectors of Correlation Matrix R_f, linked with the Eigen values $\lambda_0, \lambda_1, \lambda_2, … \lambda_{p-1}$ where as $\lambda_0 > \lambda_1 > \ …>… >\lambda p-1$ which having $\lambda_0 = \lambda max$

Useful and key Eigenvectors are these values which having highest Eigenvalues of R_f.[40] To consider the required input data by reducing total number of values called as PC (Principal Component) of the Eigenvectors (after dimensionality reduction). This transformation used Eigenvectors equivalent to highest Eigenvalues of Rf and these values corresponding to smaller Eigenvalues are useless (ignored). [16][17]

b. Multilayer Feed-Forward NN (Neural Network):-

The perceptron is a basic building unit for artificial neuron. Perceptron compute weighted sum of all input with threshold weights and then passes that sum through some activation function (preferred sigmoid):

$$Vi = S_i + \sum_{i=1}^{\infty} Wij.fj \quad (3)$$

$Yj=\varphi i(Vi)$ (4)

Where Vi is linear grouping of inputs fl, f2, ...,fp of neurons = i and wjo= Sj is threshold value of the weights linked to input fo = - 1, Yj is Output of j^{th} Neuron whereas $\varphi i(.)$ becomes forms the activation function. Here I recommend here to use a special sigmoidal function as activation function-

$$y_j = \frac{1}{1+\exp(-v_j)} \quad (5)$$

In multilayer perceptron, from the output of one layer derives the input to the consecutive upcoming layers. The Weights of each Network will generally calculated by training those networks. [15][16]

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c. Face Database -

This paper focus the work that done on database from Yale, which is having the face images of 15 (fifteen) number of subjects (shown in Fig. 2), 11 (eleven) for each subject under various poses and scales. Hence the total numbers of face images are 165. The size of each image becomes in database is 240 pixels X 320 pixels with eight-bit gray scale image. The illustration for the database face image pattern belongs to the single subject is shown below in Figure 2 below. [15][16][17]

Figure 2: - A Subject with different poses

d. Epoch: -

An epoch is an instant in instance for which coordinate is specify. A case of coordinate, the pose at another time can computes by considering precession and suitable shift. Similarly, in cases of elements, it's necessarily considers perturbation done by another object in order to analyze elements for special time. An epoch is the training of the NN Network with all data for the training for single cycle. In it, forward pass and backward pass jointly are counted as one pass: Epoch will be made-up of 1 or more than 1 batches. This paper used a part of dataset for the purpose of training the neural network and past for classification.[16][17]

2. RECOGNITION METHODOLOGY: -

Calculated PCA (Principal Components) depicts indirectly to facial posed images via Eigen value. Eigenvector calculation step is shown in following schematic diagram 3. Correlation Matrix for the training images from database are computed first from 1or 2 or… or 9 input posed faces and the classification is done by help of first 15 Eigen Vectors of calculated Correlation Matrix. After that methodology applied, the faces of subjects irrespective to the poses got the result of 95.54 % from the test input faces which are recognized fruitfully. Thus the resultant methodology on pose invariant face recognition is depicted in figure below (figure 3).

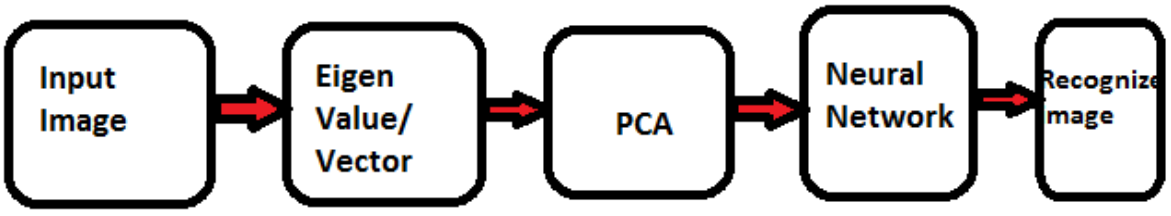

Figure 3:- Pose Invariant face recognition system

Here, the considered database is Yale Face database. In that database the subjects are fifteen (15) with eleven (11) images with dissimilar poses. Each image from database is having 240 pixels X 300 pixels size. Firstly down samples these images by 25% (¼) to get 60 pixels X 80 pixels size, which is reduced from 72000 pixels to 4800 pixels. Now from that down sampled images, considering the different number of input images (which varies from 1 to 9) for training

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purpose, even if, this paper recommended the eight face images for each subject for training of neural network but it will be possible that person in-front of proposed system may having pose differ from that consider poses.

Down Sample image = |Fn x n| (5)

Where, Fn- input Image size in Pixels and n- down sample rate in percentage. Here I am Considering n=25%. .

From that, first computes the PCA required for training purpose. Also while calculating PCA; considering here either 8 or 9 pose images for training as well as all eleven images as testing images. Considered PCA size becomes 20 X 20 for every pose image.

3. ALGORITHM-

1. Calculate Eigen value, Eigen vector for each image
2. Consider the PCA from calculated Eigen vector
3. Stored PCA values for Neural Network training
4. Considering Neural Network with 2 layers
5. Apply neural network for each pose image as input for recognition.

4. RESULT AND DISCUSSIONS-

The some Eigen Vector of Given images are as follows:-

Columns 1 through 9

-0.0003 0.0115 -0.0257 0.0582 0.0025 -0.0454 -0.0745 0.0330 0.0430

Columns 10 through 18

0.0108 -0.0154 0.0229 0.0276 -0.0713 0.0297 -0.0026 0.0794 -0.0101

Columns 19 through 27

0.0068 -0.0669 -0.0291 -0.0065 0.0068 -0.0120 0.0240 -0.0421 -0.0173

Columns 28 through 36

-0.0862 -0.0044 -0.1144 0.0408 0.6681 0.0117 -0.0035 -0.0087 -0.0018

Columns 37 through 45

-0.0016 -0.0013 -0.0011 0.0021 0.0048 0.0010 -0.0129 -0.0044 -0.0058

Columns 46 through 54

0.0083 -0.0006 0.0073 -0.0035 0.0022 -0.0113 -0.0026 -0.0020 -0.0020

Columns 55 through 63

0.0090 0.0041 -0.0011 -0.0008 -0.0064 0.0006 0.0015 -0.0057 -0.0045

Columns 64 through 72

0.0079 0.0017 0.0002 -0.0043 -0.0029 -0.0031 -0.0037 0.0036 0.0024

Columns 73 through 81

-0.0005 -0.0040 0.0013 -0.0004 -0.0034 0.0013 0.0029 -0.0062 -0.0082

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Columns 82 through 90

-0.0011 -0.0030 -0.0018 -0.0070 -0.0002 -0.0016 0.0021 0.0040 -0.0045

Columns 91 through 99

-0.0038 0.0032 0.0005 0.0020 0.0034 -0.0045 0.0024 -0.0100 -0.0031

Columns 100 through 108

-0.0057 0.0031 -0.0009 -0.0064 -0.0054 -0.0084 -0.0035 -0.0045 0.0067

Columns 109 through 117

0.0027 -0.0010 0.0047 -0.0011 -0.0060 0.0082 0.0022 -0.0021 -0.0034

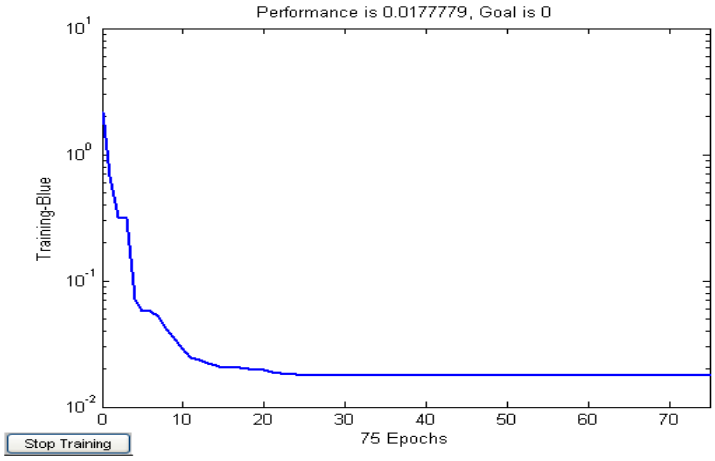

Figure 4: -Sample Results of plot for 1000 Epochs from that the image contains only 75 epochs

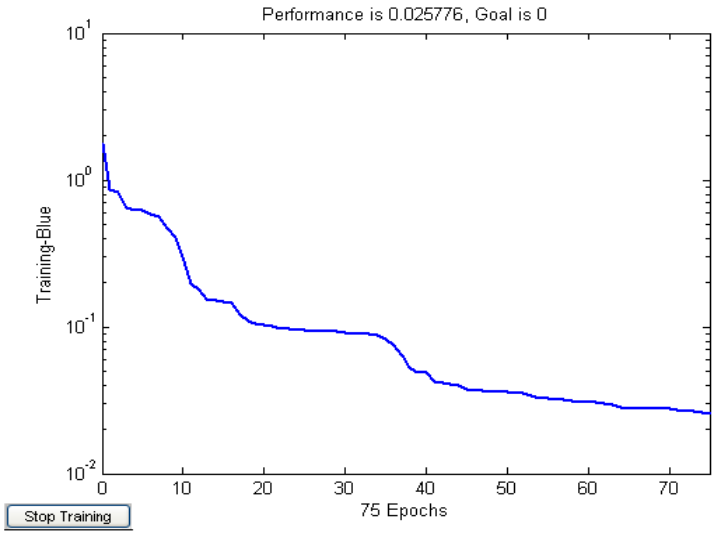

Figure 5: - Sample Results of plot for 900 Epochs from that the image contains only 75 epochs

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Figure 6: - Subject with Wink face pose

Figure 7: - Subject with sad face pose

Figure 8- Subject with Surprise face

Figure 9- Subject with Happy Pose

```
num_train= 6
     correct = 144
     total =   165
False identification rate = 12.7273
recognitionRatio =   87.2727
```

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In number of Training images consider to be less, then result is 87 % (less)

```
num_train= 8
  correct =  155
  total =   165
False Identification rate= 6.0606
recognitionRatio =   93.9394
```

As number of images for training is increases the result is increases.

As number of training Images and Epochs are increased, the result increased. The considered number of images for training varies from 1(single) image to 9 images for training. The recognition rate varies from 13% (for single image) to 96% (for 9 images). The recommended NN here is the Feed Forward Neural Network with 2 layers having 2 hidden layers.

5. CONCLUSION: -

As number of training Images and Epochs are increased, the result is also increased. Due to down sampling of images, the processing time required reduces. Initially, this paper considered the down sampling of 25%, so image size becomes 60 x 80 pixels. This is better for further processing like calculation of PCA and testing. As the numbers of training images are increased, the result of face recognition irrespective of poses can be varied from 13 % to 96%. So finally, this paper concludes that if Number of images for training is 8 or 9, the system gives better recognition result i.e. 95% to 96%. The main drawback of the proposed system is that it only detects straight face's images looking towards camera. Different poses we consider here are smile, sad, wink, happy. If the subject is in that pose, the face recognition is possible. Beside of that, if subject wears glasses, the proposed system recognizes the face. Even inside the fields of detecting frontal faces more work still remains. This paper represents the usage of 2 layered feed forward NN (Neural Networks) for pose invariant face recognition.

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