ISSN:0975-9646

Morphological based Face Detection & Recognition with Principal Component Analysis

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***Abstract*— This paper includes face detection and recognition with the help of morphological shared weight neural network. Face detection is achieved with the combination of morphological hit miss operation and edge detection. Feature extraction of face image is done using Principal Component Analysis. These features are used to train the neural network. The output of neural network is compared with database and depending on that comparison recognition is achieved. In neural network, numbers of input nodes used are varying depending on number of persons & output node is 1 with single hidden layer.. The experimental results on IIT Kanpur Indian database shows good reliability and performance with testing accuracy of 82.50%, so it is promising to be used in a personal identification system.**

***Keywords*— Edge Detection, Hit miss transform, Neural network, PCA.**

I. INTRODUCTION

To identify a human by its unique physical and behavioural nature is called a biometrics. Physiological Biometric-based technologies include recognition with face, fingerprints, hand geometry, hand veins, palm, iris, retina and voice, etc and behavioural consist of gait, signature, etc. Face recognition has its advantage because this biometrics method does not required any specific action by a person i.e. in other technique its need to place a hand/finger at specific point or to stand at a fixed place[13]. So it is useful in security purpose. Iris recognition requires costly equipment's with high resolution. Voice recognition is not useful in noisy surrounding environment It is possibility that in Signatures systems it can be changed or forged. However, it is easy to take facial images with a fixed camera. Hence face recognition is best biometric technology.

For face recognition it is needed to find out or to locate the face in the image. Face detection is defined as take a image, and find out where this image contains a face or not, if it contains the face then find out the location or position of that face in the image.

Face recognition techniques can be used to identify criminals at the various place where security is most required. In recent years various developments is happened in face recognition system. Following are some methods used for feature extraction and recognition: Eigen faces, Hidden Markov Model, Principal Component Analysis, Support Vector Machine, Probabilistic Decision-based Neural Network, Convolution Neural Network, and ARENA, etc.[12] The system we are describing in this work uses a morphological shared-weight neural network (MSNN) in its face detection phase. MSNNs have been used in many automatic target recognition applications and have shown to be un-affected by variations in lighting level and is robust enough to handle some variations in target size and/or orientation [1][2].

To the purpose of classification neural network is widely used with the above mention techniques. It works in the same manner as the neurons in the human brain works. So this is used in the process of face recognition. A neural network learns its weights according to the data during the process of training. So its result gives high efficiency into different classes. The types of neural networks for pattern classification tasks are the feed-forward network, Self-Organizing Map (SOM), or Kohonen-Network, etc. The learning process consists of getting the data, making adjustment in its architecture, its weight to perform classification work.

Morphological shared weight neural network (MSNN) is one of the methods in face detection and face recognition. Due to the use of neural network it needs some sample images to train the neural network. Hence, database is needed for this work. In this work, morphological hit miss transform is used to detect the face in input image. Region of interest is needed as this work is not interested in whole area of input image. Region of interest can be detected with two methods, one with the help of HSV & another using edge detection technique on hit miss operated image. Here we are using edge detection technique. We are applying Principal Component Analysis to the face detected area & the resulting features are fed as an input to neural network for classification. The output of neural network will show whether the person is authorized or not.

The remainder of this paper consists of System Description, System Implementation – Face detection & Face Recognition, experimental results and conclusions are covered in Sections II, III, IV and V respectively.

II. SYSTEM DESCRIPTION

Fig. 1 describes system overview for face detection & recognition. When an input image is given to the system, some preprocessing operations are performed on that image in order to enhance an image. After preprocessing feature extraction is achieved. Feature extraction is done with the help of morphological hit miss transform to detect points of interest in an image. Detection of face is nothing but interest point detection. PCA algorithm is implemented on

this interested area and resultant features are applied to the neural network as an input. For some training images, database is created. This database contains multiple images of different persons. After the training, the weights of neural network are saved i.e. neural network is trained. When test image is passed through the system, depending upon trained weights the person is recognized. The main objective of this system is to implement an open source face recognition system in order to achieve good recognition results using defined technique and emphasis is only on the software for performing recognition, and not hardware for capturing face image. The development tool used is MATLAB.

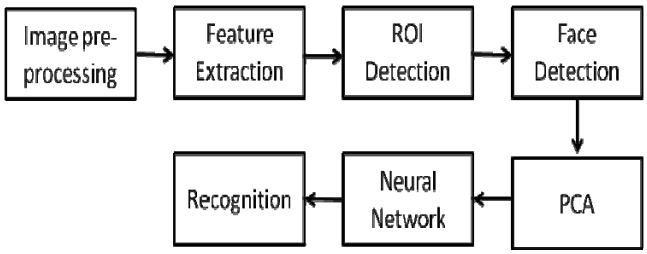

Fig. 1 Face Detection and Recognition System Overview

III. System Implementation

This section introduces the implementation techniques to detect face in the image and recognize it accordingly. The implementation technique is mainly divided into two parts.

A. Face Detection

B. Face Recognition

A. Face Detection

The face detection procedure contains input images taken from databases available from internet, image pre-processing, hit miss transform & edge detection to locate face in the image.

1) Database:

Database of faces contains a set of face images taken in February, 2002 in the IIT Kanpur campus. The database was used in the context of a face recognition project carried out in the course Artificial Intelligence in the department of Computer Science and Engineering. There are eleven different images of each of 40 distinct subjects. For some subjects, database contains some additional images. The files are in .jpeg format. The size of each image is 640x480 pixels. The images are organized in two main directories - males and females[8].

All the images were taken against a bright homogeneous background with the subjects in an upright, frontal position. Database included the following orientations of the face: looking front, looking left, looking right, looking up, looking up towards left, looking up towards right, looking down. It also included the emotions: neutral, smile, laughter, sad/disgust[8].

2) Image Pre-processing:

Image resizing and grayscale conversion is achieved in the pre-processing stage. All the images in database are of size 640x480 pixels. As we are using neural network in this work, there is need to reduce memory space. Hence to accomplish memory requirement, we have resized images to 180x180 pixel size.

As morphological operations are grayscale dependent, it is necessary that we convert the color image into grayscale image. So after resizing the images are converted into grayscale. The following fig. 2 shows original database image & its resized grayscale image.

Fig. 2 Original image and Grayscale ima**ge**

3) *Hit Miss Transform:*

Feature Extraction is achieved with the help morphological hit miss transform in order to detect face in the image. Morphological operations are useful for extracting image components that are useful in the representation and description of region shape, such as boundaries, skeletons, and the convex hull, etc. The hit-and-miss operation is a morphological shape detector that can be used to look for particular patterns of foreground and background pixels on an image. The hit miss operation is another form of dilation-erosion-based convolution. It is nothing but difference between erosion and dilation. Grayscale image is applied as input to hit miss transform. Firstly, morphological Erosion is done on this grayscale image. The basic effect of the Erosion is to erode away the boundaries of regions of foreground pixels. Fig. 3 (a) shows Eroded image. Again from the same grayscale image morphological dilation is done. Dilation is nothing but to gradually enlarge the boundaries of regions of foreground pixels. Fig. 3 (b) shows dilated image. Morphological techniques typically probe an image with a small template known as a structuring element. In this work, we are using one 5×5 disk shape structuring element. The care must taken, when we take a difference between Erosion and Dilation. It must be absolute difference instead of simple difference. Fig. 3 (c) shows hit-miss operated image.

a) b) c)

Fig.3 a) Eroded Image b) Dilated Image c) Hit-Miss ope rated image

4) Edge Detection:

To this hit miss operated image edge detection technique is applied. Sobel operator is used as edge detection operator. Following fig. 4 is obtained after

applying edge detection to hit miss transformed image. This figure shows some edges around the face. Also it contains some spikes at the background. So in next task, unnecessary spikes at the background should be removed.

Fig. 4 Edge detection of fig 3 c)

Morphological opening is used to remove spikes. A morphological opening is somewhat like erosion operation in that it tends to remove some of the foreground (bright) pixels from the edges of regions of foreground pixels. After applying morphological opening following fig. 5 is obtained.

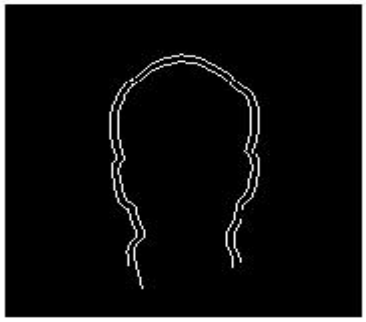

Fig. 5 Edges after morphological opening

When morphological opening is applied to edge detected image having threshold of 50 pixels then connected pixels which having area less than 50 pixels are removed. After applying edge detection, the resultant image is in binary form. In binary image, value '0' represents black pixel and '1' represents white pixel. Region of Interest (ROI) is found by locating upper highest white pixel, left most and right most white pixel. Following fig. 6 shows ROI detected inside the bounding box or it is called as face detected image. The inputs applied to neural network are PCA weights and these weights are inside the bounding box. So the location or co-ordinates of bounding box are obtained & PCA technique is applied to the part of gray scale image which is under the bounding box.

Fig. 6 ROI using edge detection

B. Face Recognition

Face Recognition procedure includes feature extraction using Principal Component Analysis (PCA) and classification using neural network.

1) Feature Extraction:

Feature extraction can also be done with the help of hit miss transform & the same weights can also be applied to neural network but there are certain limitations of hit miss transform hence we have used principal component analysis for feature extraction.

PCA implementation:

PCA uses only a part of gray scale image which is under bounding box. Following are the PCA algorithm implementation steps[5]:

1. Every ROI image is resized to [151 X 101] size.
2. Then Convert every single image into 1D vector. Obtain face images *I1*, *I2*….. *IM* (training faces). In this work, we have used total 80 images of 20 persons.
3. Represent every image *Ii* as a single column vector ***Ti***.
4. Computed the average/mean face vector "***m***" using following equation:

$$\mathbf{m} = \frac{1}{M}\sum_{i=1}^{M} \mathbf{Ti}$$ where M=80

5. Compute the difference **A** :

$$\boldsymbol{Ai = Ti - m}$$

Compute the covariance matrix ***C***:

$$\boldsymbol{C = A^T * A}$$

6. Compute the eigenvectors & eigenvalues of above covariance matrix. Then these eigenvalues are sorted in ascending order.
7. A new eigenvector is formed according to sorted eigenvalues. This matrix is multiplied with average mean matrix to create training features to train the neural network.

2) Neural Network:

The inputs which are applied to neural network are PCA weights under the interesting area. It is possible to apply whole PCA weights to neural network as input. But it is unnecessary because whole image contains face as well as background. So it is needed to take only interested points i.e. face. Face recognition is achieved with the help of neural network. Back propagation feed forward neural network is used for recognition as it is a best tool for pattern recognition task.

Back Propagation Algorithm:

1. Initialize the weights various random values.
2. Chooses input pattern $\mathbf{X}^{(k)}$.
3. Passed the signal in forward direction in network.
4. Computed δ_i^{L} at the output layer $O_i = y_i^L$ with following equation

$$\delta_i^L = g'\left(h_i^L\right)\left[d_i^m - y_i^L\right],$$

5. Errors are calculated in backward directions

$$\delta_i^l = g'\left(h_i^l\right)\sum_j w_{ij}^{l+1}\delta_j^{l+1}$$

for *l=(L-1),….,1*.

6. Weights are updated using following equation
$$\Delta w_{ji}^{l} = \eta \delta_{i}^{k} y_{j}^{l-1}$$
7. These steps are repeated until predefined threshold is not obtained.

Following Table shows Neural Network Training Parameters used in this work:

TABLE I

TRAINING PARAMETERS

No. of Inputs Nodes	Vary on no. of persons
No. Of Outputs Nodes	1
No. Of Hidden Layers	1
No. Of Hidden Nodes	42
Maximum No. Of Epochs to train	5000
Learning Rate	0.0001
Activation function	'Logsig' & 'Tagsig'

IV. EXPERIMENTATION & RESULTS

A. *Experimentation*

To enable the effective test of proposed classification strategy we have selected IIT Kanpur campus database which contains 11 images for each person. Such 11 images are having different facial orientations. All images in database are of size 640x480 pixels. Firstly, it is required to resize image to size 180x180 pixels. Images in database are RGB images; hence for further processing we have converted them into grayscale images. After that Hit-miss transform technique is applied on to grayscale image. By applying Sobel edge operator, ROI i.e. face in an image is located with bounding box. The area under bounding box is taken for further processing i.e for feature extraction using PCA algorithm. The size of bounding box is 151x101 pixels. In PCA, each image organized in a 1-D vector form.

In this work, for making training database we have taken 4 different images of each person. In this way, we have taken 80 images of 20 persons. This procedure is repeated for all remaining images & created 15251x80 matrix in which single column represents an image of a single person. Then PCA steps are implemented. Finally we are getting training feature vector of same size i.e. 80x80 pixels. This is used to train neural network. This is all about the training procedure & following is flowchart for training procedure.

During testing, a test image is passed through the same procedure as we have done it for training, up to creating column vector of 15251x1 pixels. Then mean face vector ***m*** is subtracted from above column vector. After that above resulted vector is multiplied with eigenvector & the result is passed through the neural network. Firstly, we have taken difference between target which we have set during training & actual output of neural network. If the resultant difference value is below threshold then the person is identified accordingly. The following is flowchart for testing procedure.

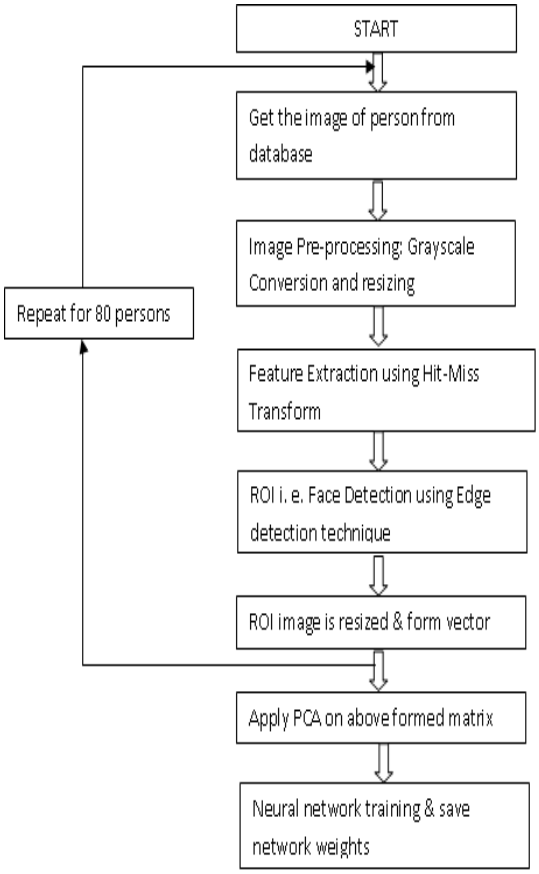

Fig. 7 Flowchart for training purpose

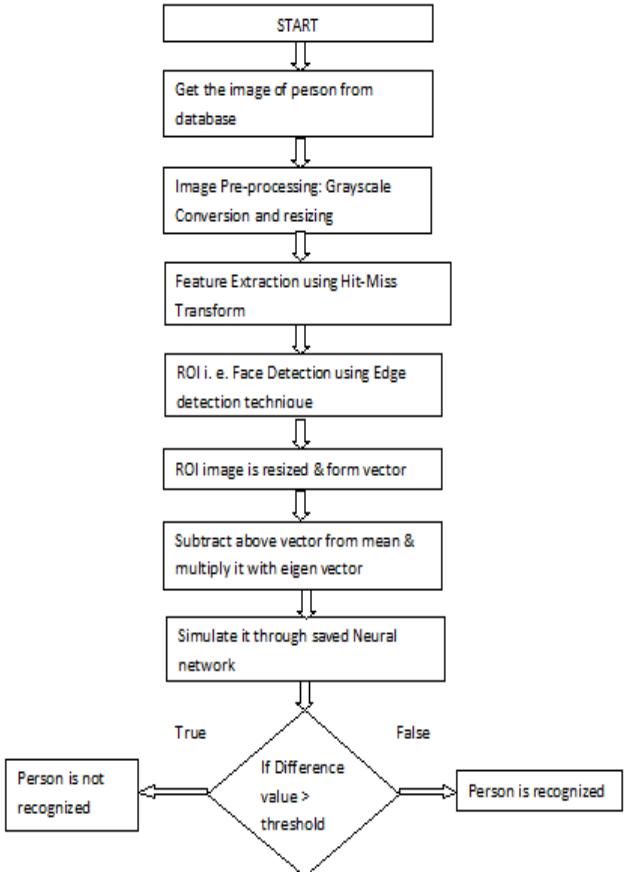

Fig. 8 Flowchart for testing purpose

B) Results

1. By applying above method (PCA algorithm) for 5, 10, 15 & 20 persons we are getting following results:

TABLE III
RESULTS BASED ON PCA

Sr. No.	No. Of persons in Database	Total No. Of Images	Training Time	Accuracy in %	
				Training	Testing
1	5	20	41 sec	100	80
2	10	40	18 sec	100	90
3	15	60	2 min 51 sec	100	85
4	20	80	1 min 39 sec	100	82.5

According to table II, as we are increasing the size of database, result accuracy is going to vary. Upto 20 person it is quite acceptable. Also as number of persons increases, training time also increases.

2. By applying MSNN method, for the same database 5, 10, 15 & 20 persons we are getting following results. In this method, we are applying hit miss weights directly to train the neural network without implementing PCA.

TABLE IIIII
RESULTS BASED ON MSNN

Sr. No.	No. Of Persons In Database	Total No. Of Images	Training Time	Accuracy In %	
				Training	Testing
1	5	20	19 Sec	100	95
2	10	40	36 Sec	100	65
3	15	60	33 Sec	100	66.66
4	20	80	41 Sec	100	52.5

By comparing table II & table III, we conclude that PCA method gives best matching results than MSNN.

The graph of comparison between PCA & MSNN is as follows:

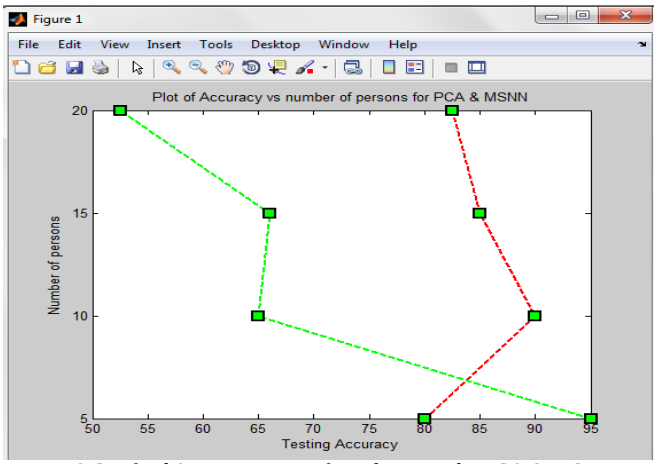

Fig. 9 Graph of Accuracy vs Number of persons for PCA & MSNN

3. FAR is the probability that a non-authorized person is identified. FRR is the probability that an authorized person is not identified; FIR (False Identification rate) is the probability that an authorized person is identified but is assigned to false id value. A perfect biometric authentication system would have a FRR = 0 and a FAR = 0 which is a little bit unachievable in reality. From table V, we may able to know that for 20 persons system gives best matching results.

TABLE V
RESULTS GIVING FAR, FRR & FIR VALUES

Sr. No.	No. Of Persons	FAR (in %)	FRR (in %)	FIR (in %)
1	5	35	0	20
2	20	55	0	17.50

V. CONCLUSION

In this paper, an image processing approach for face detection & recognition system using morphological shared weight neural network along with PCA algorithm has been implemented. This system gives good results with testing accuracy of 82.50% for 20 person's database which is taken from IIT Kanpur campus. Also comparative result analysis between MSNN & PCA shows that PCA is best technique for face identification. Lots of researches have been performed in the area of face detection and recognition. Performance of all these technique is different. In the following table, performance of various algorithms is summarised.

TABLE VI
RESULTS BASED ON MSNN

Sr.No.	Algorithm	Accuracy (%)
1	MSNN	69(Avg)
2	MSNN + PCA (Developed method)	82.5

The above table shows that MSNN with PCA developed method gives best matching results.

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