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An Efficient Face Recognition System Based on Sub-Window Extraction Algorithm

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***Abstract*— In this paper, an efficient face recognition system based on sub-window extraction algorithm and recognition based on principal component analysis (PCA) and Back propagation algorithm is proposed. Our proposed method works on two phases: Extraction phase and Recognition phase. In extraction phase, face images are captured from different sources and then enhanced using filtering, clipping and histogram equalization. Enhanced images are converted into edge images using Sobel operator and then converted into binary images. Finally sub windows from extracted using proposed sub windows extraction algorithm and extract different features (mouth, eyes, nose etc.) from these sub windows. In recognition phase, back propagation algorithm (BPA) and PCA algorithm is used. The experiments are carried out using IIIM_Gwalior database, IIT_Kanpur database and Face_94 database.**

Keywords- Sub-windows extraction, principal component analysis (PCA), Back propagation algorithm (BPA), Face recognition, Neural Network.

I. INTRODUCTION

Face recognition is a rapidly growing field today for is many uses in the fields of biometric authentication, security, and many other areas. It has been widely applied in security system, credit-card verification, and criminal identifications, teleconference and so on.

Face recognition is influenced by many complications, such as the differences of facial expression, the light directions of imaging, and the variety of posture, size and angle. Even to the same people, the images taken in different surroundings may be unlike. The problem is so complicated that the achievement in the field of automatic face recognition by computer is not as satisfied as the finger prints. Facial feature extraction has become an important issue in automatic recognition of human faces. Detecting the basic feature as eyes, nose and mouth exactly is necessary for most face recognition methods. Facial expression is interesting research concerning with a human behaviour recognition. It considered to be one of the most powerful and immediate means for human to communicate their emotions, intentions and opinions to each other and this is the why much efforts have been devoted to their study by cognitive scientists an lately computer vision researchers [13]-[15].

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In this perspective, a computer as if can feel what a human feels and it will create an interaction between a computer and a human like a friend. There are many ways to extract the facial features to be input in facial expression recognition. Majority, the object used to be input is difficult to interpret, such as, the change of the eyebrows [1]; it is almost no change between expression happy, sad, and normal. The schema that we propose in this work is very simple than any other method before. The method to recognize the facial expression in this work is back propagation of feed forward neural network.

In last many years, Face recognition [1] is one of the main critical tasks in pattern recognition area. Many techniques have been proposed for face recognition such as face recognition using PCA ([2]-[4], [16], [19]), LDA ([5], [17]-[19]), discrete cosine transform [6]-[8] and so on. Some other hybrid technologies are also proposed. These hybrid technologies are like Face Recognition Based on Haar Wavelet Transform and Principal Component Analysis via Levenberg-Marquardt Back propagation Neural Network [9], based on PCA and neural network [10], integration of FCM (fuzzy c-means), PCA and neural network [11], face recognition based on PCA, R-LDA and supervised neural network [12] and simple and fast face recognition based on edges are discussed in [20] . In all these recognition methods, the execution time is too much when the size of database is large.

The rest of the paper is organized as follows. In section 2, preprocessing steps are introduced. In section 3, we describe our methodology in details. In section 4, back propagation algorithm and principal component analysis algorithm are explained. the experiment results are shown in section 4. Finally, section 5 concludes the paper.

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II. PREPROCESSING

A. Face Image Acquisition

To collect the face images, a scanner has been used. After scanning, images are saved into JPG format. in this paper, we have used three type of databases : IIITM_Gwalior database, IIT_Kanpur database and Face_94 (male and female) database. IIITM_Gwalior database is collected from IIITM Gwalior manually using scanner and 3 MP cameras. Other databases are collected from internet via http://www.face-rec.org/databases/ .

B. Face Image Enhancement

The face images may be of poor contrast and brightness because of the poor lighting conditions and also contains noise and unnecessary background data. So histogram equalization is used to enhance the contrast and brightness of the face image. Filtering and clipping techniques are used to remove noise and unnecessary background data. this is done by finding the sub windows four coordinates : top-left, top-right, bottom-left and bottom-right.

III. METHODOLOGY

The face of a human has several features such as, mouth, eyes, nose, eyebrows, and forehead. Each of this features has a unique shape and a unique pattern, hence, many experiments have been reported in extracting facial feature for recognizing facial expression. Our methodology works on two phases:

1. Extraction Phase:

In extraction phase, face images are captured from different sources like internet, manually using scanner etc. After capturing, images are enhanced by using filtering, histogram equalization and clipping to remove noise and un-necessary background data. Now original face image, after enhancement, is converted to edge image by using Sobel operator and then using sub-window extraction algorithm, extracts the sub windows from face image. Finally extracts the features from these sub windows and organized into single image vector.

A. Proposed Sub-window Extraction Algorithm:

The steps of sub-window extraction algorithm are given below:

1. Convert edge image into binary image.
2. Load the binary image
3. For each row and each column
4. Search for the coordinates: upper-left, upper-right, lower-left and lower-right.
5. Extract sub-window from binary image.
6. Calculate standard-deviation (SD) using following derivation:

$$SD = \sqrt{\sum_{j=1}^{N} (X_j - \bar{X})^2}$$

Where X_i is data vector and $\bar{X}$ is mean given by

$$\bar{X} = \frac{1}{N}\sum_{1}^{N} X_j$$

7. If SD=0, then the sub-window is considered as background image and skipped. And GOTO step 3 to extract the next sub-window.
8. Else, extract the corresponding sub-window from original image.

The above proposed algorithm is discussed below:

From the binary image, starting from each pixel in a row, our proposed sub-window extraction algorithm searches for the first edge pixel, that will be top-left coordinate of the sub window. And in the same row, search for the second edge pixel, that will be the top-right coordinate of the sub window. Then towards column-wise, with these top-left and top-right coordinates, searches for the edge pixels. If it finds edge pixel then these pixels will be the bottom-left and bottom-right coordinate of the sub window. With all these four coordinates, the sub-window is extracted and corresponding to extracted sub-window, find standard deviation (SD). If standard deviation is zero then the extracted sub-window will be considered as background sub window and skipped. If SD does not equal to zero then it will be considered as sub window. The given algorithm is applied at all row and column and extracts the sub windows of given binary face image.

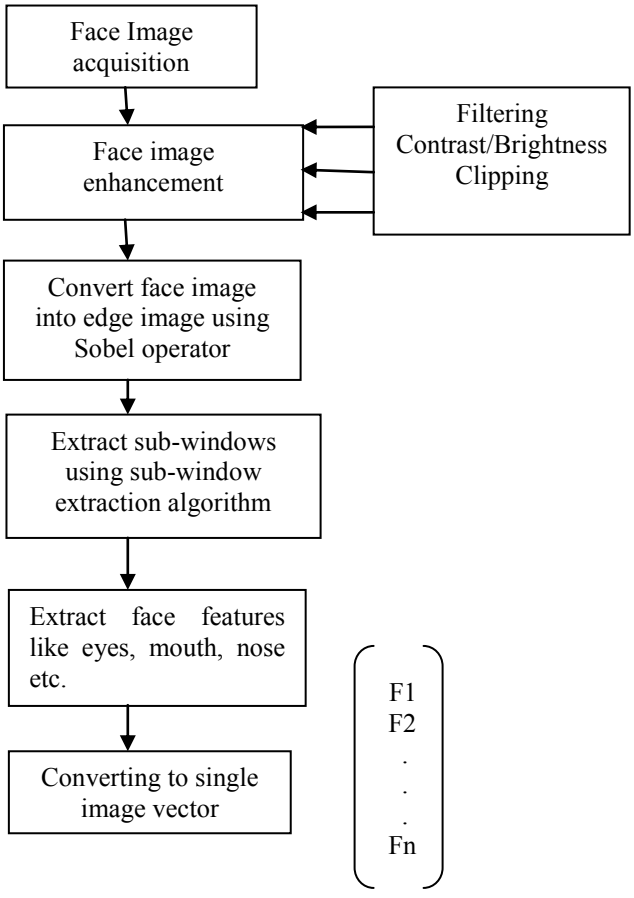

Fig 1. Shows the flow chart of extraction phase of proposed methodology

1.1 Mouth feature Extraction

Mouth has a wide area on face; the location of it is one third lower part of the face. With the help of sub-window extraction algorithm, extract the sub-window of mouth and obtained the length of the mouth using binary image. For the width of the mouth, find the mid point of the mouth length and from this mid point, calculate the width of the mouth. Figure 4 illustrates the procedures of mouth length and mouth width extraction.

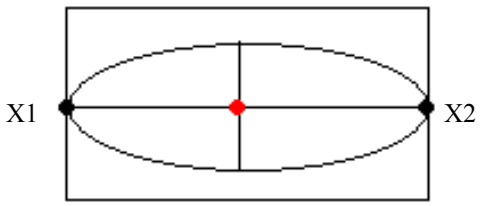

Fig. 2: The procedure of mouth length and mouth width extraction

1.2 Eye feature Extraction

The step to obtain the data from eye is almost same with the step to obtain the data from mouth. First, we will find the length of the eye, i.e. fixed for all cases, by using the sub-window that is extracted from the sub-window extraction algorithm. Then, obtained the width of the eye by calculating the mid point of the eye length. We use Sobel edge detection to obtain the data from eye sub-window.

1.2 Nose feature Extraction

The step to obtain the data from nose is almost same with the step to obtain the data from mouth. First, we will find the length of the nose, i.e. fixed for all cases, by using the sub-window that is extracted from the sub-window extraction algorithm. Then, obtained the width of the nose using binary sub-window of nose. We use Sobel edge detection to obtain the data from nose sub-window.

2. Recognition Phase:

In recognition phase, two algorithms are used: Back propagation algorithm and Principal component analysis.

2.1 Back Propagation Algorithm

Back propagation is the common method for teaching artificial neural network. it was created by generalizing the Windrow- Hoff learning rule to multiple-layer networks and nonlinear differentiable transfer functions. the steps of back propagation algorithms are:

1. Initialize weight and biases to random numbers between [-1, 1].
2. Feed all training samples to the feed forward network.
3. Propagate the inputs forward
4. Back propagate errors
5. Update weights and biases to reflect the propagated errors.
6. Terminate condition

A 2- layered feed forward network with 2 input neurons, 3 hidden neurons and 2 output neurons are given in figure 2.1

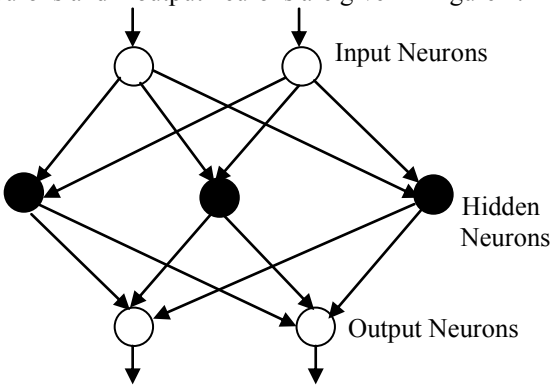

Fig 2.1 2-layered feed forward network

In recognition phase using back propagation algorithm, initially all face features (mouth, eyes and nose) are collected from sub windows, which are extracted from sub window extraction algorithms. Then these features are normalized between [0, 1] by dividing each values of the image vector to the maximum value from the vector. These normalized values are assigned to input neurons. Initial weights and bias values are assigned randomly between [-1,1]. Output from each hidden neuron is calculated using sigmoid activation function. Mean square error (MSE) is calculated at the output neuron and then back propagates the error and find the delta values at output neurons. With these value, update weights and bias values and again the same procedure is repeated until target output is not achieved.

2.2 Principal Component Analysis (PCA)

PCA algorithm is the most important technique for face recognition. The purpose of this algorithm is to reduce the large dimensionality of data space to small dimensionality of data space. the procedure of PCA algorithm is described as follows:

Initially set the resolution and PCA dimensionality parameter of all face sub images. Then read all the training face images. Convert all the face images into training data matrix and training class levels matrix. Then calculate PCA transformation matrix and obtain face features of all images and convert these features into data matrix. Now read the face images for testing and then for each face image, calculate the PCA transformation matrix of all face images and find the

distances between all training and testing feature vectors. After that store the distances with all training class labels. Finally initialize the error count to zero and for each test face, find the person Id of the most similar training vector using distance data. if the person Id is not equal to the test face image then increment error count and get the recognition accuracy using following derivation:

(1 - (Error count / total test image count))*100

In recognition phase using principal component analysis, initially mouth face features are extracted from face image using sub windows extraction algorithm. After extracting mouth sub windows, convert into gray scale images using MATLAB 7.6.0 toolbar. From all these grayscale images, some of the images are used for training and some of the images are used for testing using PCA algorithm. Finally recognition rate is calculated using both back propagation algorithm and PCA algorithm.

IV. EXPERIMENTS AND RESULTS

All the algorithms are implemented in MATLAB 7.6.8 and executed on the Pentium–IV, 3.00GHz CPU with 4 GB RAM. To validate the accuracy of the proposed algorithm, we used three different databases: IIITM_Gwalior Dataset, IIT_Kanpur Dataset and Face94 Dataset.

4.1 IIITM_Gwalior Dataset

IIITM_Gwalior dataset consists of male and female images having 50 images of female faces and 50 images of male faces having 4 distinct subjects in frontal position. From these dataset we have selected 30 individuals from male dataset and 20 individuals from female dataset. For each individual we have selected 3 images for training, chosen randomly and 1 image for testing out of 4 face images. Figure 1 shows some of the gray scale face images used from the male IIIT_Gwalior dataset. Figure 2 shows the gray scale images after applying filtering as a Pre-processing.

4.2 IIT_Kanpur Dataset

IIT_Kanpur dataset consists of male and female images having 50 images of female faces and 50 images of male faces having 4 distinct subjects in up right, frontal position with tilting and rotation. Therefore this is a more difficult database to work with. From these dataset we have selected 35 individuals from male dataset and 15 individuals from female dataset. For each individual we have selected 3 images for training, chosen randomly and 1 image for testing. Figure1 shows some of the gray scale face images used from the male IIT_Kanpur dataset. Figure 2 shows the gray scale images after applying filtering as a Pre-processing.

4.3 Face_94 Dataset

Face94 dataset consists of 50 female and 50 male face images having 4 distinct subject containing variations in illumination and facial expression. From these dataset we have selected 30 Individuals from male dataset and 20 individuals from female dataset. For each individual we have selected 3 images for training, chosen randomly and 1 image for testing from each person. Figure 1 shows some of the female images from Face_94 Dataset. Figure 2 shows the gray scale images after applying filtering as a Pre-processing.

1. Results using Back Propagation Algorithm

To test our proposed methodology, we have used back propagation algorithm. for making more efficient algorithm, we have tested our proposed algorithm at different number of hidden nodes and at different data partition schemes.

a. Using different number of Hidden nodes:

Table 4.1 shows that Accuracy of Face Recognition using Different Number of Hidden Nodes and figure 5.1 shows that the accuracy in training, testing and validation phase at different number of hidden nodes .

Table 4.1 shows that the accuracy at different number of hidden nodes

No. of Hidden neurons	Back propagation (Accuracy)		
	Training (%)	Testing (%)	Validation (%)
10	92.46	92.10	92.10
20	95.57	95.21	95.21
30	97.54	97.43	97.43
40	95.57	95.25	95.25

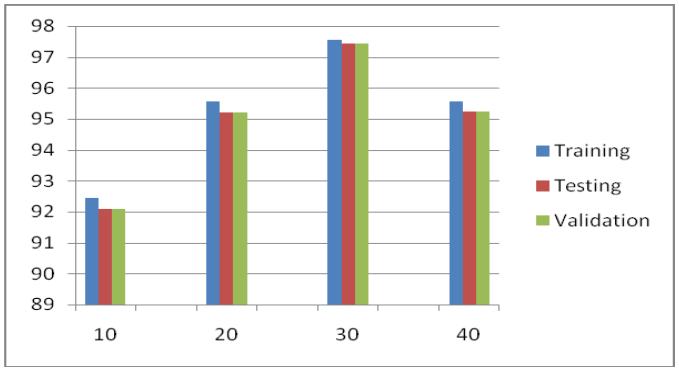

Fig 4.1 shows the accuracy in training, testing and validation phase at different number of hidden nodes

b. Using different dataset groups:

The original data set grouped into different data sets as shown in table 4.2 below and each group is partitioned into three subsets viz. training set, testing set and validation set. Results are shown in table 3 using 30 hidden nodes. table 4.3 and figure 4.4 shows the accuracy in training, testing and validation phase based on different partitions.

Table 4.2 shows that different dataset partition groups

Data Set (Group) Name	Training (% age)	Testing (% age)	Validation (% age)
Data set 1 (DS1)	50	25	25
Data set 2 (DS2)	60	20	20
Data set 3 (DS3)	70	15	15
Data set 4 (DS4)	80	10	10
Data set 5 (DS5)	90	5	5

Table 4.3 Data set results based on different partitions

Data Set Groups	Training Accuracy (%)	Testing Accuracy (%)	Validation Accuracy (%)
DS1	95.14	94.12	94.11
DS2	96.29	93.60	92.85
DS3	98.80	97.70	97.07
DS4	97.13	96.90	96.90
DS5	92.48	91.70	91.40

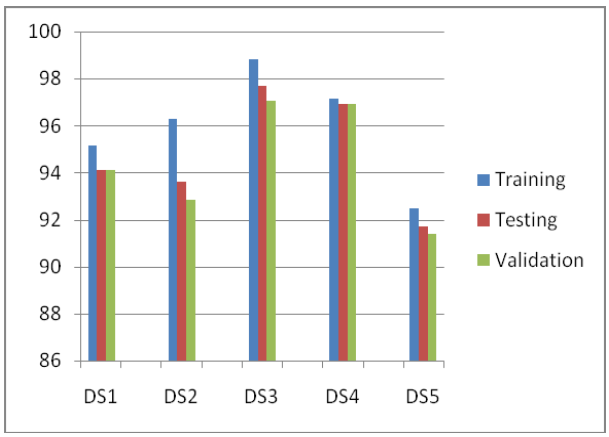

Fig. 4.4 shows the accuracy in training, testing and validation phase based on different partitions

2. Results using PCA Algorithm

Fig. 4.5 Sample face images of IIT Kanpur, IIITM Gwalior, Face 94 female and Face 94 male respectively and Fig. 4.6 sample gray scale mouth sub-windows of IIT Kanpur, IIITM Gwalior, Face 94 female and Face 94 male respectively

Fig. 4.5 Sample face images of IIT Kanpur, IIITM Gwalior, Face 94 female and Face 94 male respectively

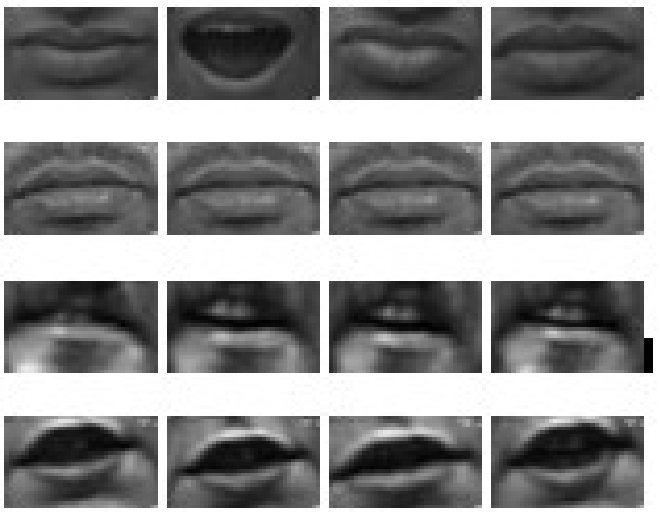

Fig. 4.6 sample gray scale mouth sub-windows of IIT Kanpur, IIITM Gwalior, Face 94 female and Face 94 male respectively

Dataset (JPEG Image)	Original Size of the image	Size of Sub windows	No. Of Images used for training	No of Images used for testing	Recognition Rate using PCA
IIIT_Gwalior	320 × 240	50 × 35	200	50	94 %
Face_94 Male	180 × 200	50 × 35	96	24	96 %
Face_94 Female	180 × 200	50 × 35	75	25	93 %
IIT Kanpur Male	640 × 480	50 × 35	100	20	88 %

Table 4 shows that the Recognition rate at different datasets

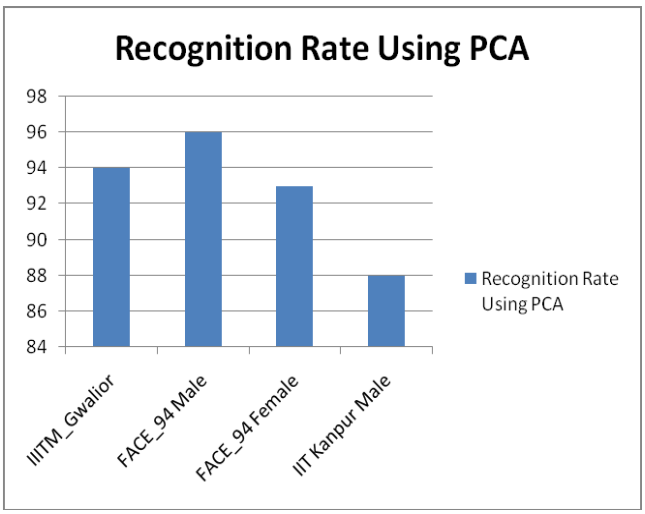

Fig. shows that the Recognition rate at different datasets

IV. Conclusion and Future Work

The main objective of this paper is to propose an algorithm that improves the recognition time and accuracy. so for getting better result and improves recognition time, we have proposed a sub windows extraction algorithm that will divides the face image into different sub windows and by using these sub windows, find out the face features and trained with back propagation algorithm, as a recognition algorithm, for getting the recognition accuracy. Also for validating our proposed algorithm, we have used PCA algorithm as a recognition algorithm. We have also tested our proposed algorithm using different types of datasets. Finally the proposed results using both algorithms are better than other algorithms in terms of accuracy and recognition time. Further research is to check the proposed algorithm on real life images.

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