ANN based Human Facial Expression Recognition in Color Images

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Abstract*---This paper describes an ANN based human facial expression recognition method. An automatic technique is generated for detecting 22 most important facial feature point and generation of facial feature vector by finding the Euclidian distances between some particular points. Here the key facial regions are found based on a defined face model. The face model is generated by the detection of the eyes and mouth points. Skin color detection is done by 2D Color Space Skin Clustering Method and face detection is done by connected component analysis followed by a set of face heuristics. Feed forward back Propagation neural network is used as the network classifier to classify the facial expression from a set of seven basic expressions like happy, sad, surprise, fear, anger, disgust and neutral. The experiment is done on Color FERET Database and got an accuracy of 100% for trained dataset and 85% accuracy for test set.

***Keywords*--- ANN , FERET, feature vector, YC_bC_r.**

I. INTRODUCTION

Face recognition is a rapidly growing research area due to increasing demands for security in commercial and law enforcement applications. Demands and research activities in machine recognition of human faces from still and video images have increased significantly over the past 30 years. Face recognition has been a major research focus area since traditional means of security such as ID cards and passwords are not reliable or convenient enough [1]. Face recognition is essential for interpreting facial expressions, human emotions, intentions, and behavior [1]. In an automatic face recognition system [2], the first step is to extract the face in an image or video irrespective of whether the background is simple or complicated. Whereas there a number of work been done in this area generating a number of great algorithms. This paper explains about an approach to the problem of facial feature extraction from a still frontal posed color image and classification and recognition of facial expression and hence emotion of a person. The paper is organized as follows, section I gives a brief introduction, section II presents methodology followed, section III gives experimental results and analysis, section IV presents conclusion and future scope and last section gives references used for the work.

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II. METHODOLOGY

The methodology consists of a set of steps. The basic flow diagram of the proposed algorithm is shown inFig.1.

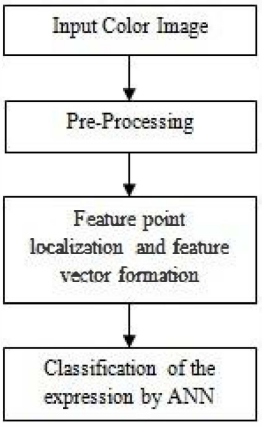

Fig1. Basic block diagram of the system

A. Input Color Image

Portions of the research in this paper use the FERET database of facial images collected under the FERET program. The FERET database is a standard dataset used for facial recognition system evaluation. The dataset tested includes 2,413 still facial images, representing 856 individuals [3].

B. Pre-Processing

The preprocessing section detects the face and its location and then crops the face, right-eyebrow, right-eye, left-eyebrow, left-eye, nose, and mouth regions from a human image.

1) Normalization

RGB images are taken as input and at very first normalize them to a size of [1000, 1000] because we want a very fine detail observation of all the values in the image.

2) Conversion of RGB to YCbCr color model

As the skin colour detection method is been realized in YCbCr format, we convert the input RGB color model to YCbCr model.

3) *Skin Colour Detection*

The detection of skin color in images is the first step for any kind of face detection or expression detection or sign language detection etc. [4] The main challenge the researchers are facing while detecting the human skin is the variation of the skin tone from person to person. [5] Good skin color segmentation is that which segment the every skin color whether it is blackish, yellowish, brownish, whitish and give good results under different light conditioning as possible.[6] YC_bC_r color space for skin color detection is used in this paper. 2D skin color clustering Method [7] is to be used for skin color detection. The method classify the pixels by using only C_b and C_r components, which can be marked this color space as 2D (chromatic) color space.

4) Face Detection:
After the skin like pixels are been detected, it is required to detect the main face region. There may be other parts also having skin like pixels that are not our region of interest. The connected region having the exact face criteria has to be detected. So first of all the region having maximum connected components is calculated in the binary image. The area of interest that is the object with the maximum connected pixels and fitting the face shape criteria was kept and others are made 0 (binary value).

5) Face Heuristics:
For a region to be detected as face we have set three conditions that are needed to be satisfied.

$$\text{number of holes (euler number)} \geq 2 \qquad (1)$$

$$\text{Circularity} = \frac{(\text{area of the object})}{(\text{perimeter of the object})^2} \qquad (2)$$

$$\text{Aspect Ratio} = \frac{(\text{Height of the objcet})}{(\text{width of the object})} \qquad (3)$$

circularity of a face area should be greater than a constant value ie. 0.06 .Aspect Ratio $\in R_R$,where (R_R= [0.8, 2.2]) is a range of valid aspect ratios for face [8].

6) Eyes and Mouth Point Detection
After finding the maximum connected region in the image, all of the 6 face components for further calculating the feature points, is to be found out the eyes and mouth points should be clearly detected. Eyes and mouth are the most suitable feature for recognition and estimation of 3D head pose. For detecting the eyes and mouth we used a method proposed by [9]. In this method eyes and mouth boundary are directly located based on measurements derived from the color-space components (luma and chroma) of an image [10].

7) Face Components detection
For various face components to be cropped out, the measurement of the following model (fig 2) is followed, since we know the center points of eyes and mouth area it is easy for us to find out the basic 6 face parts.

8) Filtering
After the face parts are cropped out from the face area, they should be filtered so that it becomes efficient for us to extract the feature points [11][24].

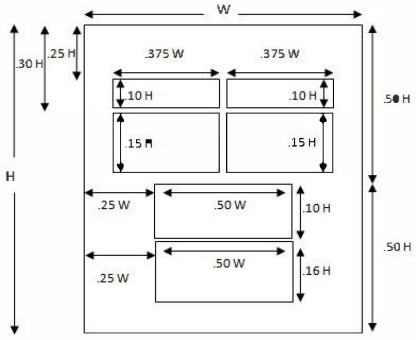

Fig.2. The location and size of the face components based on the eyes and mouth center points

a)Image Contrast Adjustment: The contrast of the output image is increased.
b)SUSAN Edge Detection Operator: The SUSAN edge finder has been implemented using circular masks to give isotropic responses. The mask is placed at each point in the image and, for each point, the brightness of each pixel within the mask is compared with that of the nucleus (the centre point of the windows).[12][13].
c)Binarization: The maximum of the resulted gray value in the output image will be taken as the threshold for binarization.
d)Negation: The image resulted after the edge detection is having mostly white pixels in background and the black pixels in the edge line. We did the negation operation to reduce the storage space.
e)Thinning: The image generated after the edge detection is a image with thick line to make it a single edge line we do the thinning operation.

C. Feature Point localization and Feature Vector Formation
1) Feature point localization
After the face parts are been detected and cropped out, we need to calculate the feature vector for that face. The 22 facial feature points that we are considering are shown in the fig. .

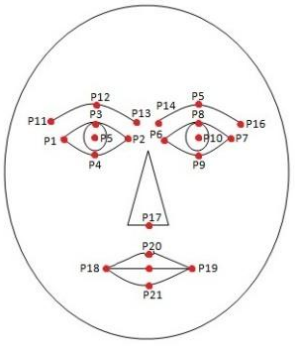

Fig.3. The face model containing the facial feature points

2) Feature vector formation
For each face image a feature vector is generated and there will be 9 feature elements having the distances between the various feature points. The Euclidian distance is calculated between the feature points and

stored as feature vector.

$$F_v = [D1, D2, D3, D4, D5, D6, D7D8, D9] \quad (4)$$

D1= Distance between the left eye midpoint and left eyebrow mid point
D2= Distance between the right eye midpoint and right eyebrow mid point
D3= Distance between the lip outer corners
D4= Distance between the lip upper and lower corners
D5= Distance between the lip mid points and nose point
D6= Distance between the eyebrows inner corners
D7= Distance between the eyebrows mid points
D8= Left eye height
D9=Right eye height

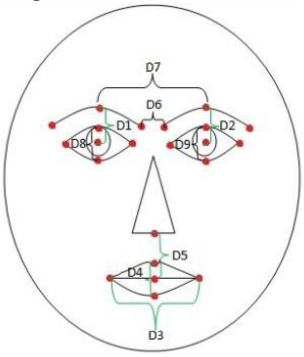

Fig. 4. The face model containing the facial feature elements

D. Facial Expression Classification Using Artificial Neural Network

In this paper, Multi Layer Perceptron (MLP) Neural Network with back propagation learning algorithm is used .[16][17] This is the type of network the units each perform a biased weighted sum of their inputs and pass this activation level through a transfer function to produce their output, and the units are arranged in a layered feedforward topology [19][22]. The network contains 9 input nodes and 7 output nodes. We used 8 hidden layers [21] in the net. The mean square error value is taken to be 0.0001 and the learning rate is taken 0.05. The 9 feature values from each face are computed.[14][15] With the help of these features the samples of seven facial expressions can be classified into seven classes such as anger, disgust, fear, happy, neutral, sad, and surprise.[18]

III. RESULTS

In this work a set of frontal posed human faces are taken as the input and classified to particular expression set. The face detection method was performed in a set of 300 images and 280 of them were perfectly detected. Then 22 facial feature points were detected using feature point localization method. Table 1 shows the rate (%) at which the individual feature points were detected. Then we used feed forward back propagation method for training and testing purpose. The training set consists of 200 images and we got best result with resilient back propagation algorithm. The resting is performed with 10 images from each expression set. Table 2 shows the confusion matrix and the graph fig. shows the overall correction rate for the test dataset.

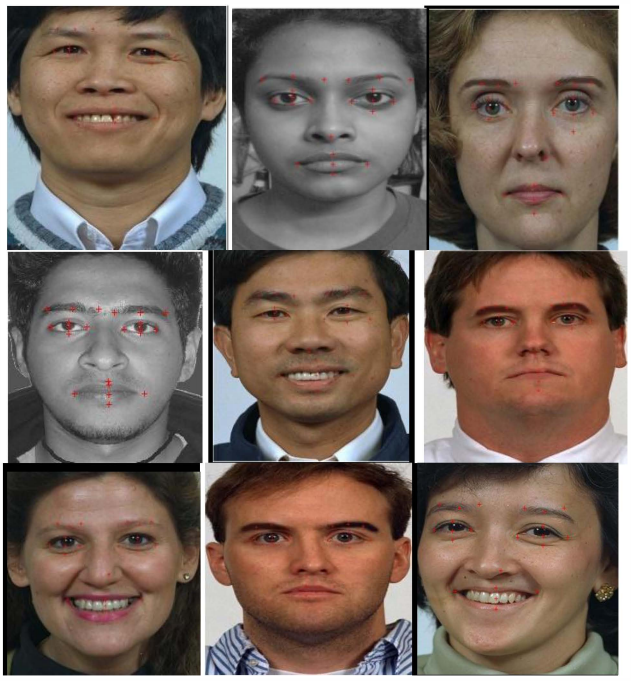

Fig .5 the sample images of happy and neutral pose with the feature points being detected

Table1. The feature point detection accuracy rates

Feature Point	Detection Accuracy of feature points On Database
P1 - Right eye right corner	95%
P2 - Right eye left corner	94.36%
P3 - Right eye upper corner	88%
P4 - Right eye lower corner	90%
P5 - Right eye mid point	95%
P6 - Left eye right corner	91%
P7 - Left eye left corner	88%
P8 - Left eye upper corner	90%
P9 - Left eye lower corner	86%
P10 - Left eye mid point	95%
P11 - Right eyebrow right most corner	78%
P12 - Right eyebrow mid corner	90%
P13 - Right eyebrow left most corner	80%
P14 - Left eyebrow right most corner	76%
P15 - Left eyebrow mid corner	85%
P16 - Left eyebrow left most corner	80%
P17 - Nose Point	86%
P18 - Right corner of mouth	94%
P19 - Left corner of mouth	88%
P20 - Upper corner of mouth	85%
P21 - Lower corner of mouth	83%
P22 - midpoint of mouth	88%

IV. CONCLUSION

It is very difficult to detect the features exactly on every face image due to the complication of human [20] face structure and the diversity of face features and shooting

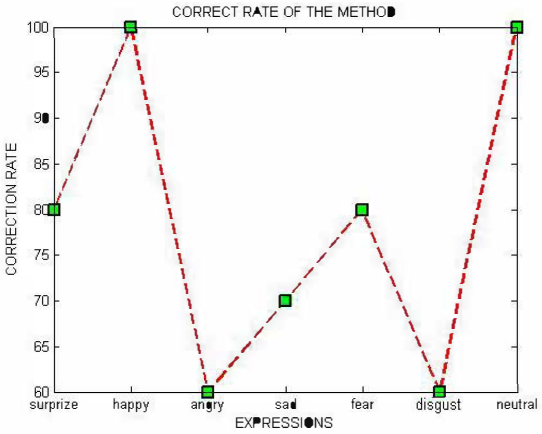

Fig 6. The graph showing the correction rate of the 7 basic expressions

Table 2. The confusion matrix of the seven expression taking 10 test images for each expression as input

Input → Output ↓	Anger	Disgust	Fear	Happy	Sadness	Surprise	Neutral
Anger	6	2	1	0	1	0	0
Disgust	2	6	1	0	1	1	0
Fear	0	2	8	0	1	0	0
Happy	1	0	0	10	0	1	0
Sadness	0	0	0	0	7	0	0
Surprise	1	0	0	0	0	8	0
Neutral	0	0	0	0	0	0	10

angle.[23] We have implemented the facial point detection algorithm on color images and found a good result .The method presented in the paper can automatically locate the facial feature points with high accuracy as for most front face images, even for some small angle left and right rotation face images, but proposed method is still limited in the application of large angle rotation with reducing of the accuracy and is partly impacted by strong sidelight. While detecting the 22 facial feature points, an average accuracy of 87.5% is obtained. A set of 240 images expressions from the color FERET database is used to train the network. The network is trained with ANN feed forward back propagation algorithm. The testing is first done with the trained database and got an average accuracy of 100%. Then the testing is continued with the test dataset and 85% of the data were correctly detected. The expression angry, disgust and sad are quite similar view in some condition so it is very difficult to detect them in various images. So the false rejection rate is more in these expressions. It will be very difficult to detect facial points for the persons that are too old having many wrinkles in face area. In the future, we will work on tracking the feature points in video sequences. The future work will also include the feature point for finding in the large angle rotation of face. The feature vector generated using the proposed method can be used for facial expression detection.

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