A framework for the Recognition of Human Emotion using Soft Computing models

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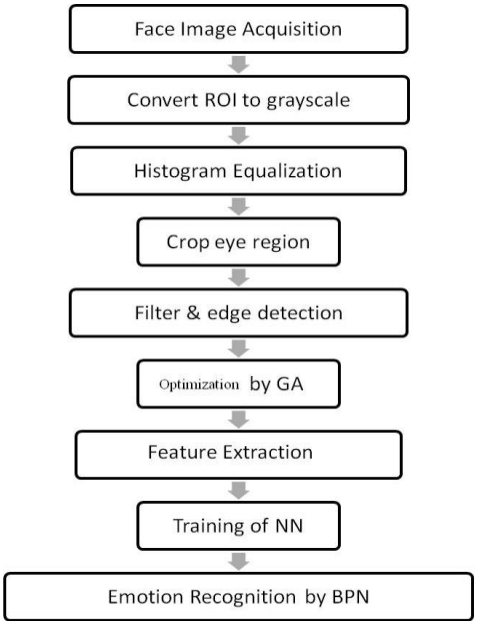
ABSTRACT
Human-computer intelligent interaction (HCII) is an emerging field of science. The interaction between human beings and computers will be more natural if computers are able to perceive and respond to human non-verbal communication such as emotions. The most expressive way humans display emotions is through facial expressions. In this paper a method for emotion recognition from facial images has been proposed.

The system consists of three steps. At the very outset some pre-processing has been applied on the input image and face features have been extracted from face images before applying the emotion recognition technique. A comparison between two edge detection techniques-Sobel edge detection and Fuzzy logic based edge detection has been shown. Observation of various emotions characterizes that eye exhibits ellipses of different parameters for different types of emotions. Genetic Algorithm has been applied to optimize the ellipse characteristics of the eye feature. Finally a classification has been carried out by using Back-propagation Neural Network (BPNN). The proposed approaches are tested on a number of face images.

General Terms
Emotion Recognition, Image Processing.

Keywords
Fuzzy Logic based edge detection, Feature extraction, Genetic algorithm, Back-propagation Neural Network.

1. INTRODUCTION
The research on human's emotion can be traced back to the Darwin's pioneer work in [1] and since then has attracted a lot of researchers to this area. Ekman and Friesen developed the most comprehensive system for synthesizing facial expression based on what they call as action units. According to Ekman et al. [2], there are six basic emotions that are universal to human beings, namely, angry (AN), disgust (DI), fear (FE), happy (HA), sad (SA), and surprise (SU), and these basic emotions can be recognized from human's facial expression. In the early 1990's the engineering community started to use these results to construct automatic methods of recognizing emotion from facial expression in still and video images[3].Nowadays, the recognition of these six basic emotions from human's facial expressions has become a very active research topic in human computer interaction (HCI). During the past decades, various methods have been proposed for emotion recognition. One may refer to [4][5][6][7] for a survey. The current literature on emotion detection through facial images indicates the requirement of two desired directions. The image processing techniques highly relevant for identifying facial features under uneven lighting and interpreting the face emotion through the processed facial features. Both of these problems have been under taken in this paper. Eyes have been used as origins of extracting facial emotion features. The methods of filtering and edge detection have been proposed for feature extraction. Then this processed image has been utilized to identify certain optimum parameters through Genetic Algorithm (GA). A new fitness function has been suggested for extracting the eye parameters through GA. Since the emotion detection algorithm can be made as an expert system through continuous processing of available data, the suggested method of emotion estimation has been considered as suitable for a personalized face. From the obtained training data set facial emotions of human are recognized using Back-propagation Neural Network.



FLOW CHART OF THE PROPOSED SYSTEM:

2. IMPLEMENTATION

2.1 Face Image Acquisition

Digital camera with 3.2 mega pixel has been used for acquiring face image. The test image has been shown in Fig-1

Fig-1

2.2 Conversion to Grayscale

The Region of Interest (ROI) has been selected from the acquired image which has been shown in Fig-2.

The Region of Interest (ROI) has been converted into grayscale image (o-255).

Fig.2

2.3 Histogram Equalization

Histogram Equalization method has been applied on the gray scale test image which has been furnished in Fig-3. Histogram equalization [8] improves the contrast in the grayscale and its goal is to obtain a uniform histogram.

The histogram equalization method also helps the image to reorganize the intensity distributions.

New intensities are not introduced into the image. Existing intensity values will be mapped to new values but the actual number of intensity pixels in the resulting image will be equal or less than the original number.

Fig.3

2.4 Cropping of Eye region

From the histogram equalized image the eye region has been cropped for further processing. The cropped test image has been furnished in Fig-4.

Fig.4

2.5 Filtering:

In the image sequence, the salt & pepper noise has been added to the histogram equalized image. This type of noise consists of random pixels being set to black or white. The average and median filters have been applied in order to make the image smoother by removing unwanted noise which has been furnished in Fig-5. Median Filtering [9] makes each output pixel set to an average of the pixel values in the neighborhood of the corresponding input pixels.

Fig.5

2.6 Edge Detection:

Edge detection methods have been applied to the filtered test image. Edge detection technique-sobel edge detection and fuzzy logic based edge detection.

2.6.1 Sobel Edge Detection

The Sobel method finds edges using the Sobel approximation to the derivative. It returns edges at those points where the gradient of the input image is maximum. The output of the eye image using Sobel (fig.6):

Fig.6

2.6.2 Fuzzy Logic based Edge detection

Fuzzy logic based algorithm detects the edges of an input image(fig.5) by scanning it throughout using a 2*2 pixel window.

P1	P2
P3	P4

This technique uses 16 rules to mark the pixel under consideration as Black, White or Edge [10].

Fuzzy Inputs				Fuzzy Output
P1	P2	P3	P4	P4_out
B	B	B	B	B
B	B	B	W	E
B	B	W	B	E
B	B	W	W	E
B	W	B	B	E
B	W	B	W	E
B	W	W	B	E
B	W	W	W	W
W	B	B	B	E
W	B	B	W	E
W	B	W	B	E
W	B	W	W	E
W	W	B	B	E
W	W	B	W	E
W	W	W	B	E
W	W	W	W	W

The output of the fuzzy logic based edge detected eye image (fig.7) –

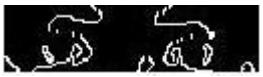


Fig.7

Optimization of edge detected eye image using genetic algorithm:

Genetic Algorithm is a heuristic method used to find approximate solutions to solve problems. In early 1970s, John Holland introduced the concept of Genetic Algorithm [11].

GA is an iterative process. Each iteration is known as generation. Here we are applying the GA for optimization of the edge detected eye image. The Algorithm is:

Step 1.

Represent the problem variable domain as chromosome of a fixed length and population, with suitable cross over probability and mutation probability.

Step 2.

Define a fitness function to measure the performance, or fitness of an individual chromosome in the problem domain.

Step 3.

Randomly generate an initial population of chromosomes.

Step 4.

Calculate the fitness of each individual chromosome.

Step 5.

Select a pair of chromosomes for matting from the current population. Parent chromosomes are selected with a probability related to their fitness. Highly fit chromosomes have a higher probability of being selected for mating compared to less fit chromosomes.

Step 6.

Create a pair of offspring chromosomes by applying the genetic operators' crossover and mutation.

Step 7.

Place the created offspring chromosomes in the new population.

Step 8.

Repeat from step 5 until the size of new chromosome population becomes equal to the size of the initial population.

Stpep 9.

Replace the initial chromosome population with the new population.

Step 10.

Go to step 4, and repeat the process until the termination criterion is satisfied.

2.7 Emotion estimation:

The edge detected eye image can be considered as an ellipse with variations. The minor axis is a feature of the eye that varies for each emotion. The major axis of the eye is more or less fixed for a particular person in varied emotions. The ellipse can be parameterized by its minor (2b) and major axes (2a).

In the analysis, face expressing six different emotions and the neutral face is considered. From the edge detected eye image the value of b i.e. value of minor axis is computed by calculating the uppermost and lowermost position of the white pixels vertically. The optimization is performed for more than 6 times for each emotion in reaching consistent minor axis value of b.

Table 1A: Value of 'b' for each emotion in case of Fuzzy Logic based edge detection technique:

Emotions	N	M	Value of b	Duration(sec)
Neutral	194	68	19.33	134
Fear	172	65	16.04	153
Happy	165	54	16.11	120
Sad	178	58	19.31	143
Angry	184	41	16.16	99
Dislike	151	40	13.59	122
Surprise	201	69	16.28	175

Table 1A

Table 1B: Value of 'b' for each emotion in case of Sobel edge detection technique:

Emotions	N	M	Value of b	Duration(sec)
Neutral	194	68	21.13	132
Fear	172	65	16.04	152
Happy	165	54	16.43	118
Sad	178	58	19.11	139
Angry	184	41	16.68	97
Dislike	151	40	13.59	112
Surprise	201	69	17.88	170

Table 1B

Comparing the outputs we can see that in case of fuzzy logic based edge detection the range of values of b overlaps for different emotions. So emotions can't be recognized perfectly by this. So, we have used the outputs based on the sobel edge detection technique for further process.

These values of b (table: 1B) are used for training the Neural Network.

2.8 Emotion Recognition using Neural Network

A typical ANN has n inputs and one or more output as shown in fig. 8. The input layer is composed not of full neurons, but rather consists simply of the values in a data record, that constitutes inputs to the next layer of neurons. The next layer is called a hidden layer and there may be several hidden layers. The final layer is the output layer, where there is one node for each class.

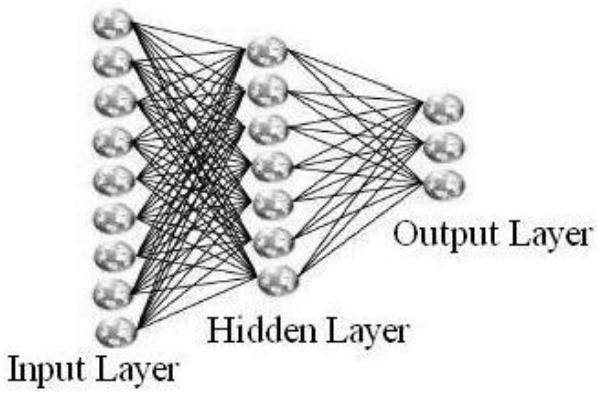


Fig.8

The recognition system of Neural Network consisted of three stages.

1. Training of Neural Network

2. Testing of Neural Network

3. Performance Evolution of Neural Network

2.8.1 Training of NN:

In this phase we have used the Back Propagation Neural Network. The learning algorithm is performed in two stages: feed-forward and feed- backward. We have used a database of 20 images of 6 emotion classes for training of the neural network. In the first phase the inputs are propagated through the layers of processing elements, generating an output pattern in response to the input pattern presented. In the second phase, the errors calculated in the output layer are then back propagated to the hidden layers where the synaptic weights are updated to reduce the error. This learning process is repeated until the output error value, for all patterns in the training set, is below a specified value.

A feed forward neural network is proposed to recognize the emotions based on optimized ranges of eye. The optimized values of the data obtained previously are given as inputs to the network. The network is considered as a model with a structure of 1 input neuron, 1 hidden layer of 20 neurons and 7 output neurons (denoted by (1x20x7)) (fig.9). The input is the estimated values of b. The output (Oi, i=1,2,..,7) of (1x20x7) is of mutually exclusive binary bit representing an emotion.

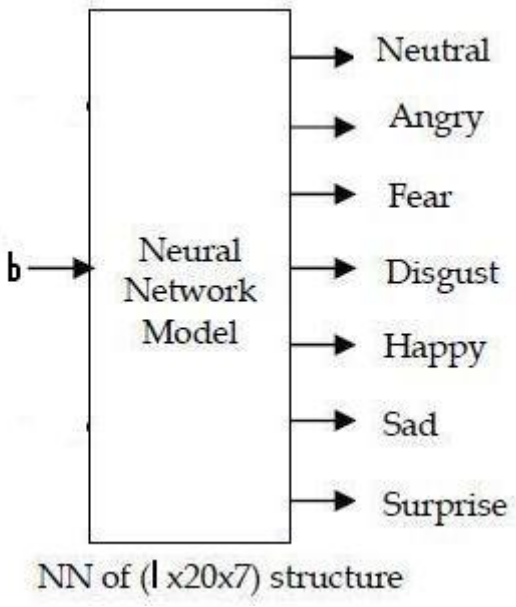


Fig.9

2.8.2 Testing of NN-

After training, some face images expressing different emotions have been taken (fig.10) for testing the Neural Network to check whether the detected emotions are Right or Wrong.

Pic.1 Pic.2 Pic.3

Pic.4 Pic.5 Pic.6

Pic.7 Pic.8 Pic.9

Pic.10 Pic.11 Pic.12

Pic.13 Pic.14 Pic.15

Pic.16 Pic.17 Pic.18

Pic.19 Pic.20

Fig.10

2.8.3 Result of Testing:

Pic.	Detected Emotion	Result
1	Sad	Right
2	Surprise	Wrong
3	Happy	Right
4	Anger	Wrong
5	Anger	Right
6	Surprise	Right
7	Anger	wrong
8	Sad	Wrong
9	Surprise	Wrong
10	Neutral	Right
11	Sad	Right
12	Happy	Right
13	Neutral	Right
14	Neutral	Right
15	Neutral	Right
16	neutral	Right
17	Happy	Right
18	Sad	Right
19	Sad	Wrong
20	Happy	Right

2.8.4 Performance Evolution of NN:

Tested Images	Correct recognition	Wrong recognition	Performance (%)
20	14	6	70

Table 3

3. CONCLUSION

In the study on a human face the classification of six emotions and one neutral has been considered. The average and median filters are applied to smoothen the image. The Sobel edge detection is found to perform well than fuzzy Logic based edge detection, since it offers a better segmentation even in non-structural light intensities. The eye regions are used for the study on emotions. The GA is then applied for optimization .It is to be indicated here that a mean value of b for an emotion is obtained through several experiments. These training values are feed to a back propagation Neural Network for emotion recognition through facial expressions. Even though the suggested methodology of face emotion estimation and recognition is general, the derived results are suitable only to the face which we have used here. The software package can be developed as an expert emotion classification system for a personalized face.

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