Emotion Recognition using Fuzzy Rule-based System

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ABSTRACT
Facial Expression Recognition has increasing importance in assisting human- computer interaction issues. This paper "Emotion Recognition Using Fuzzy Rule- Based System" proposes a fuzzy method for the facial emotions recognition on still images of the face. The technique involves extracting mathematical data from some special regions of the face. The extracted mathematical data are then fed to a fuzzy rule-based system. Fuzzification operation issues triangular membership functions for both input and output. The method is implemented on MATLAB. An Algorithm is developed which gives 6 facial expressions as an output i.e., happy, sad, disgust, anger, surprise and fear, where input is the still image of the face, on being applied to a fuzzy rule- based system. The method for the feature extraction of the still image is also developed which is very important for recognizing the facial expression.

Keywords- FER, Fuzzy Rule- Based System, Fuzzification, Triangular Membership Function.

1. INTRODUCTION
Facial Expression Recognition (FER) is one of the most important subjects in the fields of human-computer interaction. It has wide range of applications such as telecommunication, medical, Human- Computer Interaction (HCI) and biometrics. As we know, Emotions and ways of thinking vary person to person. To treat each and every user according to its expressions, emotions and ways of thinking, is the ultimate aim of all Human- Computer Interaction Systems. An Intelligent Software Assistant understands its user's expressions and provides services according to his/ her needs. The users are dealt by an intelligent software assistant in profile based manner [1]. Most of researchers who have researched on facial expression recognition have attempted to classify six basic emotion states- happy, sad, anger, surprise, disgust and fear. In this paper, also there are six emotion states that have been recognized- happy, sad, anger, surprise, disgust and fear. There are mostly four regions (eyebrows, eyes, nose and mouth) from where emotion outlets come. This has been shown by Lucey et al. [2] and Zhao et al. by studying the relationship between action units and each basic emotions. In this paper, the graphical method has been used for the Feature Extraction (explained further in this paper), and it is done with the help of these basic four regions i.e. eyebrows, eyes, nose and mouth region.

In this paper, an algorithm is developed which identifies the six basic emotions of a static face. The input, as a still image of the face is fed, and we get the emotions as an output. The basic method for the emotion detection is Feature Extraction [3].
The rest of the paper is organized as follows. A brief review of feature extraction algorithms is given in next section and further followed by the detailed description of proposed method is made.

2. FEATURE EXTRACTION TECHNIQUE
Feature Extraction is very important to recognize facial image. Stretching corner lips, raising eyebrows, opening eyes, etc. are some of the movement of face muscles that makes facial features and generates facial expressions. Various researches have been made on effective extraction of facial features as well as classifying them to the different emotions. Most common approaches are PCA (Principle Component Analysis) and LDA (Linear Discriminate Analysis) [4]. In these approaches, data are projected linearly from high dimensional image space to the low dimensional subspace. Another algorithm which is used by [5] is FLD (Fisher Linear Discriminate). FLD is a supervised learning algorithm. It seeks a transformation matrix so that the ratio of the between-class scatter and the within- class scatter is maximized. In this paper, a graph based Feature Extraction technique is used [6].

3. METHODOLOGY
Following Block Diagram shows the overall proposed method for extracting feature vectors and detecting the facial expressions.

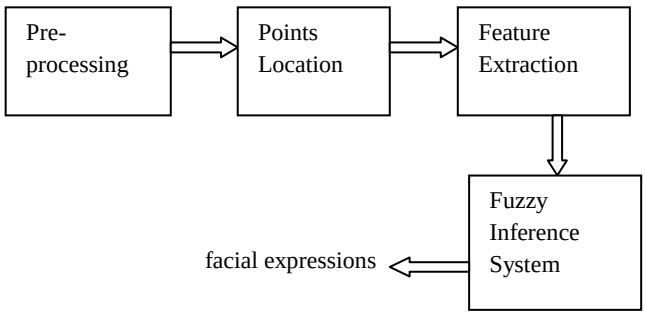

Fig.-1 Block Diagram of the proposed Method

All the steps of the methodology have been explained further one by one.

➢ Pre-processing

All conversions on image data so as to make them more effective for consequent steps is called Pre-processing of an image. For the pre-processing of an image, first the input image is smoothened by Wiener Filter of size 5*5. Wiener Filter is an adaptive low pass filter. It estimates the output pixel using mean and variance of a local neighbourhood of a pixel [7].

$\mu=1/MN \sum n1,n2 \in n \alpha(n1,n2)$ . . . . . (1)

$\sigma^2=1/MN \sum n1,n2 \in n \alpha^2(n1,n2)- \mu^2$ . . . . . (2)

μ and σ^2 are mean and variance in the neighbourhoods of size m- by- n around each pixel. The application of Weiner Filtering on the image causes more distinction between the face and the background of the image. This image will be processed in next step which is graph- based point location and Feature Extraction.

➢ Points Location

Points Location is the method necessary for the Feature Extraction. The graphical based method is used for points location [6]. Eyebrows, eyes, nose and mouth are the regions which are influenced to the six basic expressions of the face. In addition, nose region can be ignored because of its minimal influence on outlet emotions. From this reason, graph construction based on fourteen points location including two points on inner eyebrows, two points on middle eyebrows, two points on outer eyebrows, two points on inner eyes, two points on outer eyes and four points on mouth, as described in following figure- 2 (a) and (b).

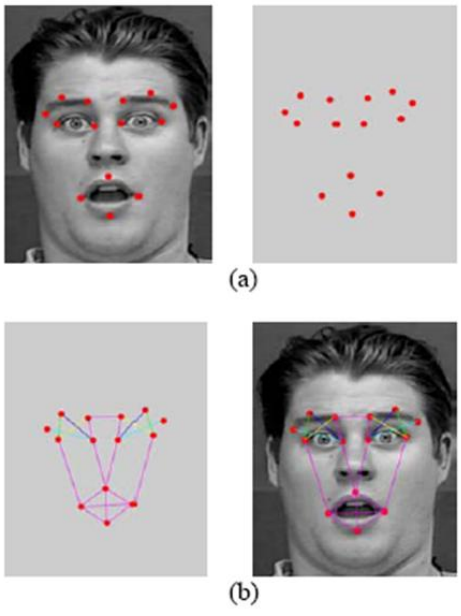

Fig.- 2 Graph based feature construction in each stage (a).Locate 14 facial points (b).Find distance between each points to form connecting edge

➢ Feature Extraction

As explained earlier in the section "Feature Extraction Technique" can be in many of the formats. Many of the researches have shown that. The graphical method used in this paper involves the points location, which is done in earlier step. Now, Euclidean Distance between the points is to be calculated.

$$D(x,y)= \sqrt{((x2-x1)^2+ (y2-y1)^2)}$$

But, before finding the Euclidean Distance, it is necessary to find the exact location of each point of the face, as shown in fig. 1(a) and 1(b).

There are methods explained in [8] for the automatic points location. If the eyes locations are found, it is easier to find the rest locations. An "eye blinking method" can be used to detect its location [9]. When the eye's location is found, the location of nose and mouth can be found out on the basis of assumption. Now, the Euclidean Distance plays an important role in success of face recognition problem.

From this, the feature vector having following elements can be detected and their contents are-

Table 1. Feature Vectors showing their elements and contents

D[i]	centre of left eyebrow to left side of the left eyebrow
D[ii]	centre of left eyebrow to right side of the left eyebrow
D[iii]	centre of right eyebrow to left side of the right eyebrow
D[iv]	centre of right eyebrow to right side of the right eyebrow
D[v]	distance between both eyebrows
D[vi]	length of the left eye
D[vii]	length of the right eye
D[viii]	width of the left eye
D[ix]	width of the right eye
D[x]	left eyebrow to left eye
D[xi]	right eyebrow to right eye
D[xii]	length of the mouth
D[xiii]	width of the mouth
D[xiv]	left corner of left eye to left corner of lips
D[xv]	right corner of left eye to centre of lips
D[xvi]	left corner of right eye to centre of lips
D[xvii]	right corner of right eye to right corner of lips

Now, by the method of [9], and further assumptions, locations are detected and thus, through above process and formula for the Euclidean Distance, the feature vector is shown below-

D[i]= 34.000000

D[ii]= 49.040798

D[iii]= 36.000000
D[iv]= 47.010635
D[v]= 41.048752
D[vi]= 42.438190
D[vii]= 44.654228
D[viii]=23.000000
D[ix]= 40.000000
D[x]= 52.000000
D[xi]= 30.000000
D[xii]= 33.000000
D[xiii]= 41.000000
D[xiv]= 35.693138
D[xv]= 37.854988
D[xvi]= 29.000000
D[xvii]= 31.000000

The values, which are evaluated, are the Euclidean distances between various points on the face shown in the fig above. Now we can implement these values in fuzzy inference system. Following figure- 3 (a), (b), (c), (d), (e) and (f) shows the comparison of graphs among six basic emotions.

Fig.- 3 Example of Graph based features on six basic emotions

➢ Fuzzy Inference System

Fuzzy logic deals with the uncertainty of information and it represents good mathematical framework to deal with them too. Just like human decision making, its ability is to work from approximate data and find precise solutions. Since the concept of fuzzy logic was formulated in 1965 by Zadeh, In the various areas of digital image processing such as image quality assessment, pattern recognition, image segmentation, etc., many researches have been employed. In this paper, Fuzzy Rule- Based System has been used for classification of six facial expressions of the face. Generally, each fuzzy image processing system has three main stages: image fuzzification, modification of membership values i.e., Fuzzy Inference System, and, if necessary, image defuzzification.

If we use simple fuzzy if- then rule, the Euclidean distance would be helpful in that. For example, if D[vi], D[vii] and D[xii] increases and D[viii] and D[ix] decreases, then the expression will be 'happy', and so on.

Implementation of proposed fuzzy inference system is carried out by introducing triangular membership functions due to the extracted features from the last section. The triangular curve is a function of a vector, x, and depends on three scalar parameters, a, b, and c, as given by-

f(x,a,b,c)= 0 , if x≤a

f(x,a,b,c)= (x-a)/(b-a) , if a≤x≤b

f(x,a,b,c)= (c-x)/(c-b) , if x≥c

This function is used to map inputs to membership values [10]. Therefore, there will be 6 linguistic variables (due to each expression) for each feature of every basic region. An example of one defined region and its relevant membership functions due to the extracted features is shown below.

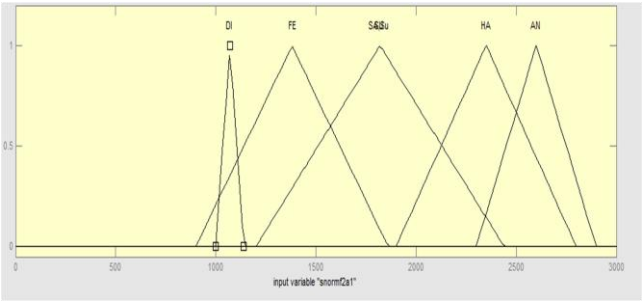

Fig.- 4 Membership Functions for one of the facial regions

4. RESULTS

The accuracy results of each of the six expressions of the face through the proposed formulae and algorithm tested on MATLAB functions, have been given below in the table-

Table 2. Accuracy results of each of the six expressions through the proposed algorithm

Expression	Accuracy of Recognition
Happy	100%
Sad	93%
Disgust	85%
Anger	85%
Surprise	93%
Fear	70%

5. CONCLUSION

Fuzzy if- then rules and its processing is desirable because of the uncertainties that exist in many aspects of image processing. In this work, a method for recognizing the emotions of a still face has been developed, which takes the still image as an input and delivers the six basic expressions as an output. Graph-based feature extraction was done by locating points on the face that influence directly on the expression of emotions. Then Euclidean Distance between each point is calculated. Then the results are fed to a fuzzy inference system. The system uses triangular membership functions for both input and output. In this paper, the emphasis has been done on the accuracy of the recognition. A very simple and small but a greatly efficient, fuzzy rule- based system algorithm has been developed. Future work can include emotion recognition considering more facial regions, improving rules and showing better performance.

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