A Comparison of South East Asian Face Emotion Classification Based on Optimized Ellipse Data Using Clustering Technique

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***Abstract*—In this paper, using a set of irregular and regular ellipse fitting equations using Genetic algorithm (GA) are applied to the lip and eye features to classify the human emotions. Two South East Asian (SEA) faces are considered in this work for the emotion classification. There are six emotions and one neutral are considered as the output. Each subject shows unique characteristic of the lip and eye features for various emotions. GA is adopted to optimize irregular ellipse characteristics of the lip and eye features in each emotion. That is, the top portion of lip configuration is a part of one ellipse and the bottom of different ellipse. Two ellipse based fitness equations are proposed for the lip configuration and relevant parameters that define the emotions are listed. The GA method has achieved reasonably successful classification of emotion. In some emotions classification, optimized data values of one emotion are messed or overlapped to other emotion ranges. In order to overcome the overlapping problem between the emotion optimized values and at the same time to improve the classification, a fuzzy clustering method (FCM) of approach has been implemented to offer better classification. The GA-FCM approach offers a reasonably good classification within the ranges of clusters and it had been proven by applying to two SEA subjects and has seen improvement compared to the earlier work.**

***Index Terms*—ellipse fitness function, genetic algorithm, emotion recognition, fuzzy clustering**

I. Introduction

In recent years, there has been a growing interest in improving all aspects of interaction between humans and computers especially in the area of human emotion recognition by observing facial expression. Ekman and Friesen developed the most comprehensive system for synthesizing facial expression based on what they call as action units [1]. In order to determine the category of emotion, 15 facial points in a face-profile sequence has been recommended. The algorithm performs both automatic segmentation of an input video images of facial expressions and recognition of 27 AUs occurring alone or in combinations in the input face-profile video. A recognition rate of 87% is reported [2]. The motion signatures produced are then classified using Support Vector Machines as either non-expressive or as one of the six basic emotions. The completed system is demonstrated in two simple but effective computing applications that respond in real-time to the facial expressions of the user, thereby providing the potential for improvements in the interaction between a computer and user [3]. The universally accepted categories of emotion, as applied in human computer interaction are:

Sad, Anger, Joy, Fear, Disgust (or Dislike) and Surprise. In this paper, image preprocessing, filtering, edge detection methods that are suitable for feature extraction are presented and compared towards applying it to get lip and eye features. A set of fitness functions for the GA methods are also proposed as suitable for face emotion recognition. Such an approach of determining the emotions are highly suited for a personalized face. Fuzzy C-mean clustering is implemented to classify the emotion based on the optimized values. The subject South East Asian; The two subject have been used for emotion classification. The developed process flow for the image processing, feature extraction and classifying the emotions is shown in Fig. 1.

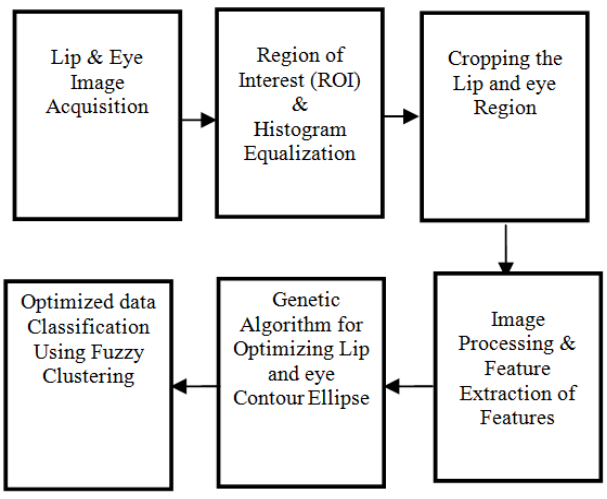

Figure 1. Process flow of image processing

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II. Face Image Processing

As the first step in image processing, the region of interest (ROI) has been selected in the acquired image. The ROI image is converted into grayscale image (0-255).

Before obtaining the filtered grayscale image, a histogram equalization method has been applied. In the image sequence, the histogram equalized image is filtered using average and median filters [4] in order to make the image smoother. Finally, Sobel edge detection method is applied to the filtered image. Due to light intensity variation, the segmentation process has not been carried out successfully. In the edge detected image of the whole face, the eyes are properly segmented whereas the lip segmentation is poor for South East Asean face; so the histogram equalized image is split into eyes ROI and lip ROI regions. The ROI lip region is cropped from the full image. Various edge detection methods such as Sobel, Prewitt, Canny, Roberts and Log have been applied to the image. A comparison has been made among the edge detection methods and it is found that the Sobel edge detection method [5] performed well compared to other four methods.

III. Feature Extraction

A feature extraction method is now to be applied to the edge detected image to extract features. Three feature extraction methods are considered and their capabilities are compared in order for adopting the one that is suitable for the proposed face emotion recognition problem. They are projection profile, contour profile and moments [6].

The performance of each of the above described feature extracting methods is compared with respect to processing time using the edge detected image of the lips and eyes. The projection profile is found to perform well in feature extraction with regards to the processing time and is adopted here. The projection profile has been also found to have performed well in earlier works [5]-[7].

IV. Face Emotion Recognition Using Genetic Algorithm

In the early 1970s, John Holland, one of the founders' evolutionary computations, introduced the concept of genetic algorithm [8]. Genetic algorithm (GA) is a heuristic method used to find approximate solutions to solve problems through application of the principles of evolutionary biology. GA adopts biologically-derived techniques such as inheritance, mutation, natural selection, and recombination (or crossover). Some aspects of vision system and image processing methodologies have been discussed in earlier literature towards approximating the face as a best ellipse using GA. In the feature extraction stage, the GA is applied to extract the facial features such as the eyes, nose and mouth, in a set of predefined sub regions. Some simulation has been carried out [4]. A method that extracts region of eyes out of facial image by GA has been suggested recently [9].

In this paper, the face features such as eyes and lips are considered in a different perspective. The human lip shape is more of towards combination of two ellipse and we call this is as irregular ellipse. The word 'irregular' means that the ellipse has two different minor axes wherein a major axe remains the same. Lengths of minor axes of the lip feature for each emotion are computed. The major axis is more or less fixed for the eye of a particular person. The major axis "2a" (considered to be fixed) and two minor axes are "2b1" and "2b2" (to be computed). It is shown in Fig. 2.

The human eye shape is more of towards ellipse. The preprocessed eye image is considered as an ellipse. Then, the minor axis of the eye feature can represent an emotion. The ellipse can be parameterized by its minor and major axes. The major and the minor axes are "2a" (more or less fixed) and '2b" (to be computed) respectively [7]. This is shown in Fig. 3. The ellipse is defined by its equation as in Equation (1). A general form of the regular ellipse defined by

$$\frac{x^2}{a^2}+\frac{y^2}{b^2}=1 \tag{1}$$

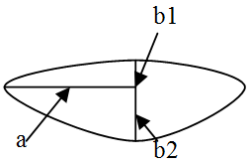

Figure 2. Irregular ellipse with minor and major axis

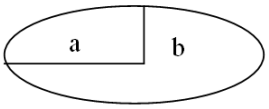

Figure 3. Ellipse with minor and major axis

In this work, a new set of fitness functions is suggested in order to find the three minor axes so that the emotion changes can be recognized. The fitness function, to be discussed latter, for applying GA, is derived to optimally compute semi-minor axes, b1, b2 and b, for the top lip area, bottom lip area and eye area respectively; emotions can thus be related to the values of b1, b2 and b.

A. Fitness Function

A fitness function is a particular type of objective function that quantifies the optimality of a solution (that is, a chromosome) in a GA problem so that this chromosome may be ranked against all the other chromosomes. A fitness value reflecting the amount of overlapping between the regions covered by the overlaid boundaries is computed for each chromosome. A pair of individuals are selected with a probability proportional to their fitness and mated to reproduce their next generation. The process is repeatedly performed with the same number of individuals of the previous epoch. The fitness function, Equation (2), (3) and (4) with b1, b2 and b are derived based on the general ellipse equation, Equation (1) as

$$f(x)=\Big(\sum_{i}^{m}\sum_{j}^{n} col(j)-2\sqrt{X_1^2\left(1-\frac{row(i)^2}{a^2}\right)}\Big)^2 \tag{2}$$

$$if X_1 \geq 0$$

$$\overline{f(x)} = \left(\sum_{i}^{m} \sum_{j}^{n} col(j) - 2\sqrt{X_2^2\left(1 - \frac{row(i)^2}{a^2}\right)} \right)^2 \quad (3)$$

$$if X_2 \le 0$$

$$f(x) = \left(\sum_{i}^{m} \sum_{j}^{n} col(j) - 2\sqrt{X^2\left(1 - \frac{row(i)^2}{a^2}\right)} \right)^2 \quad (4)$$

In Eq. (2), (3) and (4), col(j) is sum of white pixels occupied by the column and row(i) is number of rows of white pixels in the row. Equations (2), (3) and (4) are fitness functions of top lip, bottom lip and eye respectively.

The lip and eye features have been given as input to the genetic algorithm to find the optimized values of b1& b2 and b. The selected values of GA parameters are indicated in the Table I. The process of optimization has been carried out for 5 times for each emotion. This process of optimization is found to be giving favorable three minor axis values b1, b2 and b for top lip area, bottom lip area and eye area respectively. Table II indicates the manually measured values of b1, b2 and b and the corresponding optimized values of X1, X2 and X for SEA1 and SEA2 as shown in Fig. 4 for SEA1. The emotion based on minor axes of the lip feature and eye feature can now be estimated. The experiment result shows that the two minor axis (b1 and b2) of the lip feature and one minor axis (b) of eye feature are different for each emotion there by distinctions are possible. However, the ranges of (b1, b2, b) of one emotion sometimes overlap with those of other emotions. Fuzzy C-Mean clustering approach is adopted to circumvent this problem.

TABLE I. PARAMETER SETTINGS FOR GA PROCESSING

Generation	250
Population size	20
Selection Function	Roulette
Mutation	Gaussian
Crossover	Scattered
Stall generation	50
Stall time	20

TABLE II. OPTIMIZED VALUES OF THE FEATURES FOR SEA1 AND SEA2

Emotions	SEA1						SEA2					
	Manually Computed Mean Value (in pixels)			Optimized Mean Value by GA (in pixels)			Manually Computed Mean Value (in pixels)			Optimized Mean Value by GA (in pixels)		
	b1	b2	b	X1	X2	X	b1	b2	b	X1	X2	X
Neutral	38	41	21	34.26	35.25	19.62	51	54	37	50.19	49.60	36.28
Fear	25	41	16	23.03	36.95	12.20	67	51	42	65.65	50.86	41.97
Happy	25	48	16	21.59	43.47	15.04	51	77	31	49.39	76.00	30.62
Sad	33	34	18	30.91	28.52	16.96	48	61	36	47.09	60.44	34.95
Angry	25	34	16	24.28	30.84	12.84	66	48	38	64.95	39.72	36.02
Dislike	35	29	13	31.34	21.63	12.84	26	43	23	25.74	42.75	23.43
Surprise	43	57	17	42.69	55.52	16.07	92	82	42	91.21	82.43	41.01

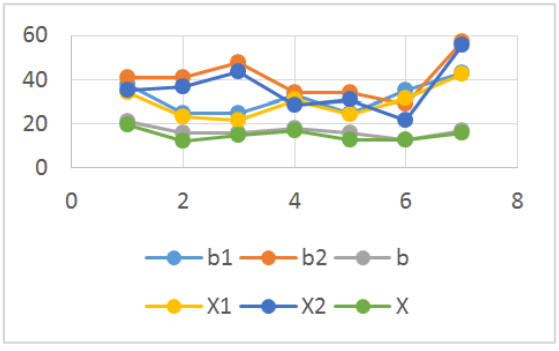

Figure 4. Optimized values of the features for sea1

V. EMOTION CLASSIFICATION USING FUZZY C-MEAN CLUSTERING

Fuzzy clustering has been widely applied in pattern recognition, image processing and data analysis. The fuzzy c-mean (FCM) algorithm has been implemented to partition a finite collection into a collection of c fuzzy clusters [10]-[12]. From these optimized value, each emotion has its own range of value for lip and eye, in some cases the emotion ranges overlap with other emotion range such that need some intelligence to cluster the each emotion. The purpose of FCM here is to clusters the given data based on the group or emotion, that means same range of data are clustered together. Even though, the ranges are overlapped, the clustering comes with proper classification of emotions. Here, FCM is employed to classify the emotion for the optimized 3-D data of top lip, bottom lip and eye value. The proposed FCM model is as shown in Fig. 5. It shows 3 optimized features value as inputs to the model for two SEA 1 and 2. It offers 7 center cluster values of the group data such as C1 to C7. The parameter setting for clustering setting is given in Table III for SEA1 and SEA2. The clustered center point value of the 3-D Data set of emotion is given in the Table IV and Table V for SEA1 and SEA2 respectively.

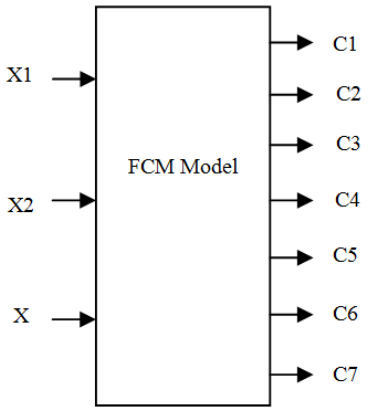

Figure 5. FCM Model

TABLE III. PARAMETER SETTINGS FOR CLUSTERING TECHNIQUE

S. No	Parameters	Implemented
1	Method of Initialization	Random
2	Exponent of partition matrix	2
3	Number of clusters	7
4	Distance Function	Euclidean distance

TABLE IV. CLUSTERED CENTER POINT SEA1

X	Y	Z	Expected Emotion
18.0096	45.9774	15.5446	Happy
34.2994	34.1146	19.2083	Neutral
47.0057	58.9311	16.0557	Angry
24.1830	35.9366	15.0224	Fear
33.6786	14.6274	13.3724	Nearly dislike
40.0994	53.4834	16.0963	Surprise
28.3922	27.8944	15.4475	Sad

TABLE V. CLUSTERED CENTER POINT SEA2

X	Y	Z	Expected Emotion
63.933	51.311	41.503	Fear
48.036	57.855	35.156	Sad
25.622	42.801	22.774	Dislike
47.411	74.653	29.879	Happy
91.185	82.221	41.028	Surprise
64.577	40.487	36.471	Angry
53.435	75.828	32.719	Neutral

VI. DISCUSSION

In this study on a South East Asean subjects for SEA1 and SEA2, six emotions and one neutral had been considered. The average and median filters were applied to smoothen the image. The Sobel edge detection was found to perform well, since it offered better segmentation than other 4 methods. The GA was then applied to get the optimized values of the minor axes, b1, b2 & b of the irregular ellipse and regular ellipse by using a set of proposed fitness functions. These optimized values of emotions range were overlapped. In order to overcome this problem, FCM was implemented to offer better classification. The parameters were set to run the FCM method. All optimized emotion data were given to FCM model. The FCM clustered the optimized emotion data were clustered (seven clusters). Based on the range of GA, the emotion of each center was determined. All center values came under their respective emotion range except one. All other center's emotion was determined by their respective range. The unknown range cannot be determined and angry emotion center is also missing for SEA. In SEA2, it is able to identify the angry emotion. This FCM were capable of giving of center value all emotion. It offered of about 85.71% successful classification for SEA1 and 88.57% for SEA2. It shows that the classification rate has been improved and able to determine the center position for Angry compared to SEA1 with the same FCM Model. The reason behind the variation in the rate and missing emotion for SEA1 is due to subject emotion expression which is unique cannot be generalized.

VII. CONCLUSION

In this paper, a set of suitable sequences in image processing and new fitness functions for the GA application have been proposed for determining the top-lip, bottom-lip and eye features. The suggested sequence of image processing offers acceptable images. The proposed method had shown successful classifications of emotion. This method of emotion classification is a general approach to lips and eyes of any face. It offered of range between 85.71% to 88.57% classification rate for SEA based on SEA1 and SEA2. The implementation of FCM played the vital role in classifying the emotions based on the optimized values of top lip, bottom lip and eye. This is more suitable to South East Asian subject. In SEA2, able to provide the angry emotion center point compared to SEA1. It has shown the improvement.

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