Available Online at www.ijcsmc.com

International Journal of Computer Science and Mobile Computing

A Monthly Journal of Computer Science and Information Technology

ISSN 2320–088X

IJCSMC, Vol. 2, Issue. 6, June 2013, pg.300 – 306

RESEARCH ARTICLE

Performance Comparison of an Effectual Approach with K-Means Clustering Algorithm for the Recognition of Facial Expressions

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Abstract— Automatic Facial Expressions Recognition and Classification has become active research field in image processing area over a last two decades. It has many applications like human computer interaction, face identification and videoconferencing. In this paper, two approaches are presented for the recognition of facial expressions from frontal facial expression images. The comparison of K-Means Clustering algorithm with proposed approach for facial expression recognition has done. The main objective of this research work is to present a new approach that recognizes facial expressions automatically and also to show the effectual outcome of this approach over the existing K-Means Clustering approach. Both the facial expression recognition system uses same number of dataset for the analysis and implemented by using MATLAB. The systems follow a procedure for recognition that include pre-processing, face boundary detection, feature extraction and expression recognition. Experimental results show that the proposed approach gave much better performance in comparison with existing approach.

Key Terms: - Facial Expression Recognition; Facial Expressions; Face detection; K-Means Clustering Algorithm; Successive Mean Quantization Transform (SMQT)

I. INTRODUCTION

Expressions are the most powerful and simplest way to express feelings and emotions between human beings. It is a medium of communication and for describing any situation. Human communication have two main types one of it is verbal that is auditory and the second one is non-verbal that is visible. Facial expressions come into the non-verbal type of communication [1]. In 1971 Ekmen and Friesen suggested six basic expressions that are universally accepted as principal expressions which include Happy, Sad, Angry, Disgust, Fear and Surprise along with neutral [2]. Facial expression recognition solves the problem of face detection, facial feature extraction and expression recognition. Because of these, the facial expression recognition becomes the most interested and active research topic into last two decades. Some of the common application areas related to face and facial expressions is video conferencing, face identification and verification, security, mobile applications and human computer interactions. Mostly, Facial Expression Recognition System have three key components face detection, facial feature extraction and expressions recognition. Face detection is the primary need of expression recognition system. Facial feature extraction includes the detection of nose, eyes and mouth parts from the face as facial information. In some of the expression recognition system, numerical values are calculated as facial features. Expression recognition components uses methods and techniques to recognize the expressions based on the extracted features. This paper proposes a new, fast and efficient approach for facial

expressions recognition that recognizes three principal expressions Happy, Sad and Neutral. The recognition system follows a procedure that includes pre-processing, face detection, feature extraction and expression recognition to recognize and classify the expressions.

II. METHODOLOGY

A. Existing System

In existing system, K-Means Clustering Algorithm is used for the recognition of facial expressions from frontal facial expression images [7]. In this system, the procedure of expression recognition comprises pre-processing, face boundary detection, feature extraction and expression recognition. Pre-processing is performed to enhance the image for further processing and then face boundary detection is performed. In feature extraction, two features are extracted: first one is height to width ratio of mouth image that is cropped as an interested region for feature extraction purpose and second pixel density is calculated. Based on these features K-Means algorithm recognizes and classify the expressions into three clusters of specified expressions that are Happy, Sad and Neutral. The performance of this system shows good result but it has some false recognition.

B. Proposed System

The Proposed Facial Expression Recognition System divides the task of expression recognition into three major parts; pre-processing, facial feature extraction and expressions classification. The step by step process for facial expression recognition is shown in Fig. 1. Pre-processing part includes four functions auto color, auto brightness, auto contrast and noise reduction. In facial feature extraction step face detection, segmentation by edge detection and feature extraction are performed. At last, based on the extracted features and proposed approach the expressions will be classify into one of the happy, sad and neutral expressions.

1) *Pre-Processing:* Pre-processing is the most important and the required step of the image processing. It is performed to get uniform and noise free image for further processing. This step includes the following functions:

- Auto Brightness- Auto brightness function adjust the brightness of the image.
- Auto Contrast- Auto contrast function automatically calculates the favorable contrast for the image will increase the brightness of the image.
- Auto Color- Auto color function adjust the color of the image.
- Noise Reduction- Noise reduction will eliminate the unnecessary noise from the image.

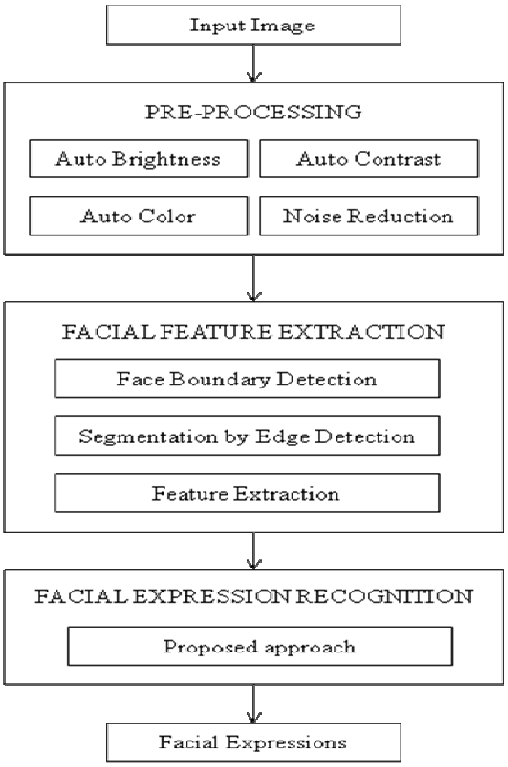

Fig. 1 Flow process of proposed Facial Expression Recognition System

2) *Facial Feature Extraction:* Facial feature extraction is the second foremost part of the facial expression recognition system. This comprises three phases: face boundary detection, segmentation by edge detection and feature extraction. Face boundary detection phase is performed to identify the face in the image that contains eyes, nose and mouth. After that, segmentation is performed to identify the region of interest. In this research work mouth is taken as region of interest for the processing. Finally the features of mouth region are extracted.

- Face Boundary Detection: Face boundary detection phase is also a very important step for the facial expression recognition. In this phase, the face boundary is detected and for that Successive Mean Quantization Transform (SMQT) features is used [3]. The Successive Mean Quantization Technique performs an automatic structural breakdown of information. This information will be applied on local areas in an image to take out illumination insensitive features [4].

- Segmentation by Edge Detection: Segmentation of image means partitioning the image into multiple parts. In this system, segmentation is used to detect the interested regions such as eyes and mouth from images and for that edge detection method is used. After edge detection the region of interest is then cropped for feature extraction, so here mouth part is cropped. Six edge detection methods are tested, named as: Roberts, Sobel, Prewitt, Laplacian of Gaussian, Zero-Cross and Canny [5]. Canny method is chosen because it gives best results for edge detection.

- Feature Extraction: In this phase, the features for cropped mouth images are extracted and stored for the classification. Now for feature extraction range of the expressions are defined by using the height of mouth images. As it is known that, range has two values minimum and maximum. So in this phase of the system, those two values are calculated for the expression recognition.

To define the range, mouth image is divided horizontally into three equal. As shown in Fig. 2, the happy expression range falls into the upper two parts, neutral expression range falls in the middle part and while sad expression range falls in the lower two parts.

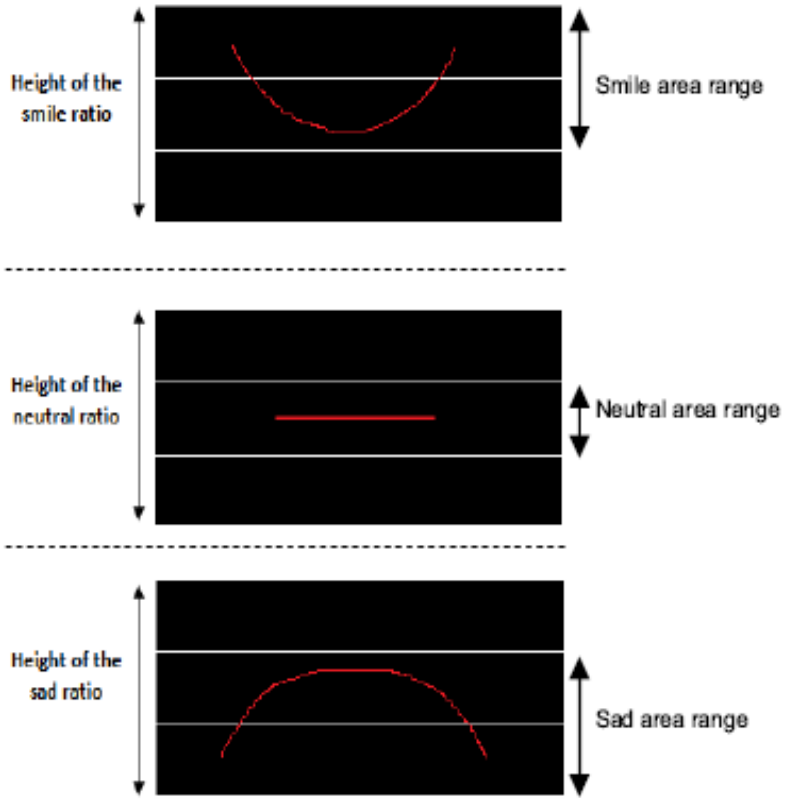

Fig. 2 Range for Happy, Sad and Neutral Expressions for the mouth image

Now, the concept used for calculation of minimum and maximum values for the expressions is, firstly find the height of all mouth images then find the two intermediate values between 0 to height value and these values are used to define the minimum and maximum value for a particular expression.

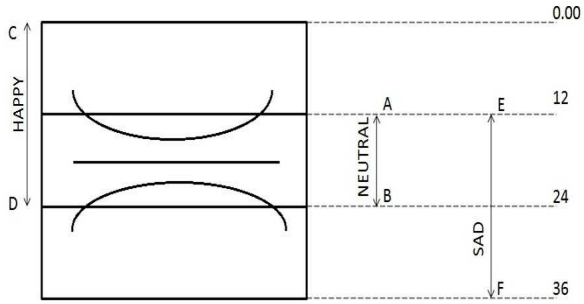

Fig. 3 Range of expressions for the height value 36

For example, as shown in fig.3, for the height 36 the range of happy expression is from C to D so the minimum value is equal to 0 and maximum is 24. While for neutral expression, minimum value is 12 and maximum is 24. On the other hand, for sad expression minimum is 12 and maximum is 36. Similarly for all the height values, minimum and maximum values are calculated for each expression. Table I shows the sample data for the expressions that include height of the mouth image, minimum value and maximum value.

TABLE I
SAMPLE DATA OF HAPPY, SAD AND NEUTRAL EXPRESSIONS WITH HEIGHT, MINIMUM AND MAXIMUM VALUES.

HAPPY		
Height	Minimum Value	Maximum Value
26	0.00	17.3333
30	0.00	20
35	0.00	23.3333
31	0.00	20.6667
NEUTRAL		
Height	Minimum Value	Maximum Value
28	9.3333	18.6667
30	10	20
33	11	22
25	8.3333	16.6667
SAD		
Height	Minimum Value	Maximum Value
26	8.6667	26
32	10.6667	32
36	12	36
30	10	30

3) *Facial Expression Recognition:* Facial expression recognition is the final step of the expression recognition system. This module uses the calculated minimum and maximum values and put into some conditions to recognize the expressions. The condition for each expression is different and it is based on its range with minimum and maximum values.

To define the condition for expression classification, first need is finding largest mouth image height value among all heights. Once it is found, then get the minimum and maximum values of it and state the conditions. In the calculated dataset, the largest height value is 36. In Fig. 3 the range of expressions for the height 36 is shown.

The condition for Neutral expression
RANGE= (A, B); Where A is min value and B is max value
Condition: min<=12 and max<=24
Now condition for Happy expression
RANGE= (C, D); Where C is min value and D is max value
Condition: min=0.00 and max<=24

And then condition for Sad expression
RANGE= (E, F); Where E is min value and F is max value
Condition: min<=12 and max<=36

So based on these conditions and the values that are calculated in the feature extraction step, expressions are recognized.

III. EXPERIMENTAL RESULT

In this paper two approaches are presented that recognizes three principal expressions that are Happy, Sad and Neutral. The procedure of expression recognition is same in presented system but the performance result shows that proposed approach gave excellent result in comparison of K-Means Clustering approach. Table II shows the recognition rates of both systems.

TABLE II
RECOGNITION RATES OF EXPRESSIONS FOR EXISTING AND PROPOSED SYSTEM

EXPRESSIONS	Total Images	Recognition rate	
		True	False
EXISTING SYSTEM			
Happy	70	53	17
Sad	60	43	17
Neutral	70	57	13
Total=	200	153	47
PROPOSED SYSTEM			
Happy	70	70	0
Sad	60	60	0
Neutral	70	70	0
Total=	200	200	0

Existing approach uses K-Means clustering algorithm for expression recognition and after execution gave three clusters of expressions happy, sad and neutral. In this system, two features are used: height to width ratio and pixel density. The database used for the recognition is of 200 real images of frontal facial expressions. Implementation is done by using MATLAB and after execution the obtained success rate was 76.5%. The system performance shows some false recognition of expressions.

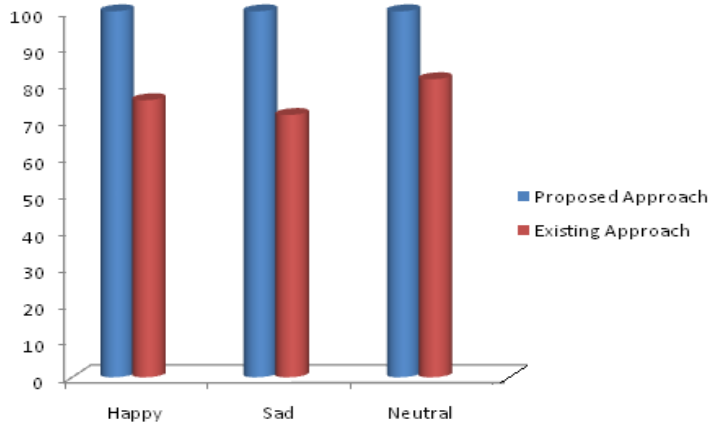

Fig. 4 Success rate of the proposed approach and existing approach

In proposed Automatic Facial Expression Recognition System three principal expressions are recognized and classified as one of the expressions happy, sad and neutral. The approach used to recognize the expressions is fast and efficient. A database of 200 images is collected. Images are taken from the Karolinska Directed Emotional Faces (KDEF) Database [6]. The whole system is implemented using MATLAB and gives the 100% performance of the recognition. Fig. 4 shows the success rate of the system. The proposed system interface is

shown in Fig. 5, which consists functions, performed during the facial expression recognition. The success rates of both systems are shown in Fig. 4 and Table III shows performance comparison of existing system and proposed system based on different characteristics.

TABLE III
PERFORMANCE COMPARISON OF EXISTING SYSTEM AND PROPOSED SYSTEM BASED ON DIFFERENT CHARACTERISTICS

Characteristics	**Recognition System**	
	Existing System	Proposed System
Method	K-Means Clustering Algorithm	Proposed conditional based approach
Dataset	200	200
Database	Real images	Existing
Expressions	Happy, Sad and Neutral	Happy, Sad and Neutral
ROI (Region of Interest)	Eyes and Mouth	Mouth
Features	Height to width ratio and pixel density	Range of expressions with their minimum and maximum values
Recognition rate	153 out of 200	200 out of 200
Accuracy (in %)	76.5%	100%
Performance	Very good and efficient	Excellent, fast and effective

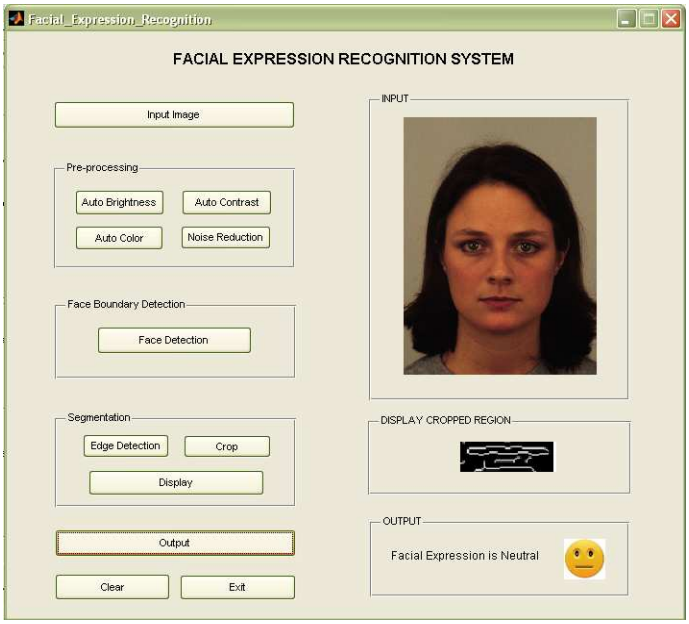

Fig. 5 Proposed Facial Expression Recognition System Interface.

IV. CONCLUSIONS

In this research work, two facial expression recognition systems are presented. And also the performances of both systems are analysed. In existing system, K-Means algorithm is used while in proposed system an effective conditional based approach is applied for the recognition of facial expression from frontal facial images. Both systems implemented using MATLAB on 200 dataset of images. After implementation, based on the experimental results, proposed system gave excellent result over existing system and gave 100% performance for the recognition of three principal expressions happy, sad and neutral. The proposed system gave fast result and it is also efficient.

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