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Efficient facial expression detection by using the Adaptive-Neuro-Fuzzy-Inference-System and the Bezier curve

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Abstract: Human beings have long been interested in detecting gestures of other human beings, especially facial gestures. The emotional states of humans are difficult to computational glean from their facial gestures; none the less, this recognition task is widely applied in daily life. In human communication the facial expressions recognition plays very important role and it is applied in many real worlds' applications. Present methods for facial expression recognition in static images are not completely utilized and considered features for muscle movements and facial features, which show dynamic, statics, and geometric as well as the emergence characteristics of the facials expressions. In our paper, we develop the system that can recognize the basic emotional states efficiently and in real time based on human facial expressions. This system uses the adaptive neuro-fuzzy-inference system (ANFIS) and the Bezier curves. The system was evaluated based on the human facial images obtained from the databases of Japanese female facial expression and Cohn Kanade. The proposed approach achieves high correct recognitions rate inthe comparisons of the state of the art techniques.

Keywords: ANFIS, Bezier curves, Classification, Feature, Facial Expression,

1. INTRODUCTION

In the current automated world Human Computer Interaction (HCl) is the general field of research and application. The interpersonal communication among humans can be classified into two types, nonverbal and verbal. The former is essential; nonetheless, non-verbal communication is also significant because expressions convey more ideas than words do (Aung and Aye, 2012) (Arca, *et al.,* 2004) (Chakraborty, *et al.,* 2009). Current human–computer interface systems cannot fully utilize these appreciated outgoing media; thus, they cannot demonstrate the advantages of normal communication with users. The usability of HCI would be enhanced if computers can identify the facial expressions of users and recognized emotion.The 1st restraint of HCI is with respect to facials expression recognition (FER). Emotions are key to communication even in verbal communication (Chelali, *et al.,* 2009) (Dalgleish *et al.,* 1999) Human beings display many expressions in response to events around them according to their internal or psychological states, and these expressions corresponded to emotions (Chelali, *et al.,* 2009) (Feng, *et al.,* Hadid, 2007) (Liu, 2012) Movements in the main facial organs are a primary factor in the formation and expression of emotions. Human beings alone recognize the emotions of other human beings based on the appearance and movements these facial organs; hence, HCI systems should be capable of sensing such movements in facial organs during communication or recognize emotions (Liu, 2012) .Moreover, fast and accurate system responses are key parameters in developing an effective system of facial expression recognition. Otherwise, the results produced by poorly constructed systems may either be in effective or may be confusing at times depending on system application (Dalgleish *et al.,* 1999) Human beings express various micro facial expressions including fondness, irritation, bother, nervousness, suffering, awe, laziness, excitement, cheek, dullness, satisfaction, nosiness, dislike, terror, unease, worry, wonder, zeal, and zest (Murthy and Jadon,(2007).

HCI cannot detect all facial expressions; therefore, facial expression scan be broadly grouped into seven basic groups like anger, fear, disgust, happiness, sadness, neutrality, and surprise (Chelali, *et al.,* 2009)].Robust feature extraction methods include PCA (Dalgleish *et al.,* 1999) Linear-Discriminate-Analysis(Arca, *et al.,* 2004) (Arca, *et al.,* 2004), Local-Binaries-Patterns (Ng, *et al.,* 1998) and the Harr-like features Ortony, A. (1990). For classification, the SVM (Pfister, *et al.,* 2012) is generally employed because of its accuracy. However, SVM is complex and utilizes additional hardware. The Euclidean distance method is less complex than SVM, but it is ineffective) (Chakraborty, *et al.,* 2009).

2. RELATED WORK

Two types of facials emotions recognition methods are dominant; the holistic and the analytical or local-

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based methods (Pfister, *et al.,* 2012) Holistic methods model global facial deformations in humans by encoding the face as a complete. Investigative approaches observe and quantify distinctive or local facial distortions in humans, (e.g. eyes, eyebrows, nose, and the mouth) and their geometrical relationships to construct descriptive and expressive models (Pantic *et al.,* 2000) The Ekman emotion model (Pavlovic, *et al.,* 1997) is a popular categorical model that identifies six elementary human emotions. Several studies and systems have used this model to recognize emotional text and the FER related to emotional states. The Or tony–Clore–Collins model (Shan, *et al.,* 2009) is another popular model that generates 22 specific emotions, in the current study, an analytical approach to the recognition of basic emotions is implemented as defined by Ekman. Specifically, special areas of interest in the human face are analyzed and their geometrical characteristics (e.g., location, length, width, and shape) extracted.

In this section some of the face detection methods are describes, beside with their advantages and disadvantages as per the limitation of our need. In (Pavlovic, *et al.,* 1997) Singhetal. Presented a face detection algorithm based on skin color, which is an important feature in the estimation of human facial presence and is a tool that is used to determine facial features in images. This algorithm is advantageous over other face detection methods. Its most significant advantage is in terms of operation speed; it processes color more quickly than other feature processing.Facial organ movement must be accurately and reliably described in this process, which can be difficult to achieve in real-time the features obtained with these methods are robust, but the techniques are highly complex in real-time hardware implementation. Appearance-based methods capture changes in image through image filters. Such methods are easily implemented and are highly accurate. In (Smitha and Vinod, 2013), Shantel. Employed LBP to study a face detection method based on local static facial features. This method was previously conducted for texture recognition. The feature is extracted by considering the 3×3neighbor pixels of every pixels and then enchanting the threshold values of every neighboring pixel with respect to the center pixel to formula to binary numbers that belongs to that block. As a result a 256-bit bin histogram is used as a feature descriptor (Senechal, *et al.,* 2012). When neighbouring size is small, some dominant feature sari lost when this method is applied to large-scale images. SVM is based on supervised learning methods. The model primarily learns through training. It then recognizes the patterns on test images. Dual SVM can be prolonged to multi-class classification, which is highly complex (Senechal, *et al.,* 2012) (Štruc and. Pavešić,2009) (Tian, *et al.,* 2011).

3. MATERIALS AND METHODS

In this section, we presented our emotion recognition system and demonstrate its functionalities. This system aims to enable software applications to recognize user emotions as the human brain does. The system receives input images of human faces and classifies them into emotional states according to the elementary emotions determined by Ekman. The images of human faces are initially pre-processes through contrast limited histogram equalization. Histogram equalization enhances contrast to equalize the histograms. This method also reorganizes the intensity distributions of the images and eliminates lighting effects (Verma *et al.,* 2013). A filter known as sobel is used to highlight facial edges, points and the transitions. The appearance of the human face is then denoted as a matrix, the elements have the only two values one and zero. The value one represents the organ of the face like eye, mouth and nose. **(Fig. 1)** shows the process of recognition system.

Extraction of appropriate facial features is considered to be the utmost significant step in FER. It is facilitated by determining the sets of features that convey meaningful information on facial expressions. In this paper, we construct the expression vector by using Bezier curve for neutral facial image. Primary facial expression is used as reference for better modelling. Based on the multi-dimensional modelling the facial expression recognition space is constructed, which map the actual image expression with the reference image. The degree of variation in FER depends on displacement of facial expression recognition space from the neutral face..

A Bezier curve *Q(t)* of the degrees *n* can be definite by the set of the controls point $P_i\left(i=0,1,2,...n\right)$ and it is explained in the paper $Q\left(t\right)=\sum_{i=0}^{n} P_i B_{i,n}\left(t\right)$.In the equation every value is the sum of the product of the joining functions $B_{i,n}\left(t\right)$ with control points P_i . $B_{i,n}\left(t\right)$, denoted the bernstein polynomials and is expressed by: $B_{i,n}\left(t\right)=C_i^n t^i\left(1-t\right)^{n-i}$, in this equation C_i^n is the binomials coefficients given by: $C_i^n=\frac{n!}{i!\left(n-1\right)}$ .The actions of the control points affect the nature of curve. In our work, Bezier curves are used to shows the displacement of the facials expressions detection and recognition space. Variable *t* denotes degree of variations in the expressions.

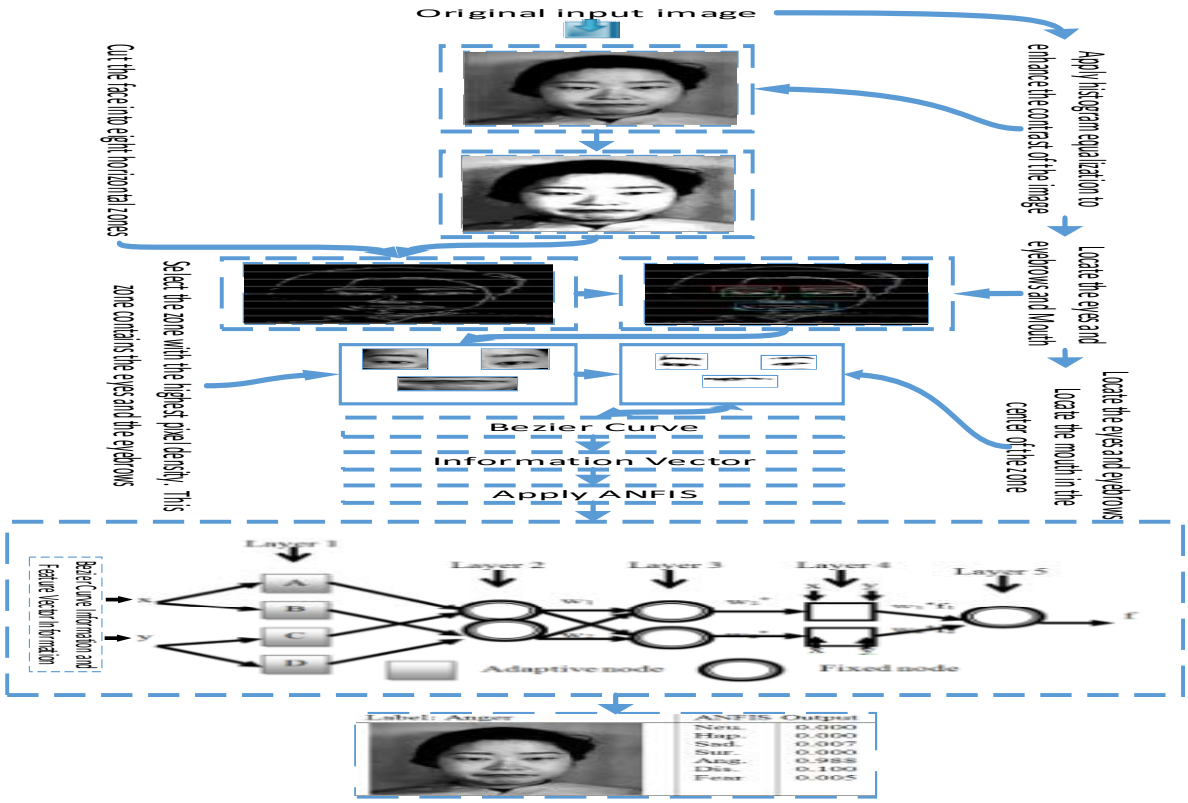


Fig. 1: Different steps of the proposed image detection and recognition

3.1. Adaptive Neuro Fuzzy Inference System (ANFIS)

Facial expressions are classified into the appropriate emotional categories based on the technique ANFIS, this method enhance the flexibility and adaptation in the training of the emotions classifications. The ANFIS techniques used the fuzzy control system with the neural networks to classify and recognize the different human expression. In our paper we recognize the different human facial expressions. In our research we used the three layers; in these layers we used 5, 9 and 13 neurons.

ANFIS techniques collect the input/output information's from the initial FIS and adjust the data by applying back propagation process presented in **(Fig.2).** ANFIS technique decided the targeted maximum velocities of expressions based on the input/output training data pairs.

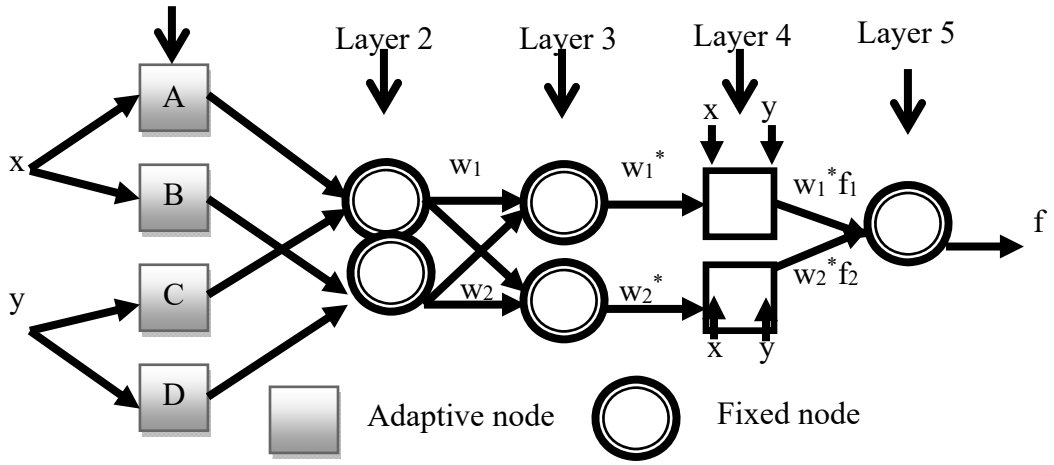


Fig.2: ANFIS structure with two input, one output, and two rules

In this paper, we use the first-order Sugeno fuzzy model (Zhang and Tjondronegoro, 2011) with two inputs and the Sugeno/Takagi fuzzy rules (Zhang and Tjondronegoro, 2011) The first layer in the system uses the membership functions and delivers the input information as output to the next layer. We choose the three bell shaped functions for the fuzzy analysis of every input. These bell shaped functions are comprises on the three parameters a, b, and c.

The second layer in the fuzzy neural system weighs the every membership function. Receive the information as input from the first layer, and the each node in second layers is the non adaptive, therefore second layer receive the input and multiply and spread the products of the input. Every neuron with output described weight or firings power of the rule.The third layer in this system is called the rule layer. This layer checks that the numbers of layers are equals to numbers of the rules with mapping of the fuzzy rules pre situations.In the 3rd layer, three nodes calculate the standardized weight. The third layer is the non-adaptive as well, and each neuron calculated ratiofor the firings power of a rule to regulate the firing powers of all of the rules. The production of third layers is the normalize weight or firings power.

The forth layer is the de-fuzzification layers, which presented output improved from the inference rule. All neurons in this layer can adjust to the neuron function. The fifth layers is the output layer of interface systems, that merge all of input information from the 4th layer and converted the results of fuzzy arrangement into the binary value.

Parameter set in the ANFIS architecture system is obtained using the hybrid learning algorithm. In the onward documentation of hybrid learning, the functional signal reaches the fourth layer. Moreover, the consequently set parameters are recognized using the LSE. By contrast, the error rates are spread in the backward direction in the backward pass of the algorithm. Moreover, the decreasing gradient updates the premise parameters.

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4. RESULTS AND DISCUSSION

Our system depicts sample facial and non facial class variance images, respectively. The facials expressions detection and recognition algorithm misstated using images from the JAFFE database.It was planned and assembled by and the images in this database were captured as these emotions were stimulated in the female models. Figure 3 displays a chart that compares the performance of the planned technique with those of prevailing, highly correct models of facial emotion appreciation models. The technique proposed in the base on the fuzzy model and displays an overall correctness of 89.98 when tested on JAFFE database and 89.14 % when tested on Cohn-Kanade database. The method described in based on facial movement analysis and reports91.1% accuracy when tested on JAFFE and 87.32 % when tested on Cohn-Kanade database, which contains180 images portraying six emotions(except the neutral expression) as obtained from the JAFFE database. The method is87.32 %accurate when tested on Cohn-Kanade, whichcontains800 images portraying six emotions as obtained from the Cohn—Kanade database. The system proposed in based on a local directionals numbers patterns and reports 95.5 %accuracy when tested on JAFFE, and 92.14 % on Cohn- Kanade database. The method presented in uses the hidden Markov model for recognition and is93 % accurate and on Cohn-Kanade database it is 92.34 % accurate. The method described in based on action units and is 94.5 % accurate when tested on JAFFE and 88.42 % accurate when tested on Cohn-Kanade database,. Our proposed system outperforms all other methods that are described in literature in accuracy and efficiency. Our system shows 99.4 % accuracy on JAFFE database and 98.94 % accuracy on the Cohn- Kanade images. The performance of our proposed system is displayed in the **(Table 1).**

Table 1:Evaluation of JAFFE and Cohn-Kanade databases with different images

Emotions	Results						
	Anger	Disgust	Fear	Happiness	Normal	Sadness	Surprise
Anger	98.8 %	0	0	0	0	0	0
Disgust	1	98	0	0	0	0	0
Fear	.2	0	99.1 %	0	0	0	0
Happiness	0	1	0	99.9 %	0	0	0
Normal	0	0	0	.1	100 %	0	0
Sadness	.3	1	.9	0	0	100 %	0
Surprise	0	0	0	0	0	0	100 %
Overall Accuracy	99.41 %						

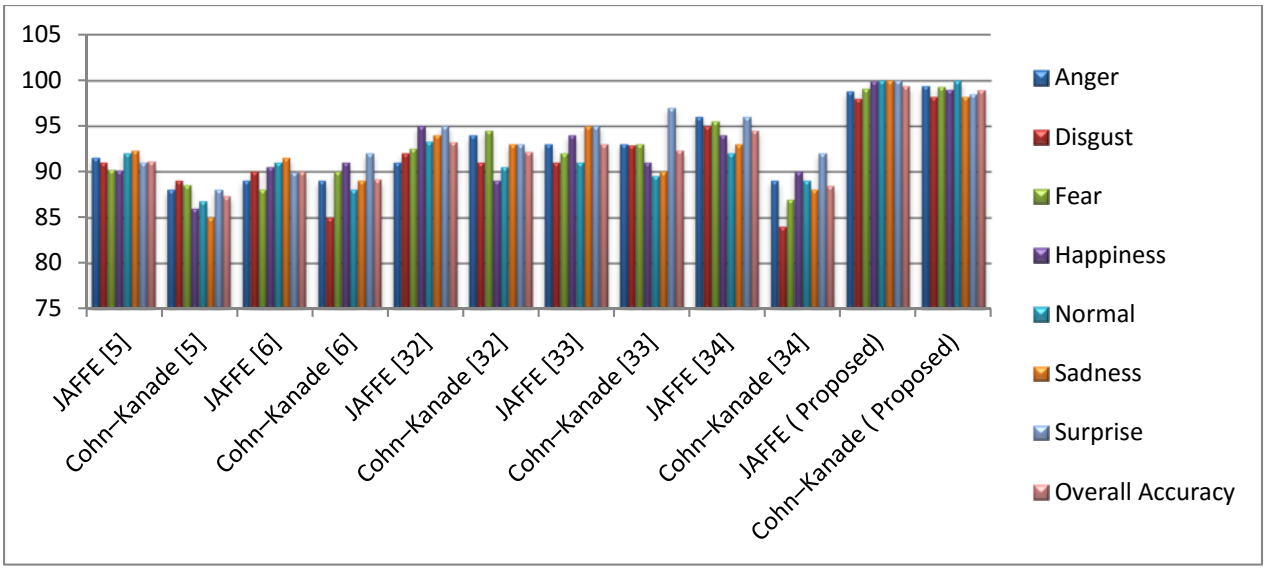


Fig. 3: Evaluation of proposed technique with the traditional techniques.

5. CONCLUSION

In our research, we present an involuntary system of facials expressions detection and recognition system. This system aims to analyze and recognize emotional content of human facial expressions. It initially analyzes facial images, locates and measures distinctive formations in the human face (e.g. the eyes, the eyebrows, and the mouth), and extracts appropriate features using the Bezier curve. The extracted features are used to model the geometric characteristics of each part of the human face. Finally, ANFIS is trained and used for categorization. The performance of this system is promising, as per the experimental study. However, it can be improved further. First, the system should be evaluated using different facial expression databases to enhance our insight into the effectiveness of the methodology. Moreover, current facial analysis and ROI determination methods focus only on frontal images of the human face. Thus, the system can be challenged to detect and analyze facial expressions from different poses.

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