IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE)
e-ISSN: 2278-1676,p-ISSN: 2320-3331, Volume 9, Issue 5 Ver. II (Sep – Oct. 2014), PP 63-68
www.iosrjournals.org

Automatic face emotion recognition and classification using Genetic Algorithm

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***Abstract*:** *Facial expressions analysis most significant part for human computer interaction. Now days, face emotion recognition is most important application of computer vision that can be used for security, entertainment and human machine interface. Automatic face emotion recognition is still challenging & emerging problem with many applications such an automatic surveillance, robot motion, video indexing and retrieval and monitoring systems. Emotion recognition and classification depends upon gesture, pose, facial expression, speech and behavioral reactions, etc. In this paper, an automatic emotion recognition and classification method is based on Genetic Algorithm and on neural network. This system consists of 3 steps which automatically detect the face emotion image: First, pre-processing such as adjusting contrast, colour segmentation, filtering, and edge detection is applied on the input image. Secondly, features are extracted with projection profile method due to high speed which has taken as processed input image. Finally, in third stage to compute optimized parameters of eyes and lip through the GA, then emotions (neutral, happy, sad, dislike, angry, surprise and fear) is classified using artificial neural network. The proposed system is tested on a face emotion image. The obtained results show that better performance of genetic algorithm along with neural network.*

Keywords: *pre-processing, feature extraction, projection profile, recognition, Genetic Algorithm, Neural network.*

I. Introduction

Facial expressions are most important part in human communication. Also, facial expression gives the idea of emotions. Emotion is a psycho-physiological process based on conscious and unconscious situation which is associated with mood, personality, motivation. Emotion is a function of time, space, culture and person. It may differ from user to user or from situation to situation. Emotions plays important role in human communication which can be expressed as either verbally or non-verbally such as voice, facial expression, and gesture. 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 expressions. In human communication, the facial expression and understanding of emotions helps to achieve mutual sympathy but absence of mutual sympathy between human and machines is one of the most burning issues in advanced human-computer interaction, today [1]. So, to fill this gap, we need to equip the machines to understand human emotions without input of users translated intension. Hence, develop such a system which requires analyzing, processing, training and classification through understand emotional features such as gesture, pose, speech, facial expressions [2]. Human face detection, then extracting the features is most important process with wide range of application such as human face recognition surveillance, HCI, video conferencing etc. From last few years, automatic emotion recognition shows the more interest in digital image has grown widely on World Wide.

In this paper, such a system consists of three parts which can detect emotions from input image. First, pre-processing task such as adjusting contrast, filtering, and edge detection takes an image, it detects human face. Then it crops the eyes & lip from the face. In Second part, eyes and lip features are extracted with projection profile method from input image. Finally, in third stage, this processed image is used to compute the optimum parameters of eyes and lip using genetic algorithm, and then emotions such as (sad, happy, fear, surprise, neutral, dislike, and angry) are classified using neural network.

The rest of the paper is organized as follows. Introduction is included in section I. Related work is included in Section II. Methodology of Emotion Recognition Process is given in Section III. Result of work done is provided in Section IV. Finally Conclusion is provided in Section V.

II. Related Work

Generally, emotions related to facial expressions. Hence, the features based on position of the face. Hence, several methods have been proposed to classify emotions. Mase proposed emotion recognition systems that use directions of facial muscles. Muscle movements were extracted use of optical flow with 11 windows method place in face [3]. For classification, K-nearest neighbor rule was used with an accuracy of 80% with

happy, anger, disgust, surprise emotions [4].Yacoob proposed same method instead of muscle action, he use edge of mouth, eyes and eyebrows, into a per frame, mid-level representation, classify the emotions[5]. Black et al. proposed parametric model. In this model to extract the shape and movement of eyes , mouth, eyebrows, into a mid and high level representation of facial expression with 80% of accuracy [5]. Ekman proposed geometric model in which to extract shape and appearance of lip, nasolabial furrow and wrinkles with 82% accuracy [6]. Recently, M. Karthigayan proposed a method that extracts region of eye and lip by genetic algorithm. Emotion detection is indicates two requirements: 1) Identification of facial expressions under the uneven lighting 2) Identification of facial expression through the processed facial features. In this paper, lips and eyes are used for feature extracting.

III. Methodology

To illustrate the general process for emotion recognition and classification process as shown in following fig.1.

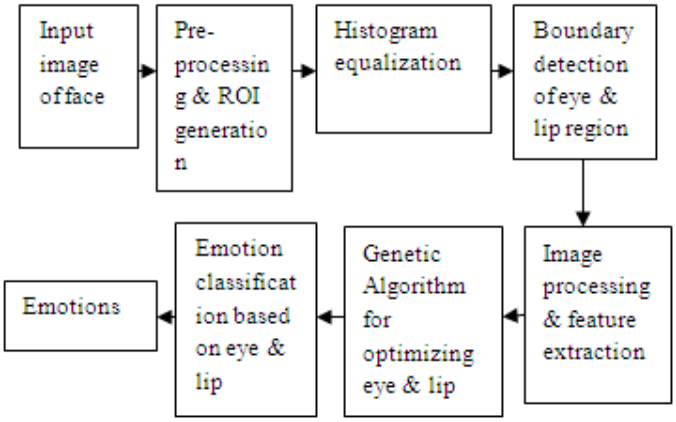

Fig.1. Block Diagram of Emotion Recognition Process

A. Pre-processing:

In pre-processing, firstly input image is obtained from digital camera, then use histogram equalization which enhances the image quality. After this process, to find the probability of the largest connected region this is related to face. If the largest connected regions height & width is larger or equal than 50 and the ratio of height/width is between 1 and 2, then it may be face. For face boundary detection, first convert RBG image in to binary image. For this conversion, calculate the average value of RGB for each pixel and if the average value is below the predefined threshold, replace it by black pixel and otherwise replace it by white pixel. Then, this binary image may be used to isolate the forehead from the face in the binary image [7]. The steps for this isolation would be Scanning from the mid- point of the image horizontally and vertically. Then, find the maximum width of the white pixel on both left and right side. If find the new width is half of previous maximum width, then we reach the eyebrow region. At this stage, cut the face from the starting position of the forehead and its height will be 1.5 multiply of its width.

B. Boundary detection of eye and lip regions:

For detecting the boundary of eye region, consider the face width by W, and starts scan from the W/4 to (W-W/4) for to find the middle position of the two eyes. Then find the upper position and lower position of the two eyebrows. For left eye, scan from w/8 to mid and for right eye scan from mid to w – w/8. Here w is the width of the image and mid is the middle position of the two eyes [9]. Some white pixels present between eyebrow and eye, to make connection between eyebrow and eye some black pixels are placed from eyebrow to eye. Also, scan the black pixels vertically and horizontally for lower and upper position of two eyebrows [11]. For detecting the boundary of the lip region, first consider the lip box and calculate the distance between the forehead and eyes. Then determine the lower height of eyes and upper height of the box which will contain the lip [12]. Therefore, this box will contain lip and some part of nose. Then, cut the RGB image according the box. Finally, sobel edge detector is applied to the eyes and lip image for edge detection [6]. The sobel edge detected image of lip and eyes shown in Fig.3.and Fig.4

Fig.2. The Neutral Emotion

Fig.3. Sobel edge detected eyes regions

Fig.4. Sobel edge detected lip region

C. Image processing and Feature Extraction:

Now, a feature extraction method is applied to sobel edge detected image. This feature extraction method is associated with the row-sum and column-sum of white pixels of edge detected image. For this purpose, projection profile method is used because of high speed. In this method, let f (m, n) represents a binary image with m rows and n columns. This projection profile is divided into 2 types such as horizontal and vertical profile. The vertical profile is defined as sum of white pixels of each column perpendicular to X-axis which is represented by,

$$Mvj = \sum_{i=1}^{m} f(i,j) \qquad j = 1,2,3 \ldots. \quad (1)$$

The horizontal profile is defined as sum of white pixels of each row perpendicular to Y-axis which is represented by,

$$Mhi = \sum_{j=1}^{m} f(i,j) \qquad i = 1,2,3 \ldots \qquad (2)$$

The human eye is like an ellipse so; it is called as regular ellipse. The length of minor axis of eye is varies for each emotions and the length of major axis of eye is fixed. The edge detected and whitened eye image for neutral emotions is shown in fig.5. The major and minor axis of eye shown in fig.6 and the ellipse equation is defined by following equation,

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1 \qquad (3)$$

Where, a - major axis, b – minor axis

The human lip is a combination of two ellipses which is called as irregular ellipse. Irregular means it has two minor axes wherein major axis remains same .For each emotion, the lengths of minor axes are computed and major axes are fixed. The edge detected and whitened lip image for neutral emotion is shown in fig.7.The major axis and minor axes of lip shown in fig.8. Emotions totally depend on facial expression of lip is represented as b1, b2 and expression of eye is represented as b.

Fig.5. Edge detected and whitened eye image

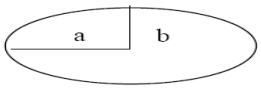

Fig.6. The regular ellipse

Fig.7. Edge detected and whitened lip image

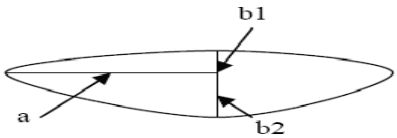

Fig.8. The irregular ellipse

D. Emotion recognition using Genetic Algorithm:

GA is an iterative process [5, 6], each iteration is called generation. In each generation, the fitness of each individual is calculated and to form new population. In this paper, GA algorithm is used to calculate the optimized value of eye and lip features. For this purpose, length of chromosome is 7 bits and size of population is 20 used. In our approach, first select a pair of eye and lip region. The GA process is described in the following steps.

1) First, represent the fixed length of chromosomes and initial population with cross-over and mutation probability.
2) Define fitness functions of individual chromosomes.
3) Randomly, generate an initial population of chromosomes.
4) Calculate the fitness of each individual chromosome.
5) Select a pair of high fitness chromosomes for matting from initial population.
6) By applying genetic operators such as crossover and mutation - to create a pair of offspring.
7) Created a new pair of offspring placed in new population.
8) Repeat from step 5 until the size of initial population becomes equal to the size of the new population.
9) Replace the initial population with the new population
10) Go to step 4, and repeat the process until the criteria is satisfied.

Fitness Function:

A fitness function gives optimality of a solution which is the type of objective function. Using fitness function to obtain lip and eye features. Equation (3) is derived from fitness function. Equation (4) (5) are fitness functions for 'b1', 'b2' to obtain optimized value of lip features. Equation (6) is fitness function for 'b' to obtain optimized value of eye feature.

$$f(x) = (\sum_{i}^{m}\sum_{j}^{m} \text{col (j)} - 2\sqrt{X1^2(1-\frac{\text{row(i)}^2}{a^2})})\text{^}2 \quad (4)$$

If X1 > 0,

$$\overline{f(x)} = (\sum_{i}^{m}\sum_{j}^{m} \text{col (j)} - 2\sqrt{X1^2(1-\frac{\text{row(i)}^2}{a^2})})\text{^}2 \quad (5)$$

If X2 < 0,

$$f(x) = (\sum_{i}^{m}\sum_{j}^{m} \text{col (j)} - 2\sqrt{X^2(1-\frac{\text{row(i)}^2}{a^2})})\text{^}2 \quad (6)$$

Where, col (j) is sum of white pixels in jth column, row (i) is the sum of white pixels in ith row.
Table I. shows the manually computed mean value of (b, b1, b2) and optimized mean value by GA (X, X1, X2).

E. Emotion classification using neural network:

An artificial neural network is a non- linear network which is working like a human brain. This network consists of neurons which is working in parallel and communicating with each other through weighted interconnection.

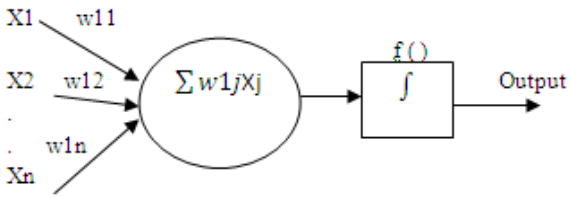

Fig.8. A simple neuron network

In this paper, the ANN is used for database in which optimized values (X, X1 and X2) are used as a input to train the network. These inputs are trained using back propagation training algorithm. For this purpose, 3 inputs, 20 neurons and 7 0utputs are used.

In this paper, feed-forward back-propagations neural network is used. A BPN (back propagation network) in which the input layer composed of neurons. These neurons provide the data of eyes, lip to the next layer is called a hidden layer which the calculate the value and provided to the output layer where the system provides the different expression as output. Finally, emotions (Happy, sad, angry, fear, dislike, surprise, neutral) are classified.

IV. Results

In this paper, Eye and lip regions are used for classification of emotions. The eye and lip features have been given as input to genetic algorithm to find optimized values. Optimization process is repeated for each emotion. Genetic Algorithm is applied to obtain the optimized values of the X1, X2 related to lips and values of X related to eyes. The Manually computed parameters and optimized parameters are calculated through genetic algorithm are shown in Table I. and Table II. Shows the neural network classification of emotions.

Table I. Optimized value of three features using GA

Emotions	Manually Computed mean value (in pixels)			Optimized mean value by GA (in pixels)		
	b	b 1	b 2	X	X1	X2
Neutral	9.961	9.452	19.37392	12.1875	8.9375	18.4375
Fear	6.8582	10.1474	15.1063	7.0625	6.0625	13.3125
Happy	15.0087	13.8983	10.73562	13.8125	9.9375	9.8125
Sad	10.7820	9.9412	11.6803	13.0625	9.9375	10
Angry	13.18486	11.6735	9.91540	16.56	5.125	8.0025
Dislike	14.106	9.29956	16.83349	18.0625	8.375	15.0625
Surprise	19.144175	6.543906	6.698019	21.625	5	6.3125

Table II. Neural network classification of emotions

NN structure	Epoch (in 10 trials)			Classification %	
	Min	Max	Mean	Range	Mean
3*20*7	19	320	147	90-96	94

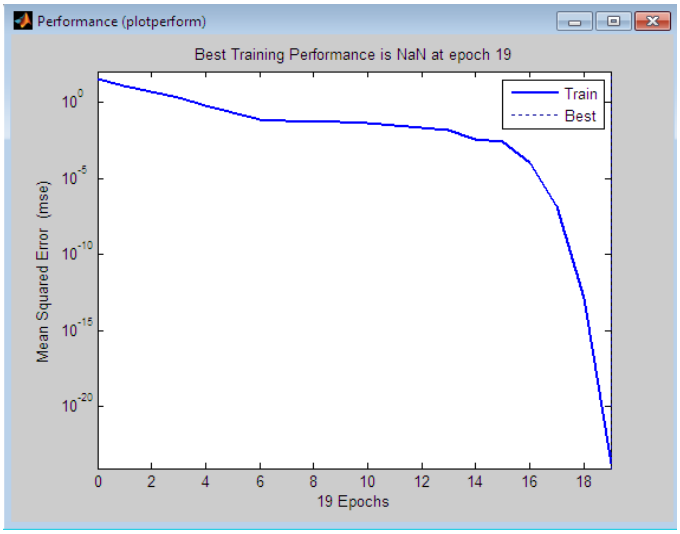

Fig.10. Performance plot using ANN

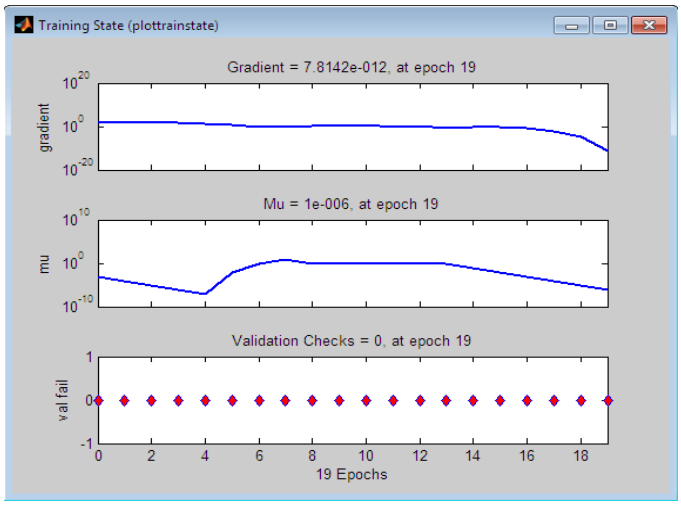

Fig.11. Training state graphs using ANN

V. Conclusion

In this paper, a method of classification and detection of emotions (Happy, sad, fear, angry, dislike, and surprise, neutral) based on a genetic optimization algorithm and neural network is used. Then, % accuracy is obtained in the NN model of (3*20*7) structure. Finally, the result of ANN is used for optimization and the ANN provides the best accuracy of classification.

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