Emotion Recognition from Facial Expressions using Neural Networks

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Abstract
Automatic facial expression recognition is the kernel part of emotional information processing. The regions of interest for extracting the features from the facial images include eyes, eyes with eyebrows, mouth. In this paper there are two main parts locating the points in the face region to form graph based features and training the neural network to recognize the emotions from the corresponding feature vector. For the first phase, sixteen points are manually located to create graph with edges connecting such points. Subsequently, the Euclidean distances from those edges are calculated and defined as features for training in the next phase. The next phase is using Feed forward networks (FFN), a kind of artificial neural network (ANN), with back propagation algorithm to recognize the emotions like excitement, happy, shocked, confusion, and disgust.

Keywords
Graph, Facial Features, Feed Forward Network, Back Propagation Algorithm, Facial Expression Recognition.

I. Introduction

Facial expression analysis goes well back into the nineteenth century. Emotion recognition plays an important role in human interaction. Facial expressions may be expressed differently by different people. Facial expression recognition becomes an interested topic for researchers because it is the human body language to increase understanding in interaction between human and human, human and computer. The psychologist Mehrabian said "The facial expression sends the 55% information during the process of human communication while language sends only 7%" [2]. As the points are located on the face and Euclidean distances are calculated between the edges connecting the points, if the facial point markers are sufficient then the recognition accuracy will be high. However if the number of facial point markers is too high then the over fitting and time consumption problems will occur. If the number of facial point markers is too low then the recognition will not be good.

In this work, the high accuracy recognition system based on machine learning with a reasonable number of samples (images) and sufficient amount of facial points are introduced. These number of facial points are sixteen including inner eyebrow of two points, middle eyebrow of two points, outer eyebrow of two points, inner eye of two points, outer eye of two points, mouth of four points and two of philtrum. These points are defined as vertices of graph. Then connecting edge is formed from a pair of vertices along with its Euclidean distance. The distances are interpreted as features that send to the learning process to recognize the expressions like excitement, happy, shocked, disgust and confusion using Artificial neural networks(ANN). MATLAB is used as tool in this paper.

II. Implementation

A. Database

Database is selected because it is reliable benchmark with variety of samples. It contains 50 adults with ages ranging from 22 to 50 years old and 70% of them are females. The database contains image resolution: 690x487.

B. Graph Based feature extraction

In this subsection, graph based feature extraction is proposed in two steps: locating points in the face image and constructing feature vector.

1. Locating Sixteen Points

The regions of interest in the face are eye, eyebrows, nose and mouth. Nose region can be ignored because of its minimal influence on outlet emotions. Graph construction based on sixteen points location including inner eyebrows of two points, middle eyebrows of two points, outer eyebrows of two points, inner eye of two points, outer eye of two points, philtrum of two points and mouth of four points are manually defined and denoted by point numbers as shown in fig. 1.

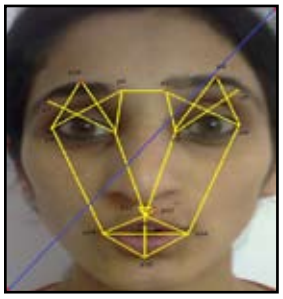

Fig. 1: Graph Based Feature Extraction

2. Constructing Feature Vector

Euclidean distances between 16 points are calculated as shown in equation1.

$$D(p, q) = \sqrt{(p2-p1)^2 + (q2-q1)^2} \quad (1)$$

From the equation above there are 24 distances totally for all possible pairs of two points. Each feature vector containing all distances was normalized by the distance of diagonal line. Across the face as shown in fig. 2, to reduce error caused by image scaling obtained from the distance between face and camera as shown in fig. 2.

$$\hat{D}(p, q) = \frac{D(p, q)}{\sqrt{(p2-p1)2 + (q2-q1)^2}} \quad (2)$$

Where $\hat{D}$, (p, q) is normalized distance between p and q calculated from the ratio of D(p,q), original distance, and the distance of diagonal line across the face.

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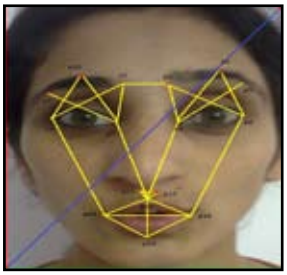
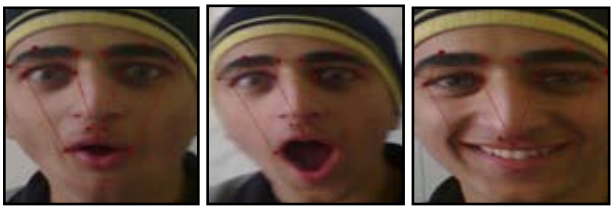


Fig. 2: Normalized Distance by Dividing the Original Distance with Diagonal Line Across the Face

From this step 24 features were reduced to 5 features. Fig. 3, shows the comparison of graphs among the five emotions like excitement, happy, shocked, disgust and confusion.



Excitement Happy Shocked

Confusion Disgusted

Fig. 3: Graph Comparison

C. Recognition system

Artificial Neural Networks (ANNs) are applied in various majors, e.g. mathematics, statistics, physics engineering and computer science. ANN can be used in many applications such as time series analysis, signal processing, and pattern recognition with learning ability from input vectors. Feed forward neural network consists of a large number of simple neuron-like processing units, organized in layers. Every unit in a layer is connected with all the units in the previous layer. In this network, the information moves in only one direction, forward, from the input nodes, through the hidden nodes (if any) and to the output nodes. Data enters at the inputs and passes through the network, layer by layer, until it arrives at the outputs. During normal operation, that is when it acts as a classifier, there is no feedback between layers. This is why they are called feed forward neural networks. For learning of the network back propagation algorithm based on error collection learning rules was used. Basically the network consists of two parts in different directions: a forward pass and a backward pass. In forward pass, input vector was applied to the sensory neuron of the networks then output value was produced while, in the backward pass, all of synaptic weights were adjusted with respect to the difference between target and actual output.

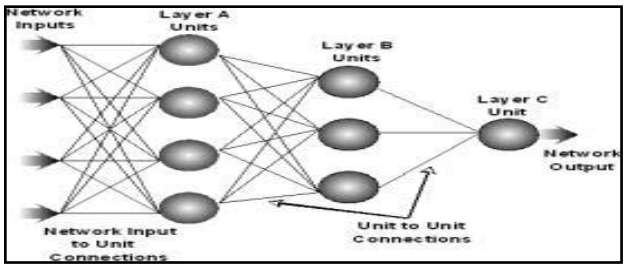


Fig. 4: Feed Forward Network

The proposed method contains network for emotion classification. Feed forward networks with back-propagation learning algorithm were applied in term of binary tree as shown in figure5. According to recognition architecture, the decision vertices in biclassification tree are sorted with easiness of classification.
In addition the learning rate and maximum epoch are 0.1 and 1000 respectively. Training targets are set to be 1, 2, 3, 4, 5 for confusion, disgusted, excitement, happy and shocked respectively.

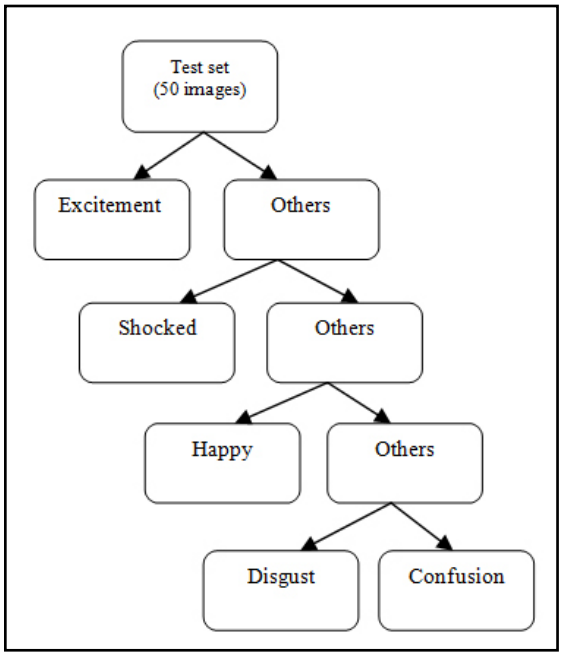


Fig. 5: Binary Tree of Classification Based on Neural Networks

III. Experimental Result

A. Preprocessing

Pre processing of the images is done in image processing toolbox in mat lab. After graph based construction an image is read into mat lab for feature extraction. Feature

B. Distance Calculation

Distance between every two points is calculated. For calculation of distance the points must be defined first. The original distance between two points is divided by the diagonal line distance in order to get the normalized distance.

C. Clustering

The feed forward network is designed and the input to the network is grouped into 5 clusters according to the distances calculated before the neural network is being trained. Figure6 shows the clustering of the inputs.

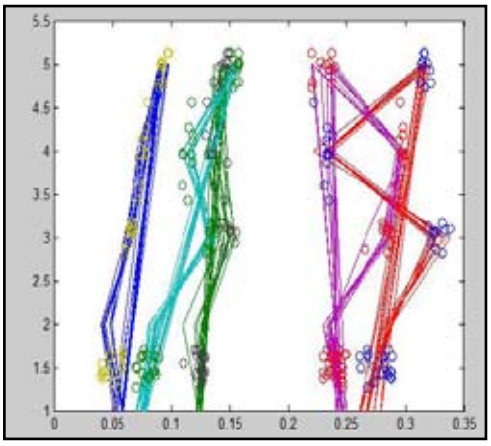


Fig. 6: Clustering of Inputs

D. Performance

After training the network, the performance graph shows the performance of the network as shown in fig. 7.

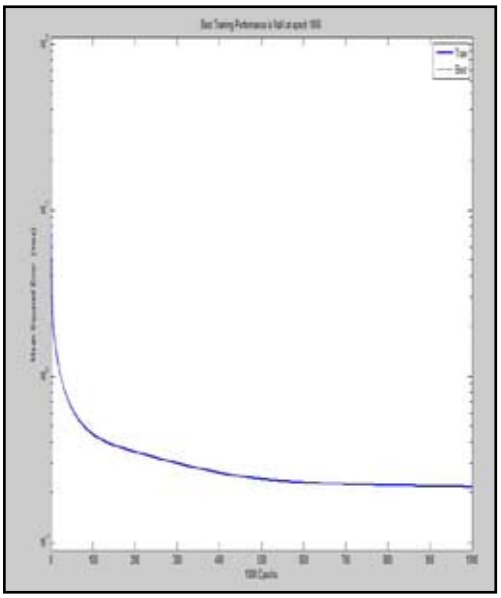


Fig. 7: Performance Graph

E. Regression

Regression is used for curve fitting. The primary goal of linear regression is to find the line that best predicts Y.

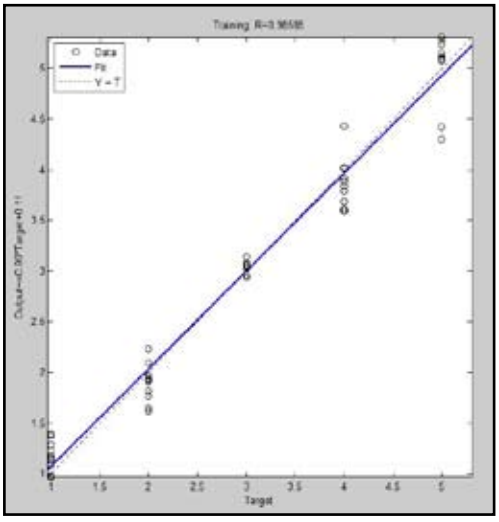


Fig. 8: Regression Graph

F. Testing

Testing of the network is done with the data that has not been used for the training of the network.

The accuracy is computed by the equation as;

$$\text{Accuracy} = \frac{\text{Number of correct classifications}}{\text{(Number of all classifications)}} \times 100$$

IV. Conclusion

In this work, the high accuracy recognition system based on machine learning with reasonable number of samples and small amount of facial points are introduced. Graph based features were developed by locating sixteen facial points that influence directly on the expression of emotions. Then Euclidean distances between each point were computed and reduced to twenty four distances for describing geometric facial structure. For recognition system of five emotions, feed forward network with back propagation algorithm are used. The neural network was used to classified test set in each state of excitement, shocked, happy, disgust, confusion respectively. The proposed method was evaluated with test set comprised of 50 images from five emotions and the results have shown that the proposed method can perform 98% accuracy.

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