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Human Emotion Recognition by Using Pattern Recognition Network

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Abstract
Identifying Human Emotion is important in facilitating communication and interactions between individuals. They are also used as an important mean in studying behavioral Science and in studying Psychological changes. Since face is the prime source for recognizing human emotion, the proposed system will provide a quick and practical approach for non-invasive emotion detection. The recognition of emotions is done by deploying an intelligent system using neural network, signal processing and image processing toolbox of Matlab 7.12.0(R2011a). The network classifier is pattern recognition network which is actually a feed forward neural network that will be trained for some images bearing different emotions. The trained network is then simulated to test the new data for recognizing different emotions.
Keywords- Discrete Cosine Transform, Pattern Recognition Network.

I. INTRODUCTION

Communication through words to convey a message by an individual is called verbal communication while wordless communication is called non verbal communication. Thus, these are two modes of communication in humans. Non verbal communication involves facial expressions, gestures and sign languages to convey messages[1].Non verbal method of communication thus plays a significant role in society. Various applications like lie detection, behavioral studies, automatic tutoring system and entertainment have caught the attention of most of the researchers in the last two decades and led to the development of automatic Human Emotion Recognition System. Emotion Recognition is to detect changes in facial expressions in according to an individual's internal emotion state and intentions. Charles Darwin was the first to describe in detail the specific facial expression associated with emotions in animals and humans and he argued that all mammals show emotions reliably in their faces[1][2].As Human face is a significant place for detecting emotions, six emotions detected from human face. They are Happy, Surprise, Anger, Sad, Fear and Neutral. Fig 1 shows different human emotions. So in the proposed paper Human Emotion Recognition system has been developed that will train feed forward neural network for various images showing various emotions and also identify all six basic emotions i.e. Happy, Fear, Sad, Surprise, Anger and Neutral using neural network toolbox of Matlab 7.12.0(R2011a). A Graphical User Interface Application needs to be developed that will help to select various options from menu like Select Image , Train Network, Empty database and Detect Emotion.

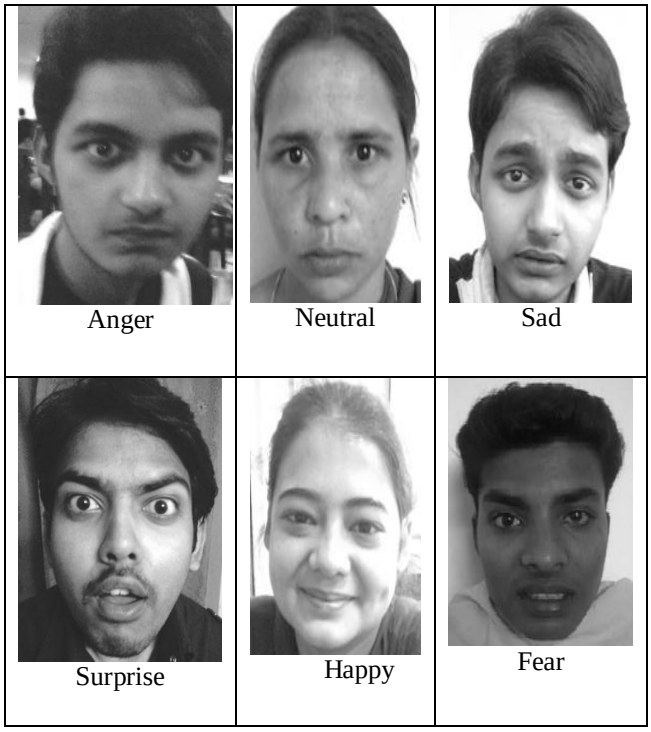

Fig.1 Different Human Emotions

II. LITERATURE SURVEY

Human Emotion recognition has been one of the most interesting topics for researchers. Various researches have been done in this field; self organizing maps have been used to classify facial expression. They used competitive learning approach to learn the network. Every neuron at input layer is connected to every other neuron at output layer. Only one neuron at output layer give response to some input data which is called winning neuron[3].This

neuron has the features more similar to input data features. Principal Component Analysis(PCA) technique have been used for extraction of features and dimensionality reduction. Eigen vectors for 2-D images are calculated and vectors that corresponds to maximum eigen values are selected for dimensionality reduction [4][6].Gabor Wavelet, an effective feature extraction method have also been used for classifying facial expressions. They used a fuzzy controller with four input variables and orientation of filter is decided for images[5].Committees of Neural network have also been used to classify various facial expressions. Two types of parameters were used, real valued and binary. Real valued parameters denote Mouth width, distance between upper eyelid and lower and Eyebrow raise distance. Binary parameters include presence or absence of wrinkles, forehead lines, and teeth visible and so on. All these parameters were used to train committee of neural network. Generalized and Specialized Committee consisting of multiple neural networks were formed. Accuracy for such networks was 90.34%[7].Another method uses Point counter detection to extract facial features and then PCA along with neural network were used to identify emotions [10]. Another technique uses Support Vector Machines(SVM) for emotion classification. Vladimir Vapnik and their colleagues gave the introduction of SVM. Their aim was to generate a classifier that will work well for unknown examples. It uses the concept of n dimensional hyper plane which separates n feature vectors of different classes[8][11]. Multi-Layer Perceptron (MLP) have also been used in recognizing facial expression in which neural network is not trained fully and output of hidden layers are used as features[12]. Linear Discriminant Analysis(LDA) is another technique used for emotion detection. In this approach Projection axes is searched on which data points of similar classes are close to one another while inputs of different classes are far from one another. It uses Euclidean distance as measure for nearest neighbor classifier for different human emotions[1].But the performance of LDA system was not better than that of Support Vector Machines.

III. METHODOLOGY

The proposed system will perform emotion recognition process using following steps which are explained below. Fig 2 shows a methodology adopted for implementing the system.

1. *Acquiring Images*

The emotion recognition process begins by first acquiring the images of different people bearing different emotions. Sample size for this system is 100 i.e. images of about 100 people are collected in order to train Classifier. Either already saved image can be used or image can be captured from webcam using Image acquisition toolbox of Matlab 7.12.0(R2011a).

2. *Processing Image*

The acquired image is resized and converted to gray scale for further processing. In gray level images R, G & B components have equal intensity in RGB space. Gray scale images are very common and sufficient for various tasks. Thus there is no need to use color images that are harder to process. Images are processed using Image processing toolbox of Matlab 7.12.0(R2011a).

3. *Feature Area Extraction*

From gray scale images eyes and mouth portions are extracted since these areas carry the more essential emotion information. These extracted areas will account into a 64X64 matrix each. The matrices will contain numeric values ranging from 0 to 255. The two matrices are then manipulated for feature extraction. Fig 3 shows cropped eye and mouth portion of human face.

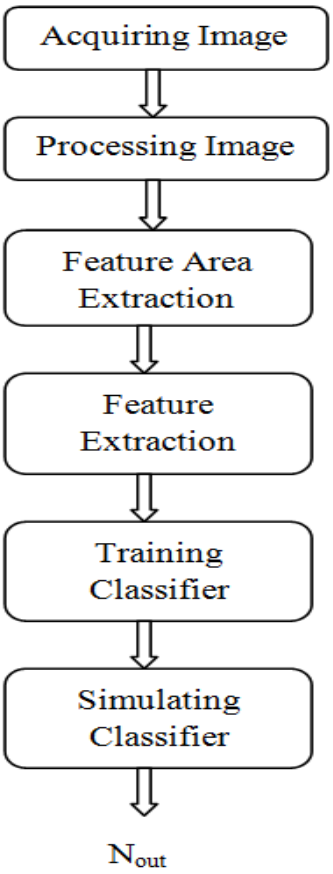

Fig.2 Human Emotion Recognition system

Fig.3 Cropped Eye and Mouth portion

4. *Feature Extraction*

Feature extraction is done using 2D Discrete Cosine Transform (2D DCT) which changes the image data from the spatial to the frequency domain[9].2D DCT is calculated for matrices of eye

and mouth which again resulted into two 64X64 matrices. In this matrix low frequency components are located at the top left corner of the matrix and the high frequency components are located at the bottom right corner of the matrix. Since high frequency components are more variant across images, low frequency components are selected[9]. 66 coefficients for eye portion and 66 coefficients for mouth portion have been extracted. Thus there are total 132 coefficients which form a feature vector. This feature vector is used to train the Pattern Recognition Network i.e. Feedforward neural network.

5. *Training Classifier*

Training classifier is Feedforward neural network which uses backpropagation algorithm to train the classifier for input data against given target data i.e. all six emotions. Training function for this network is Trainscg which is a scaled conjugate gradient function. For a classifier, input data values are extracted features which form a 132X1 feature vector and target data is 6X1 feature vector. T is a matrix for target data where emotions Happy, Sad, Fear, Anger, Surprise and Neutral are denoted by first, second, third, fourth, fifth and sixth rows of matrix respectively. For an image carrying an angry emotion, T will hold 0 values in all rows except 1 in the fourth row. Fig.4 shows one such example. In this way classifier is trained for multiple images enabling the system to learn various emotions.

$$T = \begin{matrix} 0 \\ 0 \\ 0 \\ 1 \\ 0 \\ 0 \end{matrix}$$

Fig.4 Target data for an image showing Anger emotion

6. *Simulation*

The trained classifier is then simulated to test new real world data and identify all six basics emotions i.e. Happy, Sad, Anger, Fear, Surprise and Neutral. For simulation trained network is given a 132X1 feature vector of a new image whose emotion is to be detected. As shown in Fig. 2 N_{out} is output of classifier which is a 6X1 matrix generated after simulation. The system will generate emotion corresponding to the row having maximum value in the matrix N_{out} . Fig.5 shows the value of N_{out} for an image is maximum in fourth row of matrix, so the emotion is Anger for this image. Fig. 6 shows GUI of the system that has detected Anger emotion for a selected image.

$$N_{out} = \begin{matrix} 0.1848 \\ 0.3204 \\ 0.0100 \\ 0.5857 \\ 0.1008 \\ 0.0258 \end{matrix}$$

Fig.5 Value of N_{out} for Anger emotion

IV. EXPERIMENTAL RESULTS

After implementing the system in Matlab 7.12.0(R2011a), performance graph is plotted. Fig 7 shows a neural network model for Human Emotion Recognition system. The network contains 2 layers: one hidden layer and one output layer. There are 132 input neurons; hidden and output layer contains 15 and 6 neurons respectively. Both the layers use tansig transfer function which normalizes the output of each layer between -1 and +1.

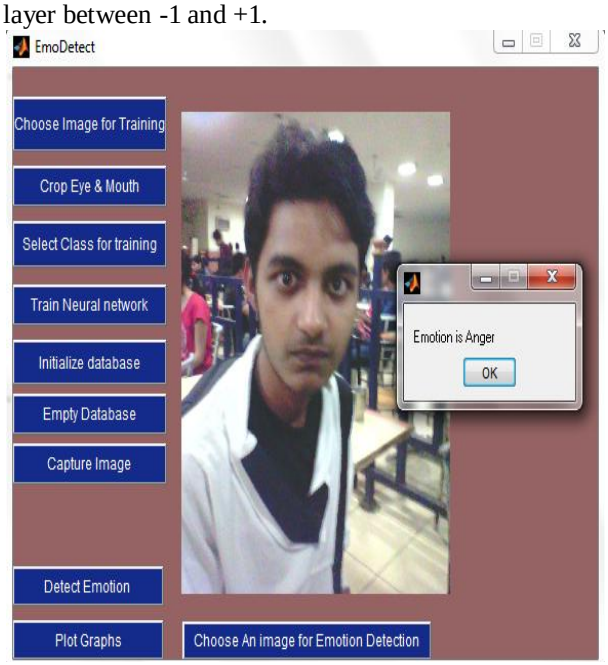

Fig.6 GUI of Human Emotion Recognition system detecting ANGER emotion for an image.

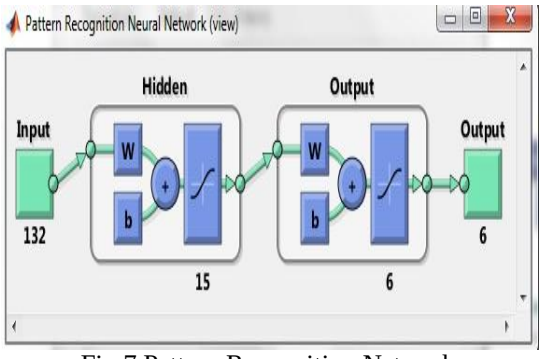

Fig.7 Pattern Recognition Network

As shown in Fig.8 is Performance graph of Human Emotion Recognition system. Collected data is divided into three parts: Training data, Validation data and Test data in the ratio of 80:10:10 respectively. Performance is measured in terms of

mean square error which decreased as the network was trained.

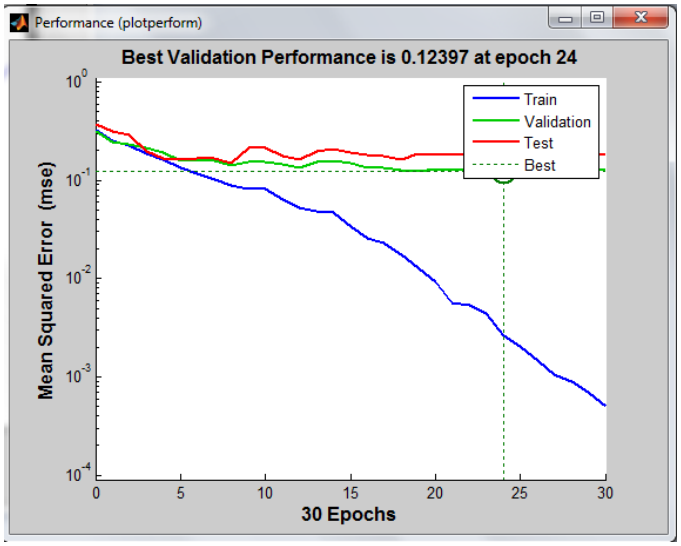

Fig.8 Performance Graph (mse vs epochs)

Best Validation performance for the system was at epoch 24 i.e. 0.12397; minimum the error better the system will perform. Performance of system can be thus be improved if the sample size for training is increased.

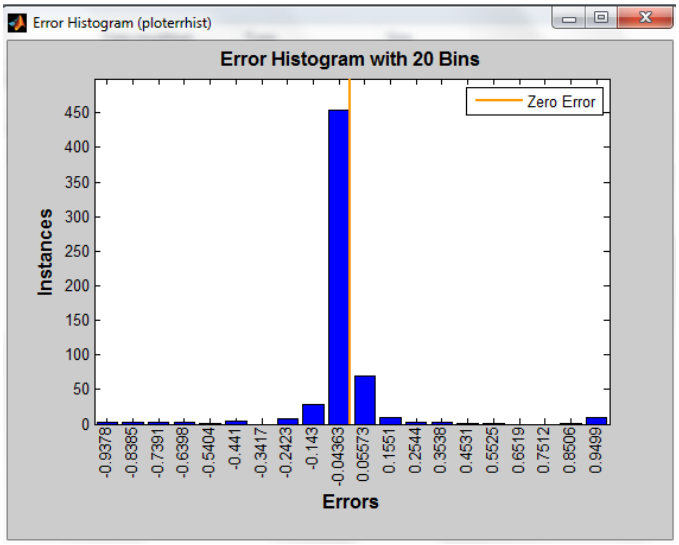

Fig.9 Error Histogram

Histogram of error values has been plotted in Fig. 9. It shows that for most of the instances errors are near zero and very few instances have errors that are away from zero which is good for the system.

Regression plot is another criteria for cheking network performance. Fig. 10 shows this plot with R=0.87171. For best fit of data by network, value of R=1 and for worst fit R=0. For this system value of R is close to 1 and therefore network has fit the data well after training.

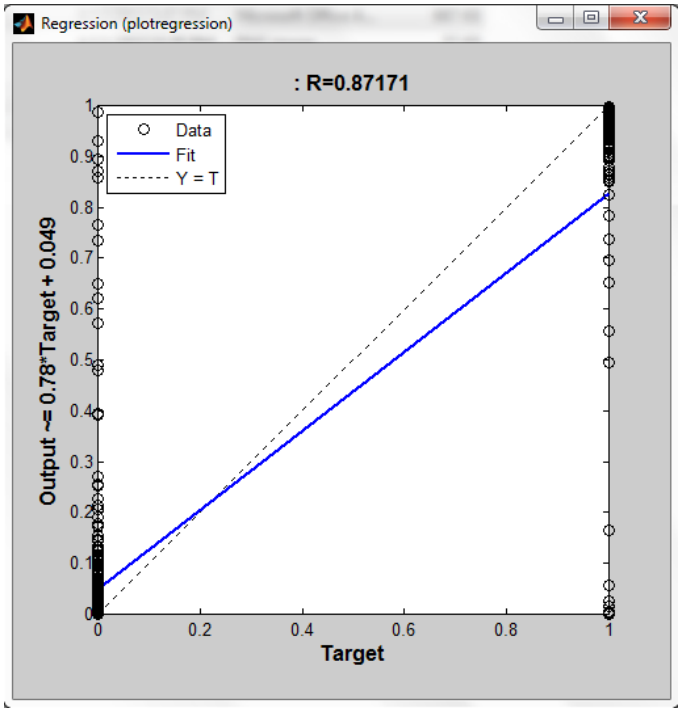

Fig.10 Regression Plot

There is one more measure which verify system performance i.e. Confusion matrix which shows percentage of right classification and percentage of wrong classification. Fig.11 shows confusion matrix in which diagonal elements represent right classification by the system. In the matrix, one to six rows and columns represent all six classes of human emotions. 94.1% is the highest percentage of right classification for class 1 and 6 which represent Happy and Neutral emotion respectively. There is difficulty in classifying Fear emotion as the percentage is lowest for class 3 i.e. 76.5%. Overall right classification by the system is 88%.

V. CONCLUSION

In this paper six emotions have been identified by extracting feature areas of human face and finding the 2D Discrete Cosine Transform of extracted feature area. Then performing training of pattern recognition network for the extracted features and simulating the trained network to identify emotions of new images.

VI. FUTURE SCOPE

More real life applications can be explored like driver monitoring and studying human psychology. In the proposed system the feature areas are extracted manually, automatic feature area extraction can be done. Mix Emotions like Happy and Surprise, Sad and Fear from an image can also be detected.

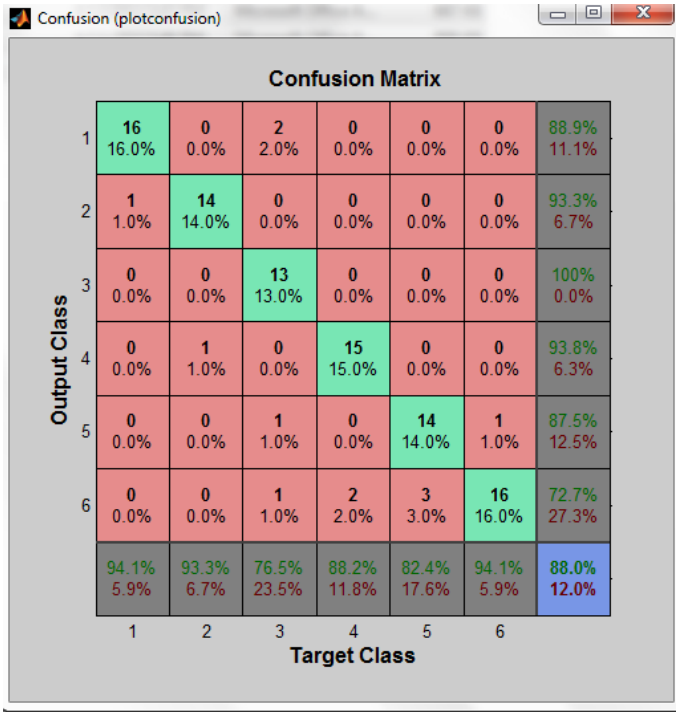

Fig.11 Confusion Matrix

VII. ACKNOWLEDGMENT

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