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Certain Investigations for Human Emotion Classification with Sugeno Model of ANFIS

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Abstract: ***Emotion detection has always been a challenging task in our day today life. Identifying emotion of a person will be useful in many areas like in medical field, in interviews, in education, in working environment and so on. Human mind can be read in several ways like, by their standing position, by hand keeping position, but emotion detection by using a human face will be a best choice because of its numerous muscle movements for even a small emotion, and moreover hiding a real feel through face is quite difficult. Emotions are basically classified into Happy, sad, anger, disgust, neutral, fear. The aim of this paper is achieving 100% Human emotion detection using Sugeno model in Adaptive Neuro fuzzy interface system (ANFIS). In this work, initially the human face will be detected. From the detected face the eyes, mouth and eyebrows are extracted and for this feature the various dimensions are measured and the ANFIS is trained with these measurement to identify the emotion of a human. And their performance is justified with various performance measures such as confusion matrix, Regression Plot, Mean Absolute Error, Error Plot, and Error Histogram.***

Keywords: Sugeno model, ANFIS, Confusion matrix, Error Histogram, Mean Absolute Error, Error Plot, Regression Plot.

I. INTRODUCTION

One of the strongest indicators for emotions is our face. It allows us to share social information with others both by the way of speaking and by actions. When we speak out most of our problems will be sort out by openly telling our emotion openly, but there will be a situation where human cannot show their emotion in openly which will be mostly reveled by their facial movements like opening the eyes big to small, mouth movements and eyebrow movements which various from milli second to micro second which left unnoticed, but which need to be noted for understanding one's mentality for a particular incident happening.

II. RELATED WORK

Anagha S. Dhavalikar et al., [1] involve two process for Automatic facial expression detection by involving simple Euclidean distance method between the feature points and based on this they have achieved 90%-95% recognition rate by using the features such as eyes, nose, mouth using Active Appearance Model(AAM), and the second process is made with ANFIS.

S.P. Kahandit et al.,[2] features such as eyes, eyebrows mouth and nose are extracted by using SUSAN edge detection operator and face geometry by using JAFFE database and the AFED is done using approaches of ANFIS and NN with 30 test samples and has achieved recognition rate upto 97.142% and 94.7%. Swathi Mishra et al.,[3] in this viola Jones face detection technique has been used for face detection and after this features like eyes and mouth are extracted and this is given to ANFIS for Emotion Detection(ED) with KDEF database with 150 images. Swathi Mishra, Avinash Dhole et al., [4] but ED is done with the Indian image which is database created and it has achieved the recognition rate upto 85.45% with trained images and 38.89% for untrained images with ANFIS

V Gomathi et al.,[5] here the facial image is segmented into 3 regions form which the uniform local binary pattern texture features distributions are extracted and represented as a histogram descriptor and the ED is recognized using MANFIS. S.P. Khandait et al.,[6] this paper uses facial geometry algorithm propagation neural network (BPNN) and (ANFIS) for ED by using the JAFFE database and achieve the recognition rate upto 95.33%to 93.33% using BPNN and 95.71% to 95.33% with ANFIS Approach. Nicegeorge Bizdoc et al., [7] here they have used viola jones algorithm for face detection and for tracking in videos they used camshift algorithm. The detected human face is given to Sugeno type decisional fuzzy system, which is based on the variable fuzzy measurements of the face, eyes, eyelid and mouth.

S.P. Khandait et al.,[9] curvelet transform is applied on the database images and the curvelet features are obtained and it is compressed using singular value decomposition(SVD). And it is given to classifier such as BPNN and ANFIS for ED. N.M. Jothi swaroopan et al.,[10] here the feature are extracted using PCA technique which calculate the principal component and it is given for ANFIS for AFED. M.A. Shaha et al.,[11] this paper achieves high AFED rate than the state of art technique by using ANFIS and the Bezier crves with the helpofJAFEE database and cohn kanade database. Shubhangi Giripunjje, Narendra Bawane et al.,[12] they have done with speech based emotion classification method by using ANFIS with the help Voice pitch, formants, energy and speaking rate as the babes features.

Derya Yilmaz et al., [13]they have done a SRS(Snore related sounds) for detection of sleep apnea/hyperpnoea syndrome(SAHS) which prove SVM is better than ANFIS.

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Ganeshan.R et al., [14] gives brief review about ANFIS. Pijush Kanti Ghosh et al., [15] In this AFED is done by using ANFIS and they have shown that PCA with SVD is superior to PCA in terms AFED rate for Basic emotions. Sasi praba et al., [16] here the age of a person is estimated with the help of ANFIS. Mythi Asaithambi et al., [17] here the AFED has been done with the help of eyes, lips by using ANFIS as a classifier for detection four basic expressions angry, happy, sad and surprise. Shinde A.R et al.,[18] a comparative study of facial feature extraction, expression and emotion recognition using ANFIS has been done and concluded that ANFIS can achieve AFED than BPNN. Urvashi N. Agrawal,[19] here the brief review about the ANFIS classifier for emotion recognition has been done.

III. METHODOLOGY

For implementing the methodology there are two main things which has been used is ANFIS and Analysis of Variance (ANOVA),

A. ANFIS

Neuro fuzzy techniques are the fusion of Artificial Neural Networks (ANN) and Fuzzy Inference Systems (FIS). Jang (1993) proposed an Adaptive Neuro Fuzzy Inference System, in which a polynomial is used as the defuzzifier. This structure is commonly referred to as ANF1S. ANFIS differs from normal fuzzy logic systems by the adaptive premise and consequent parameters. Recent studies (Ya Lei Sun and Meng Joo Er 2004, Tiberiu vesseenyi et al 2007, Hong-Rui Wang et al 2007, Duraisamy et al 2007) show that the use of a system that utilizes neural networks and fuzzy logic can be attractive.

Fuzzy Sugeno models (Jang put in the framework of adaptive systems to facilitate learning and adaptation. Such framework makes Fuzzy Logic system more systematic and less relying on expert knowledge). A first order Sugeno model can be defined by the following two rules.

Rule 1: if (x is A_1) and (y is B_1) then ($f_1 = p_1x + q_1y + r_1$)

Rule 2: if (x is A_2) and (y is B_2) then ($f_2 = p_2x + q_2y + r_2$)

The ANFIS Architecture for the Sugeno model mentioned above is shown in Figure 1. The ANFIS architecture shown has 5 layers. In this a circle indicates a fixed node whereas a square indicates an adaptive node. In the adaptive node the parameters are changed during training.

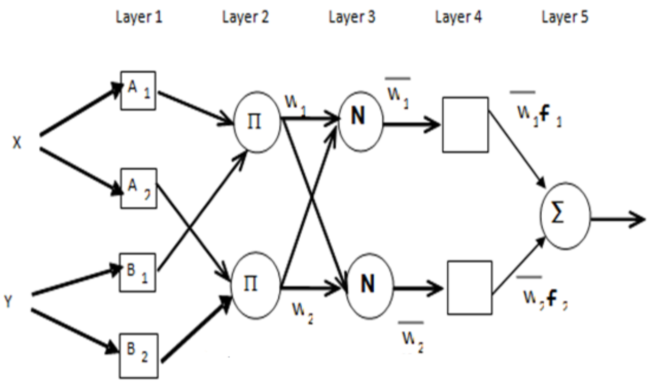

Fig. 1 ANFIS Structure

B. ANOVA

The credibility check on the feature set was performed through ANOVA. It refers to Analysis Of Variance. The main concept behind this is the rejection of null hypothesis. If the means of the different classes are same (null hypothesis), then it can be said that there is no significant difference between the class else significant difference is present. The variance between the four different classes may be due to significant difference in texture between them or may be random and insignificant texture differences. But the variance within the class will be due to random and/or insignificant texture differences only. So diving the between class variance by within class variance results yields the measures that is due to significant texture difference only. This is called F ratio as given below:

$$F = \frac{\text{Variance between the classes}}{\text{Variance within the class}} \rightarrow 1$$

It is interesting to note that if the variance within the class is small, then statistically the same small value in variance between the classes is sufficient to yield significant result. The variance was calculated through the sum of squared distances. Let V_b be the collective sum of the squared distance between the individual class mean and cumulative class mean. V_w is the collective sum of the squared distance between the samples and their class mean.

In general the statistical analysis is often sensitive to the amount of the sample size used for estimation. The more the number of samples, better the approximation in classifying the unknown sample. This sensitivity is often explained by the term, Degrees of freedom. It refers to the difference between the number of independent values and the dependent ones in the estimation of a particular parameter. The magnitude of inter and intra class variations are obtained Via Mean Squares (MS). Difference in the number of samples in each class is another important factor that affects the variance calculation.

$$MS_b = \frac{V_b}{d-1} \rightarrow 2$$

$$MS_w = \frac{V_w}{f-d} \rightarrow 3$$

Where MS_b refers to the between class variance measure, MS_w refers to the within class variance measure and d=No. of classes, f= Total No. of samples. d-1 and f-d are called degrees of freedom. It refers to the number of ways in which the variability in the given sample can be estimated. F can be written as follows

$$F = \frac{MS_b}{MS_w} \rightarrow 4$$

Fcrit value was obtained from the F-Table in accordance with the no. of degrees of freedom in the numerator and denominator of the F ratio. SS-Sum of Squares: It refers to the sum of squared deviations from the mean. P-value refers to the measure of arriving at this accuracy by pure chance, that is, despite the absence of substantive difference. Lower the p-value better the chance of null hypothesis rejection. The significance level was set as 0.05.

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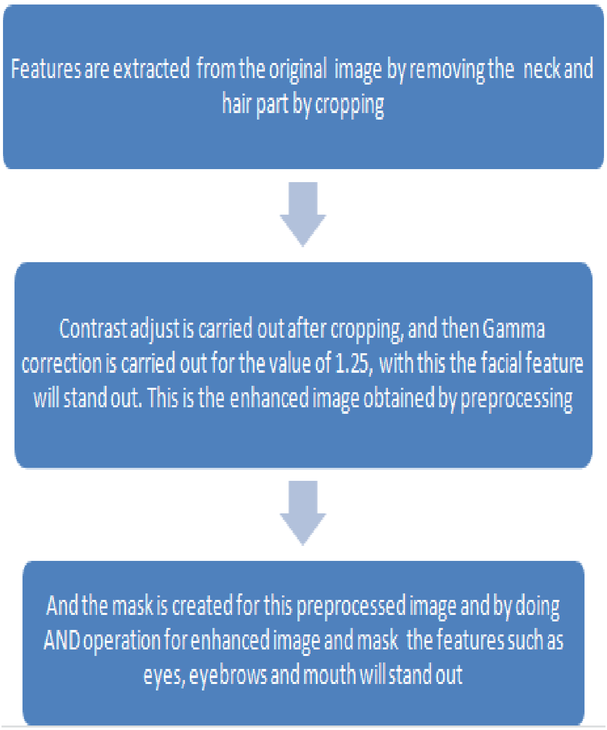

Fig. 2 Methodology for feature Extraction

Step 1: A Jaffee Database is obtained and from that an image is taken and from the image using the methodology shown above the eyebrows, eyes and mouth is extracted as shown in Figure 3 and 4.

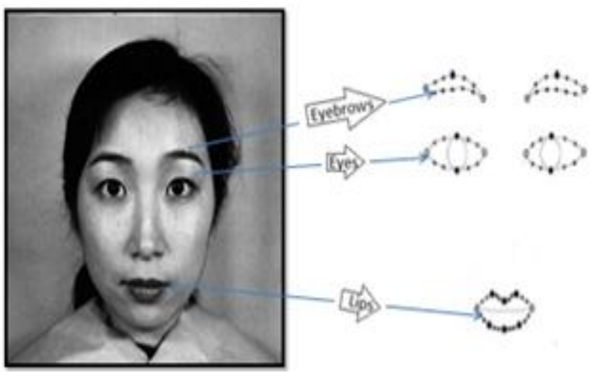

Fig. 3 Extraction of Feature

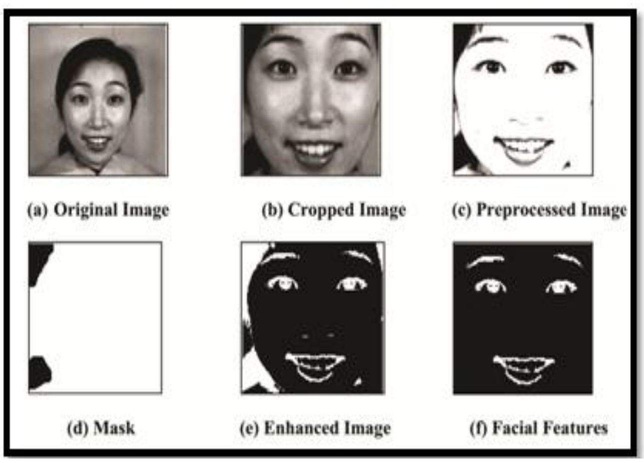

Fig. 4 Extraction of Feature with Matlab Step by Step Process

Step 2: For the obtained eyebrow, eyes mouth the parameters such as area orientation, perimeter, solidity, major axis length, Minor axis length; Centroid(x, y axis) is obtained as shown in Figure5 and 6. So that we have 8 parameters, with 5 features so that for each image for identifying an expression we must use 40 inputs. And it is like we must give these 40 inputs for training a network, but in this case we use ANFIS, so when we go for more number of inputs the ANFIS runs with more number of rules so we have to reduce the number of input so we go for ANOVA.

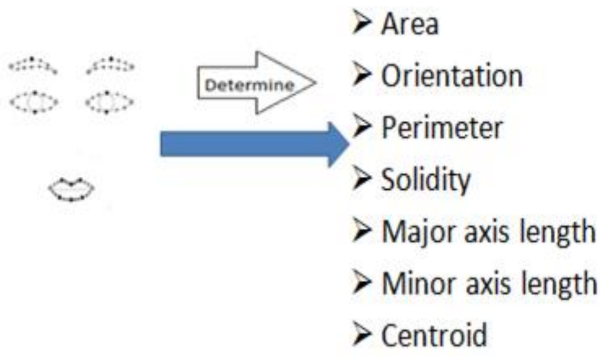

Fig. 5 Geometrical Features to be Measured

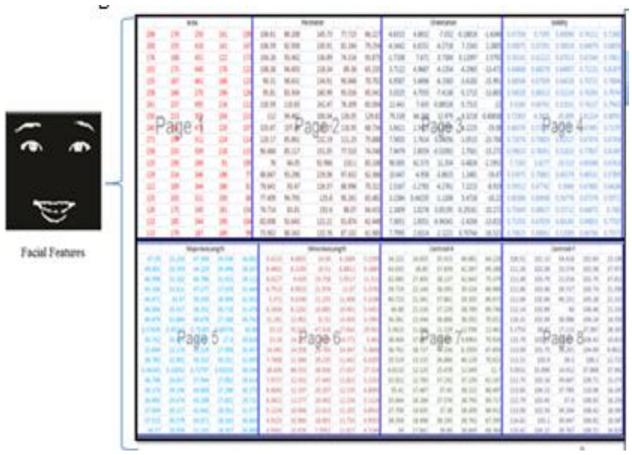

Fig. 6 Values of Measurement

Step 3: These parameters are given for training ANFIS as shown in figure 6.

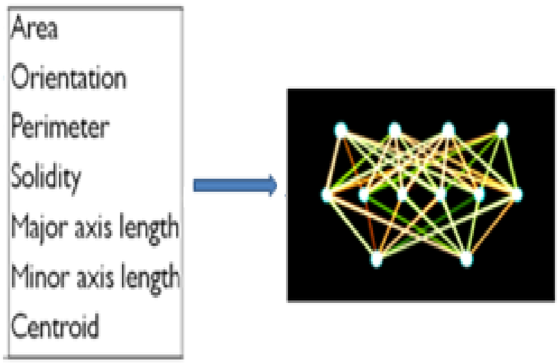

Fig. 7 Training With ANFIS

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Step 4: Problems with ANFIS

ANFIS is based on Fuzzy logic. Fuzzy Logic requires fuzzy rules. No. of fuzzy rules is equal to product of no. of Membership Functions in each input variable. As ANFIS changes the parameters of the MFs, the time taken for training is directly proportional to no. of input variables. So, the no. of input variables is reduced. ANFIS is based on Fuzzy Logic. Fuzzy Logic requires fuzzy Rules. No. of Fuzzy rules are equal to product of no. of membership function in each input variable. When Triangular membership function is used with 40 inputs, the number rules created are (3^40=12157665459005693000). Therefore, when more number of inputs is used in ANFIS it comes out with problems like: Time consumption, And also Increase in number of rules will make Matlab to run out of memory.

So these forty inputs are must be reduced to in order to process in ANFIS. So the obtained geometrical parameters are given for ANOVA to reduce the number of inputs, It refers to Analysis Of Variance. The idea is to reduce the no. of input variables based on their variance in the group of input variables. p value that is smaller than the significance level indicates that at least one of the sample means (indirectly variance) is significantly different from the others. Common significance levels are 0.05 or 0.01. Four parameters are chosen based on least p value. (20, 7,15,1). 20th parameter has least p value. It has least variance with 7th parameter. 7th parameter has least variance with 15th parameter. 15th parameter has least variance with 1st parameter. So, the parameters 1,7,15,20 are chosen as input variables as shown in figure 8.

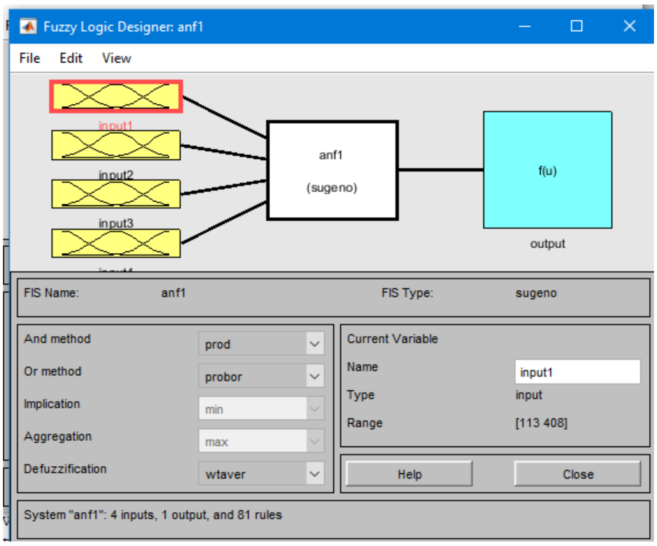

Fig. 8 After Implementing ANOVA Input With Number of Reduced Number of Geometrical Values

- The main concept behind this is:
  - ➢ To reduce the no. of input variables based on their variance in the group of input variables.
  - ➢ And based on this concept four parameters are chosen as the inputs for ANFIS (i.e., 1, 7,15,20)
- And this four inputs with Triangular membership function is given to Sugeno model
- So the number of rules gets reduced to 3^4=81

Step 5: After the training the test input is given for validation as shown in figure 9.

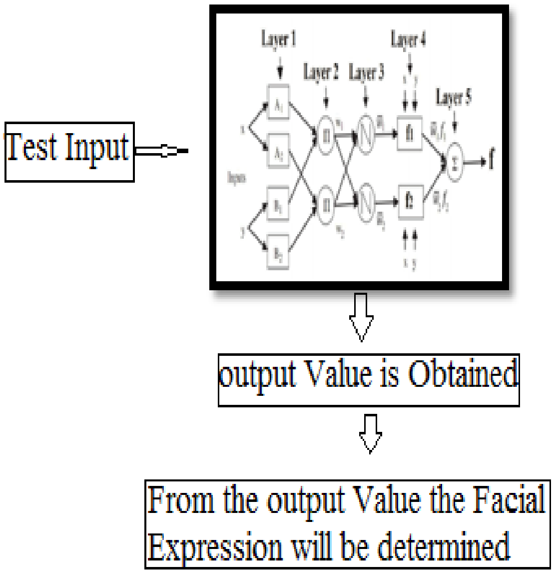

Fig. 9 Validation the Network with Test Input

IV. PERFORMANCE EVALUATION

An automatic facial expression recognition system has been developed using image processing and artificial neural networks. The system performance is tested with the jaffe image dataset. The performance is evaluated using the evaluation parameters viz. confusion matrix, error histogram, mean absolute error, error plot and regression plot.

A. Error histogram

The dispersion of the system errors is depicted by the error histogram plot. This histogram is a measure of anomalies. The anomalies are the data points where fit between the original class and the target class significantly worse than the majority of data.

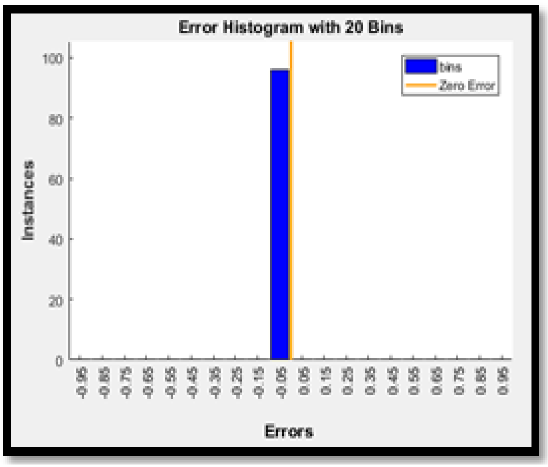

Fig. 10 Error Histogram

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Here(in Figure 10) it can be seen that the maximum errors fall between -0.1 and-0.05, the error for entire input falls within this span which indicates that all the expressions are correctly recognized

B. Confusion Matrix

The performance of a classifier is better evaluated by the confusion matrix. It is an error matrix portrayed by a table layout which helps in visualizing the performance of classifier. The columns of the confusion matrix represent the instances in the output class whereas the rows represent the instances in the actual class.

Fig. 11 Confusion Matrix

Figure 11 shows the confusion matrix of ANFIS. The diagonal elements of this matrix are 1 and off-diagonal elements are 0. This shows that, there is exact identification of the expression by ANFIS.

C. Error plot

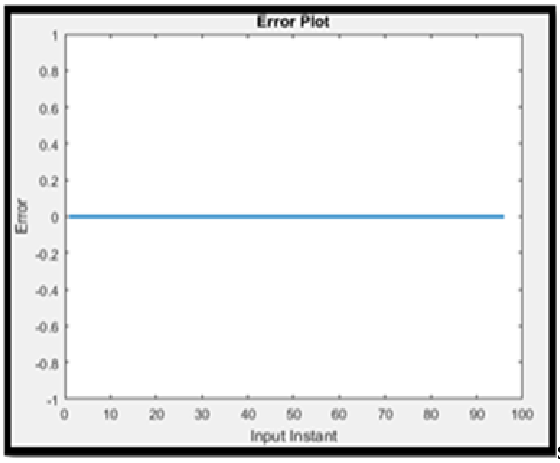

Fig. 12 Error Plot

The horizontal line indicates zero error. The error plot of ANFIS is shown in Figure. It is a horizontal line at zero error. It indicates no error for all the inputs.

D. Regression Plot

The regression plot is drawn between the system outputs and actual classes. It shows the regression between them. The R value of 1 indicates perfect fit.

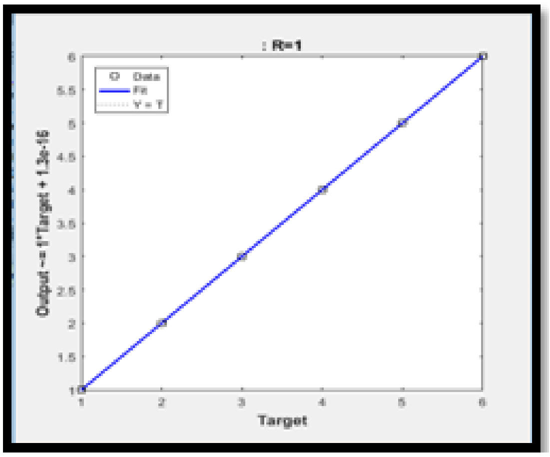

Fig. 13 Regression Plot

In ANFIS system the R values of regression plot of training, validation, testing and for entire data are equal to 1. It results in perfect fit as shown in Figure 13.

E. Mean Absolute Error (MAE)

Mean absolute error is a measure of error between the output class of data points and the actual class of the same. It is represented by

$$MAE = \frac{1}{n}\sum_{i=1}^{n}|y(i) - t(i)| \quad \rightarrow (5)$$

Where y (i) is the output class of the ith data point and t (i) is the target class of the same. ANFIS resulted in 0 MAE. This shows that in ANFIS, there is absolute match of output class and actual class. This indicates that ANFIS is 100% effective in recognizing the facial expression.

V. GRAPHICAL USER INTERFACE

Fig. 14 GUI For ANFIS Expression Identification

A graphical user interface has been developed for automatically recognizing the facial expression as shown in figure 14. The facial image is given as input to the expression recognition system. The features extracted are shown. From the features the type of expression recognized is displayed for ANFIS.

The above Figure shows the GUI for ANFIS expression identification. The input image of face registering afraid is properly identified by ANFIS as afraid.

VI. CONCLUSION

A novel Feature extraction algorithm based on image processing is applied. The algorithm created a mask form the enhanced image and the mask is utilized for extracting facial features. The Facial features are then converted to geometric values and used for training the Adaptive Neuro fuzzy interface system with the Backpropagation algorithm and triangular membership function and this ANFIS is dependent on the fuzzy rule, and this fuzzy rule is dependent on the number of input given so when we give 40 input for each image the number of rules gets increased, so the number rules must be reduced by reducing the input this input is reduced by using analysis of variance(ANOVA) and the number of inputs gets reduced to four and so the rules gets reduced so the processing time gets reduced . So after this the ANFIS is trained and the test input is given and output performance is measured using error histogram, confusion matrix, regression plot and error plot. And the ANFIS Achieves 100% efficiency in identifying the facial expression identification and future work will be based on trauma identification or any other clinical application using ANFIS.

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