Facial expression recognition & classification using hybridization of ICA, GA, and Neural Network for Human-Computer Interaction

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Abstract – Facial Expression classification is becoming one of the foremost challenges in the area of computer vision & artificial intelligence that can be used for security, entertainment and human machine interface. The emotion recognition and classification depends upon gesture, pose, facial expression, speech and behavioral reactions etc. The task of face detection is very much complex due to the variations in color, pose, expression, position, and orientation across human beings. The various modeling techniques make it convenient to recognize various facial expressions like by observing the movement of eyes, mouth, nose, etc. this paper presents a methodology which is a connection of three stages- Feature extraction using Independent Component Analysis method, Feature optimization using Genetic Algorithm and finally facial expression classification using Back Propogation Neural Network. This proposed methodology yields the better recognition rate easily and effectively.

Index Terms –Face recognition, Emotions, Feature Extraction, Classification, Genetic Algorithm, Neural Network, ICA.

1. INTRODUCTION

Human beings express different emotions according to the activities performed in routine. Emotions play a vital role and often reflected on the face. Recent research has shown that most expressive way of showing emotions is via face expressions. The importance of facial expression system is widely recognized in social interaction and social intellect. Since 19th century, the system analysis has been dynamic [18] research subject matter. In 1978, the facial expression acknowledgement system was presented by Suwa et. al. The foremost problem that occurs in constructing a facial expression recognition system is detecting face, normalizing image, extracting features, and cataloging. There are several number of methods which we can use for recognizing the facial expression. Some of the researchers [1] introduced the system can recognize the different human gesture in color image.

The Facial Expression recognition system is increasingly used in the fields of gaming and internet with the widespread use to increase the efficiency of robots in the fields of military, medicine and manufacturing works. It is being considered to be a very efficient signed language recognition system that proves to be very powerful in dealing with deaf and dumb people. No doubt this system works well in Lie detection from the time it is discovered but it is improving and modernizing with time. It is effectively used in chewing analysis to determine the softness and hardness of food. The FER systems are extensively used in the safety applications like to determine the lack of attention during driving etc. But to react appropriately to the human, computer needs to detect the facial expressions with the highest possible accuracy so as to make the correct and valid decisions. The system being proposed in this work, aims to increase the accuracy as compared to the existing ones taking into consideration the time constraints. The system is implemented using JFFE (Japanese female Facial Expression) database with sample as shown below:

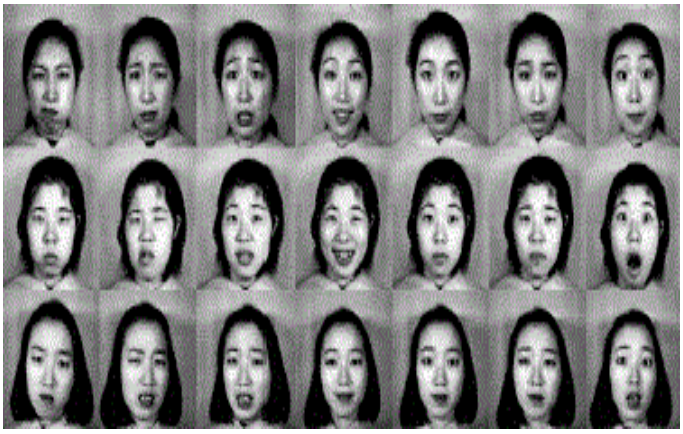


Figure.1 Japanese Facial emotion Samples

2. LITERATURE SURVEY

In this paper, LBP and AAM are used for finding combination of local feature information, global information and shape information to form a feature vector. They have used nearest neighborhood with weighted chi-sq. statistics for expression

classification. Feature point localization is done using AAM and centre of eyes and mouth is calculated based on them [2].

The paper proposes the different techniques to extract the features such as mouth, cheek, mid forehead, and forehead. These separated characteristics offers different recognized output using back propagation technique which show that the back propagation algorithm can identify the suitable facial expression as compared to other techniques. These networks are being extensively used and also the work is deliberated as a focal part of artificial neural network. The efficient algorithm for motion detection based facial expression recognition is an optical flow algorithm that helps in facial motion detection. This method is established on optical flow method which abstracts the obligatory motion vectors. Optical flow reflects the image changes due to motion during the interval of time. This algorithm works on frames of segmented image and gives us their result which is depending on motion vectors. The strongest degree of similarity determines the facial feelings. The procedure test the work has been done on the basis of Action units (AU) coded facial impression database. Using this method, in which through matching of the system can diagnose the facial expression. There are four types to identify that expression. The first kind of this uses emotion space to identify facial impression. The second category is to identify facial expression of a picture frame through using optical flow. The third kind is to use some of the dynamic shape models to identify facial expression. The fourth kind is used to identify the facial expression via using neural network [3].

The paper proposes a system that demonstrates an automated facial expression recognition system using neural network [4]. Facial expression recognition provides an important behavior for the detailed research of emotion or feelings. Now this paper, the neural network models define the mechanized facial expression recognition method with hybridization of ICA and Genetic procedure. The researcher presented a new method that is the point counter detection method; through using this method the system can extract the features from individuals face. The face is a multifarious multidimensional visual model and it is used for developing a model for face recognition is difficult job.

Repeated recognition of facial terminology is a significant [5] part for human machine interface. It has lot of magnetism in research area since 1990's.Though humans distinguish face without attempt or delay; gratitude by a machine is still a face. Some of its challenge is highly dynamic like orientation of face, lightening effects, scale of face, facial expression and occlusion in the image. Applications are being used in the fields like verification of user, detection of person, observation of any video, information security purposed, isolation of data etc. A mixture of approach for facial recognition is categorized into two ways- explicitly holistic based facial recognition and quality based facial recognition.

Uddin, J.J. Lee and T.S. Kim [6] used enhanced Independent component Analysis (EICA) to extract locally independent component features which are further classified by Fisher linear Discriminant Analysis (FLDA) .Then discrete HMM is used to model different facial Expressions. Feature extraction results of various conventional method (PCA, PCA-FLDA, ICA and EICA) in conjunction with same HMM scheme were compared and comparative analysis is presented in terms of recognition rate. PCA is unsupervised learning method used to extract useful features and 2nd order statistical method for deriving orthogonal bases containing the maximum variability and is also used for dimensionality reduction.

GRS Murthy and R.S. Jadon [7] proposed modified PCA (Eigenspaces) for Eigen face reconstruction method for expression recognition. They have divided the training set of Cohn kanade and JAFFE databases into 6 different partitions and Eigen space is constructed for each class, then image is reconstructed. Mean square error is used as a similarity measure for comparing original and reconstructed image.

Hadi Seyedarabi et al. [8] developed facial expression recognition system for recognizing basic expression. They have used cross correlation based optical flow method for extracting facial feature vectors. RBF neural network and fuzzy inference system is used for recognizing facial expressions.

Nectarios Rose. [9] Presented a FER system where they have compared the use of two type of features extracted from face images for recognizing facial expression .Geometric positions of set of fiducial point and multiscale & multi orientation gabor wavelet coefficient extracted from the face image at the fiducial points are the two approaches used for feature extraction. These are given to neural network classifier separately or jointly and results were compared. Comparison of the recognition performance with different types of features shows that Gabor wavelet coefficients are more powerful than geometric positions.

Junhua Li and Li Peng [10] used feature difference matrix for feature extraction and QNN (Quantum Neural Network) for expression recognition from the survey, it is observed that various approaches have been used to detect facial features [25] and classified as holistic and feature based methods to extract facial feature from images or video sequences of faces. These are geometry based, appearance based, template based and skin color segmentation based approaches. Recently large amount of contributions were proposed in recognizing expressions using dynamic textures features using both LBP and gabor wavelet approach and appearance features and increases complexity. Moreover one cannot show features located with the help of bounding box. Hence, the proposed

facial expression recognition system aimed to use image preprocessing and geometry based techniques for feature extraction and feed forward neural network for expression recognition for the frontal view face images

This exploration goes for creating "Personality Implemented Robots" that can do scholarly discussion with people. The initial phase in this course is to perceive human feelings by a PC utilizing neural system [11]. This paper investigates a method for human PC cooperation that empower the PC to be more mindful of the client's enthusiastic outflows we introduce a methodology for the feeling acknowledgment from an outward appearance, hand and body carriage [12].

This study researches the vicinity of entrainment at the feeling level in cross-methodology settings and its discussion on multimodal feeling acknowledgment frameworks. The examination investigates the relationship between acoustic highlights of the speaker and outward appearances of the conversationalist amid dyadic associations [13].

The paper mostly concentrates on static 2D face pictures through recreating 3D model by a particular calculation [14].

The proposed calculation is in light of a far reaching examination of the cross-connection properties that portray FAPs, which is here reported and talked about broadly [15].

In this paper they propose a consolidated technique for face identification and distinguishing proof utilizing SIFT descriptors. This consolidated system incorporates a current identification model and another ID technique in light of item class invariants (OCIs), which is invariant to interpretation, scale, in-plane pivot and little 3D perspective changes [16].

This paper introduces another example acknowledgment system for face acknowledgment taking into account the blend of Radon and wavelet changes, which is invariant to varieties in outward appearance, and brightening [17].

In this paper, a summed up structure for demonstrating and perceiving outward appearances on different manifolds is displayed which expect that distinctive articulations may dwell on diverse manifolds of conceivably distinctive dimensionalities [18].

They propose an effective strategy for feeling acknowledgment from outward appearances in static shading pictures containing the frontal perspective of the human face [19].

In this paper, a way to deal with the issue of programmed facial highlight extraction from a still frontal postured picture and characterization and acknowledgment of outward appearance and consequently feeling and temperament of an individual is exhibited [20].

3. CURRENT PROBLEMS OF FACIAL EXPRESSION SYSTEM

There are various factors that needs to be taken under consideration while constructing the FER system but three main factors to construct a Facial Expression Recognition system, namely identification of face, extraction of facial features, and cataloging the reactions or feelings.. An ideal emotion analyzer should recognize the subjects irrespective of age, sexual characteristics and any society.

The facial expression recognition system should be never changing with respect to the diverse lightening surroundings and disturbance as changes in style of hairs, presence of hairs on face, spectacles, beard, etc. and also should be able to “fill in” missing parts of the face and helps in producing a whole face. It should perform efficient facial expression analysis despite large changes in viewing condition, rigid movement, etc. A good reference system is the human visual system [10]. The current systems are far from ideal and they have a long way to achieve these goals.

4. METHODOLOGY

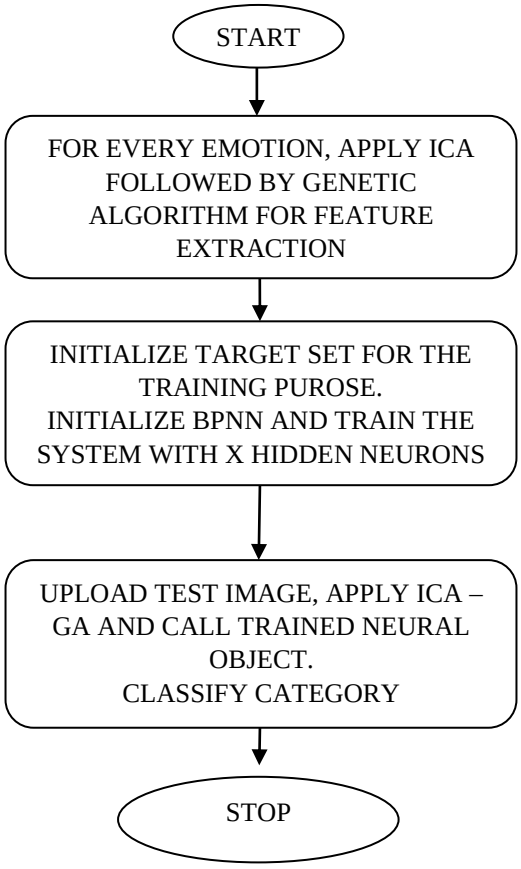


Figure 2: Architecture of Facial Expression Recognition System

In this article, the system proposed undergoes five stages which are: face detection, pre-processing, extraction of facial features using Independent component analysis (ICA), optimizing these features using Genetic Algorithm and classification of expression using Neural Network. The methodology is as given in the figure below. This section also provides the knowledge about the topics as given below:

- Neural Network Work Structure
- GA work structure
- ICA work Structure

The first stage is face recognition method. In this technique the database of pictures are almost indistinguishable environment of distance, background, etc. the collection of all the images includes different poses with different impressions. These are intended for constructing any sort of database of some pictures that are used for training and some for testing, both of which include number of expressions [11]. The proposed technique depends on coding and decoding technique. In the first step, information is obtained, programmed as well as then matched with the given database of model. The next step is the preprocessing module, in this the image gets normalized and it also removes the noise from the picture. In the eigen face library the database picture set is further divides into two sets- training dataset and testing dataset. The Eigen faces are calculated from the training set. These training set pictures are compared through the finest Eigen faces, which also have the biggest Eigenvalues. For computing those particular eigenvalues that are the independent component analysis algorithm (ICA) used [12]. Then feature reduction is done using genetic algorithm (GA). At the last stage of architecture the neural network trained the function in various field of application. The Artificial Neural Network (ANN) can be used for the database in which the face descriptors are used as an input to train the network.

4.1 Neural Network Work Structure

The following figure gives an example of feed-forward back propagation neural network, in which the input layer is a collection of neurons [13]. These collections of neurons arrange for the information of forehead, mid forehead, and mouth to the next layer of the neuron collection. Then the following layer is known as a hidden layer which is used to calculate the values and provided to the output layer, where the system provides the different expression [14] as an output. For all positive result the network shows 1 in output and for all negative result 0 is present in output result. If any fresh database is acquired for training then firstly the neural network match all the new result to the pre-built dataset and match the maximum threshold values and provide the output. Then it is confirmed that the new facial expression is belong to the recognized person with the maximum output.

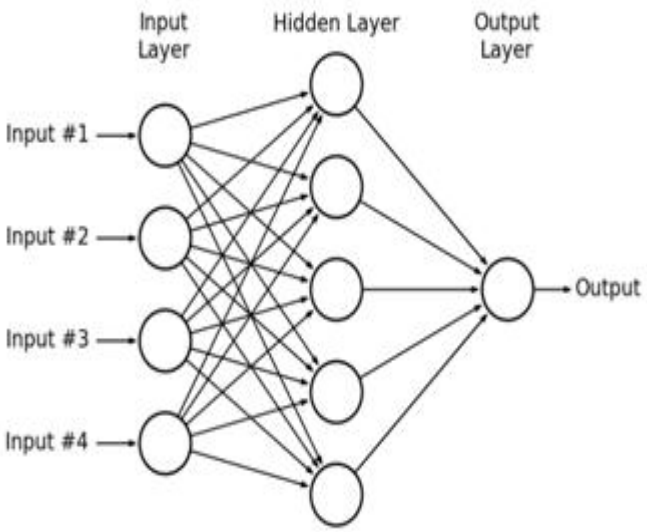


Figure 3: Architecture of feed-forward back propagation neural network

4.2 GA Work Structure

Hereditary Algorithms is created by Darwin's hypothesis. In this from number of populaces, single arrangement is produced then from this next populace is created. It is trusted that new created populace is superior to the past populace. This is rehashed up until some condition (for instance number of populaces or change of the best arrangement) is satisfied. GA tries to discover least of the capacity & procedure is as follows:

1. **[Start]** Generate the random population of *n* chromosomes (suitable solutions for the problem)
2. **[Fitness]** Evaluate the fitness function *f(x) for* each chromosome *x* in the population
3. **[New population]** Create a new population by repeating following steps until the new population is complete[15]
4. **[Selection]** Select two parent chromosomes from a population according to their fitness (the better fitness, the bigger chance to be selected)
5. **[Crossover]** This step crossover the parents to form a new offspring (children) with a crossover probability,. If no crossover was performed, offspring is an exact copy of parents.
6. **[Mutation]** With a mutation probability mutate new offspring at each locus (position in chromosome).
7. **[Accepting]** Place new offspring in a new population
8. **[Replace]** Use new generated population for a further run of algorithm[16]
9. **[Test]** If the end condition is satisfied, then **stop**, and it will return the best solution from the current population
10. **[Loop]** Go to step **2**

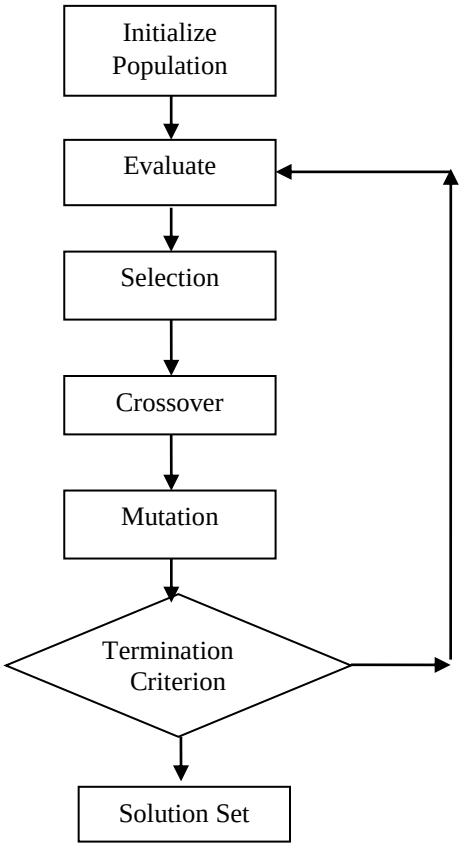


Figure 4: Architecture of Genetic algorithm

4.3 ICA Work Structure

Independent Component Analysis is a measurable and computational strategy. ICA is a general model for multivariate information. In this model information variables are thought to be direct and other obscure variables are thought to be inert variables. The inactive variables are called autonomous segments of the watched information. ICA is to some degree identified with PCA. ICA is significantly more effective strategy. ICA is begun from numerous application fields, databases, monetary pointers and estimation and so forth.

The two broadest meanings of freedom for ICA are

1) Minimization of common data
2) Maximization of non-Gaussian.

In the ICA algorithm the data are represented by the random vector x = $(x1\ldots\ldots xm)^{Tm}$ and the components as the random vector s = $(s\ldots\ldots Sn)^{T}$ The task is to transform this observed data x into maximally independent components S using a linear static transformation *W* as S = Wx measured by some function F(S……..S1) of independence [17].

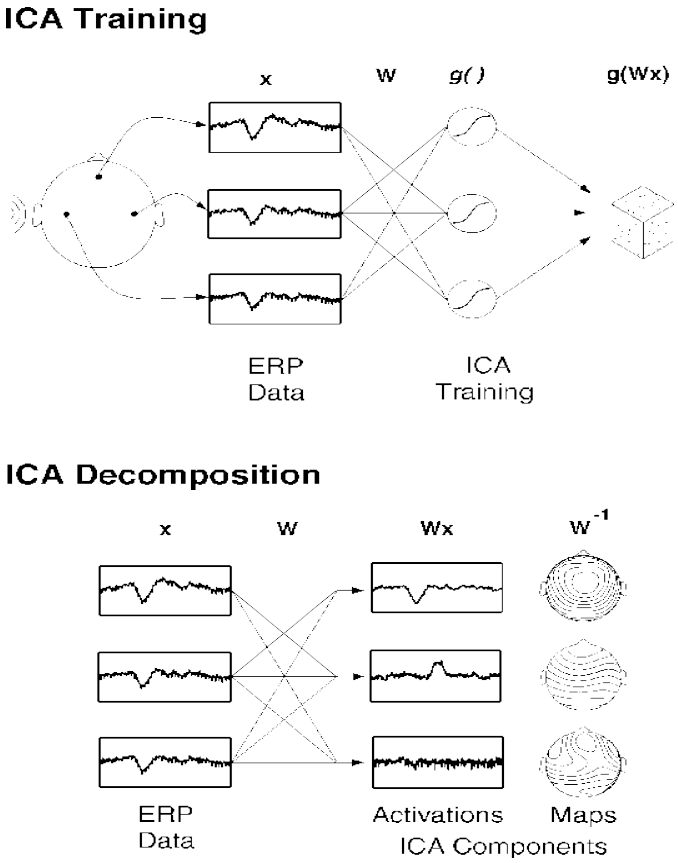


Figure 5: Architecture of ICA

5. DATABASE

Since the main purpose of this project is facial expression recognition, therefore, the sample pictures must be taken under special consideration so as to ease up the face identification procedure. Each image is captured following the condition that, only face is the largest skin colored continuous object in the frame. There are two sets of images. One of the set is used for training purpose and second one is used for testing purpose. The pictures are classified in the following expressional classes.

1. Happy
2. Sad
3. Surprise
4. Angry
5. Neutral

Another picture set is used for testing purpose. This dataset contains the images for which we need to detect the emotion.

These pictures are captured in quite a random manner. It also includes some impressions that are not contained in the training set.

The following pictures are some examples for the different classes of expression

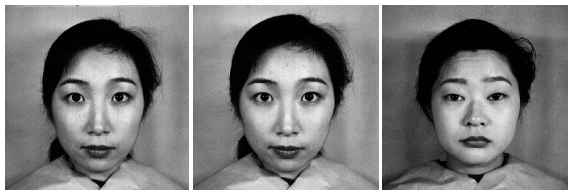
HAPPY:

SAD:

SURPRISE:

ANGRY

NEUTRAL



6. IMPLEMENTATION AND RESULTS

The whole implementation has been taken place in MATLAB environment. Below figure shows the implementation results of the proposed technique.

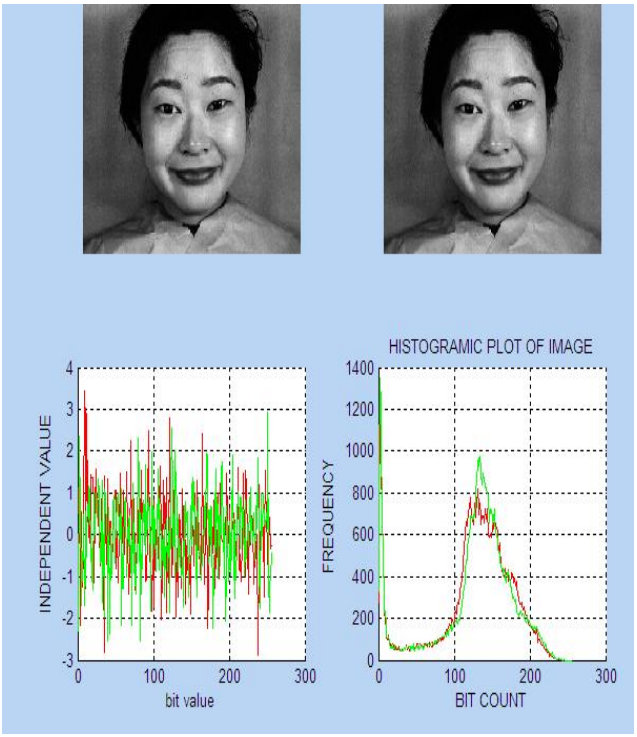


Figure 6: Histogram Plot

The above figure represent the feature extraction process performed while the execution. The figure contains the Independent values extracted by the algorithm and the histogram equalization process. The entire process extracts around 500 independent components which are further optimized using Genetic Algorithm. The above figure represents the ICA Feature extraction procedure in which the graphs shows the values of the independent components and the histogram equalization of the images processed one by one. Above figure illustrate that ICA has been implemented over 20 images of the category and it has provided 256 features for each image whereas when Genetic Algorithm is applied to it, the features are reduced to 59 for each sample. The population size for Genetic algorithm is total number of features extracted while processing using Independent component analysis. The entire data obtained after applying GA is set to be an input to the neural network and it trains the data in the following manner.

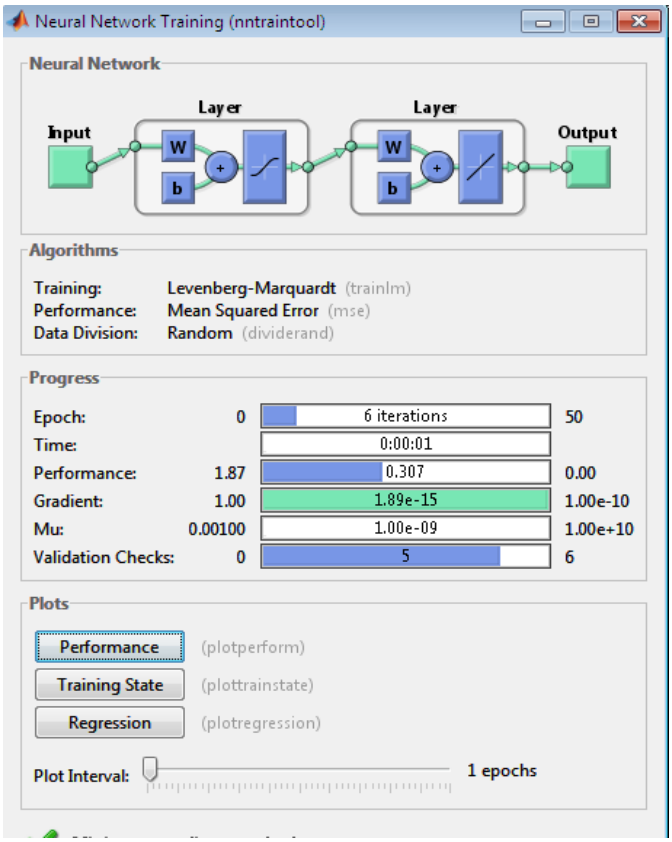


Figure 7: Neural Network Model

The above figure represents the trained Neural Network which has 6 epochs running i.e in 6 epochs the training has been completed and total number of iterations is 50. This indicates that the validation procedure is complete on the 6th iteration only.

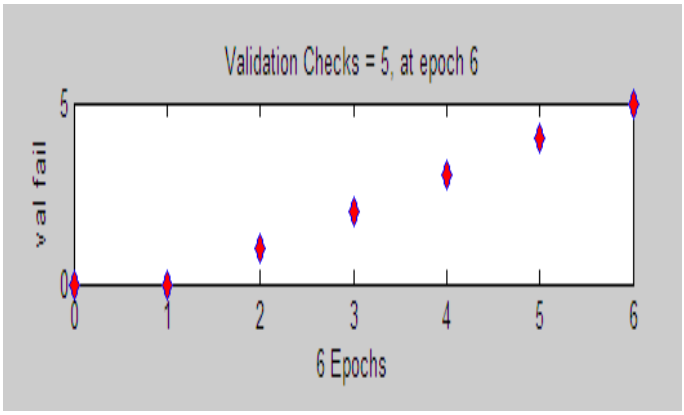


Figure 8: Validation Checks

The above figure shows that at how many epochs, how much validations have been applied. Maximum of 5 validations has been achieved at epoch number 6 hence neural network stops at 6 iterations.

- **Calculate FAR**

FAR=

$$\frac{\textbf{Total number of sample} - \textbf{Number of samples that falsely accepted}}{\textbf{Total numbber of samples}}$$

- **Calculate FRR**

FRR =

$$\frac{\textbf{Total number of samples} - \textbf{Number of samples that falsely rejected}}{\textbf{Total number of samples}}$$

This shows that:

FAR = (error/(result*100));

FRR = (error-Far)/(result*100);

Where,

error = sqrt(((result)-pos_c)^2/result)

And

result = sim(net,ga_test_set_final')

- **Calculate Accuracy**

Accuracy = (1-(FAR+FRR))*100

The Accuracy, FAR, FRR values for the proposed system are as given below with their graphical representation:

CATEGORY	ACCURACY
SAD	98.23
HAPPY	95.63
ANGRY	98.78
SURPRISE	99.21
NEUTRAL	98.65

Table: 1 Accuracy Table

The above table represents the accuracy of the performed process.

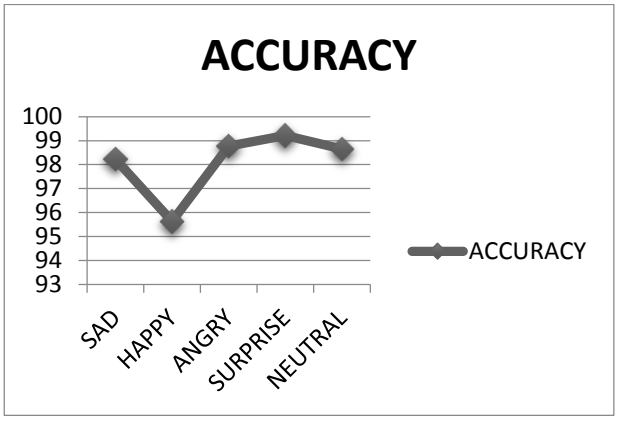


Figure 9: Accuracy Graph

CATEGORY	FAR	FRR
SAD	.00882	.00888
HAPPY	.020	.02185
ANGRY	.0056	.0067
SURPRISE	.00391	.00396
NEUTRAL	.00671	.00771

Table 2: FAR and FRR values

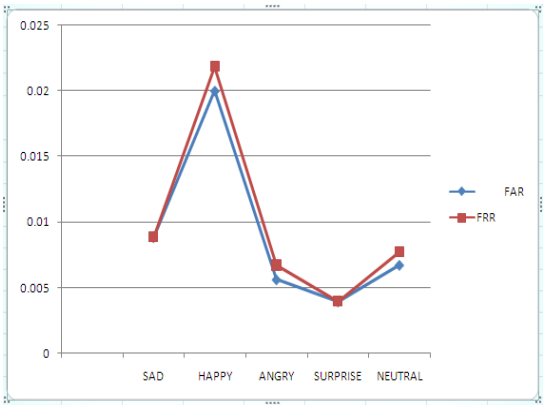


Figure 10: FAR and FRR graph

The above graphs represents the FAR and FRR for the specified accuracy.

7. CONCLUSION

In this paper the five emotions HAPPY, SAD, SURPRISE, NEUTRAL and ANGRY based on automatic facial expression recognition systems are overviewed. The neural network, Genetic algorithm approach is based on face acknowledgement, classification and feature extraction. The methodology of facial expression identification technique involves the optimization technique, independent component analysis algorithm (ICA) and neural network method. The methodology does make available a real-world clarification to the problem of facial expression recognition and it can work well in constrained environment.

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