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NEURAL NETWORK BASED IDENTIFICATION OF AN EMOTION USING ICA OF HAND GESTURES OF A HUMAN BEING

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Abstract- *This paper presents the identification of an emotion of a human being expressed by various Hand Gestures with respect to that emotion. A complete database of the images of various hand gestures of an individual's are stored in the system then, with the use of Mathematical Imaging, step by step process is performed on it. It includes, Image Normalization, Features Extraction by Independent Component Analysis (ICA) and finally the Classification of hand Gesture over basic seven emotions Neutral, Happy, Sad, Fear, Anger, Surprise, and Disgust by Neural Network (NN) using Multi-Layer Feed Forward approach with Backpropagation Algorithm.*

Keywords- *Emotion, Hand Gesture, ICA, Neural Network, Multi-Layer Feed Forward, Back Propagation.*

I. INTRODUCTION

Communication is an essential part of any sectors in which, to deal with a human being is complicated as he has his own thoughts, feeling and ideas which creates complexity in the nature of behavior [1] [4]. To identify those hidden emotions is quite difficult and thus difficult to judge the human attitude and behavior as it is in virtual form created in the human mind. Though, it is intangible but reflected in physically by human body in the form of gesture or posture is created by different body parts viz. Head, Face, Hands, Legs etc. [1],[2]. In this paper we are talking about the emotions expressed by different hand gestures, which is again a single or aggregate form of Fingers, Palm and Arm gestures [3]. In whole body, Hands are the most flexible part of human body even its combinations with other parts generates varieties of gestures related to an emotion. Also, it has a wide range of expression which is used by a communicator majorly during communication [5],[6]. In this research work, we are trying to compress all those hand gestures of an individual and categorized them in basic seven emotions as mentioned above with the use of Mathematical, Image Processing and Information Technological tools, and the newly created hand gesture of an emotion is classified in one of the emotion-category.

II. MATHEMATICAL SYSTEM TO IDENTIFY EMOTION BASED ON HAND GESTURE

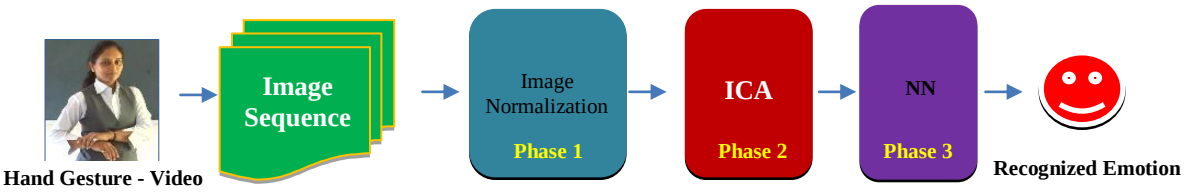


Figure 1. Mathematical System to Identify Emotion based on Hand Gesture

The Mathematical system to identify an emotion of an individual using hand gestures is shown in Figure 1. It indicates that the whole system processes the hand gesture data set into three different phases i.e. Image Normalization, ICA-Feature Extraction and Neural Network (NN) – Classification. The algorithm of this system along with all phases is described as follows.

1.1 Step 1 - Image Normalization [9] [16]

Step 1.1 : Load video (.avi file) of a single emotion of an individual in system, processing under MATLAB interface.
Video_Happy = VideoReader(Hand Geture-Video);

Step 1.2 : Capture sequence of expressive image (.jpeg, RGB file) frames from emotion video, which are significantly variant with desired image region.
Image_frame = imcrop (Video_Happy, [Xmin Ymin Width Height]);

Step1.3 : Balance Darkness and Lightness of RGB input image using Gamma Correction method.

$$X_{New} = X^{Gamma}$$

Where, Gamma $= \frac{dlog(I_{out})}{dlog(I_{in})}$, represents the slope of Gamma curve

I_{in} = Image input and I_{out} = Image output.

Image_Gamma = vision.GammaCorrector(Image_frame, *Value*)

Step 1.4 : Reduce Image Pixel Dimensions by converting RGB image to Gray Scale image method.
I_{gray} = 0.2989 * R + 0.5870 * G + 0.01140 * B
Iamge_Gray = rgb2gray(Image_Gamma);

Step 1.5 : Adjust contrast of gray image using Histogram Equalization method. Histogram equalization transformation:

$$s_k = T(r_k) = \sum_{j=1}^{k} p_r(r_j) = \sum_{j=1}^{k} \frac{n_j}{n} ,$$

For k = 1, 2, -----, L, where s_k is the intensity value in the output image corresponding to value r_k in the input image.
L is total possible intensity levels in the range [0, G],
n_k is the number of pixels in the image whose intensity level is r_k,
r_k is the k^{th} intensity level in the interval $[0, G]$,
$p_r(r_j), j = 1, 2, \dots, L$, denote the histogram associated with the intensity levels.
Image_Histogram = histeq(Image_Gray, hgram);
Where, (hgram) *is intensity values in the appropriate range: [0, 1] for images of class double, [0, 255] for images of class uint8, and [0, 65535] for images of class uint16.*

Step 1.6 : Resize the Histogram Equalized image to convert in same dimension of image matrix.
The Image matrix dimension
[Height , Width] = [numrows , numcols] = [30 , 27]
Image_Resize = imresize(Image_Histogram,[numrows numcols]);

1.2 Step 2 - Feature Extraction: Independent Component Analysis (ICA) [7], [8], [13]

Step 2.1 : Load m, PC [15] eigenvectors of the image set X for ICA. (Here $X = A$).
[Eigen_Fetures, Rm, Eigenvalue] = pca(X);
P_m = Eigen_Fetures (: , 1:m)' ;

Step 2.2 : Separate higher order dependency from inputs by sphering the input matrix.
The row means of X are subtracted from each row of X, called zero-mean and then it is passed through the whitening matrix W_z ,

$$W_z = 2 * (Cov(X))^{-(1/2)}$$

Xzeromean = X-(ones(P,1)* mean(X'))';

W_z = 2 * inv(sqrtm(cov(Xzeromean)));

Step 2.3 : Obtained minimum squared error approximation $\hat{X}$ of matrix X .
$\hat{X} = R_m {P_m}^T$ Where, $R_m = X P_m$.

Step 2.4 : Find transformed matrix $W_I = W W_z$, such that ${W_I P_m}^T = U$
and $\hat{X} = R_m {W_I}^{-1} U$ where, U is required Basis Images.

Step 2.5 : ICA based m statistically independent feature images are rows of the matrix

$$B = R_m {W_I}^{-1}$$

B = Rm(:, 1:m) * inv(W_I);

1.3 Step 3 – Classification – Neural Network

Step 3.1 *Back Propagation Algorithm:* [12]

Step – 3.1.1 : Initialize all network weights to small random numbers
Until the termination condition do:

Step – 3.1.2 : Propagate the input forward to the network and compute the observed outputs.

Step – 3.1.3 : Propagate the errors backward as follows:

(i) For each network output unit k, calculate its error term

$$\delta_k = O_k(1 - O_k)(t_k - O_k),$$

Where t_k is target value and O_k is output value.

(ii) For each hidden unit calculate its error term

$$\delta_h = O_h(1 - O_h) \sum_{k \in outputs} W_{kh}\delta_k$$

Step – 3.1.4 : Update each weight

$$w_{ji} = w_{ji} + \Delta w_{ji}, \text{ where } \Delta w_{ji} = -\eta . \delta_j x_{ji}$$

(Here, 'ji' means from unit 'i' to 'j')

Step 3.2 : Decide Neural Network parameters and other important values by following steps ; [10], [11], [12]

Step 3.2.1 : *Number of Hidden Layer:* Generally for pattern recognition, one hidden layer is enough for classification thus, here we have taken only one hidden layer in Multi-layer Perceptron (MLP)- NN Architecture, can be seen in Figure 2.

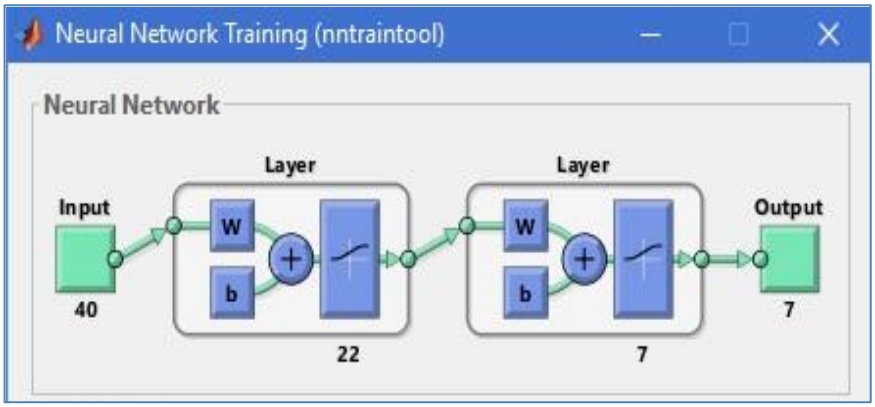


Figure 2. Multi – Layer Feed Forward NN Architecture

Step 3.2.2 : *Number of neurons at hidden layer:* It is difficult to decide the number of neurons at hidden layer prior to training. It is an area of research, decided based on Accuracy of Experiment and Mean Square Error (MSE) obtained.

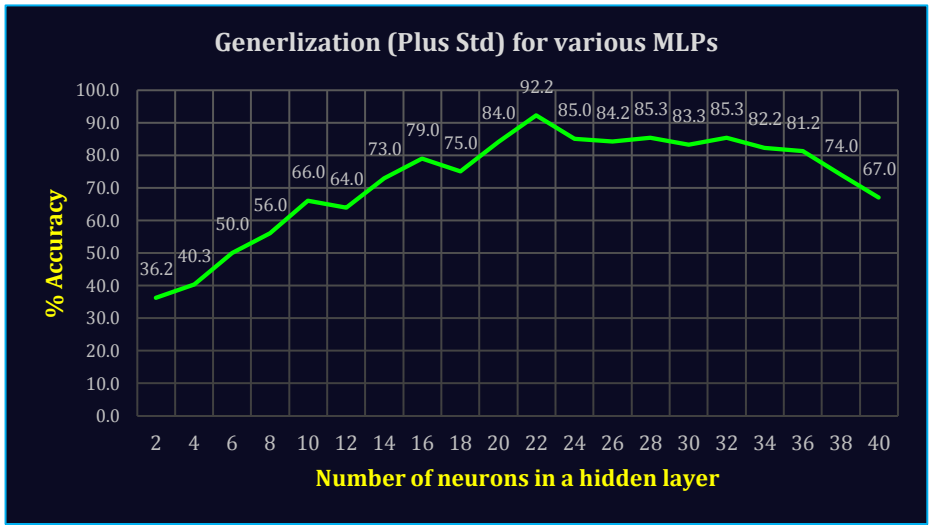


Figure 3. Accuracy V/s Number of Neurons at Hidden Layer

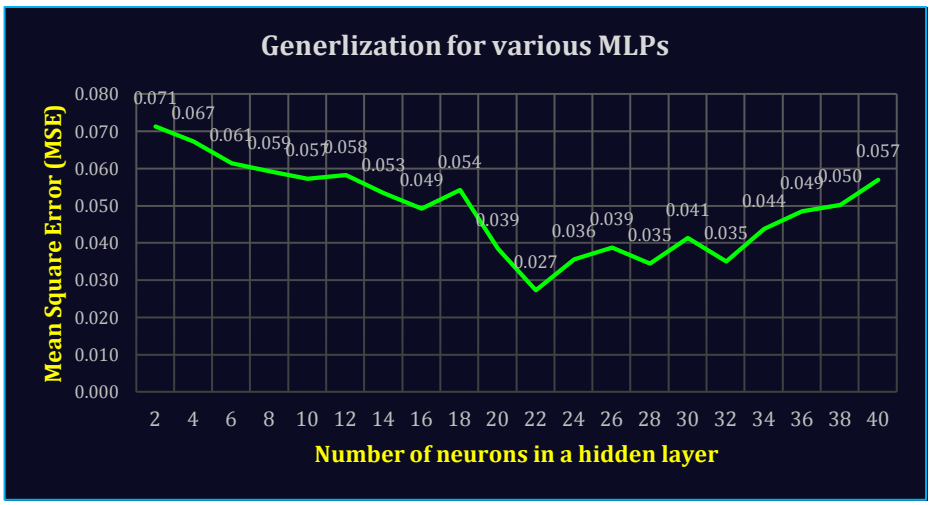


Figure 4. MSE V/s Number of Neurons at Hidden Layer

It is observed from Figure 3 & Figure 4 that, at the setting of 22 neurons at hidden layer nodes the accuracy level of NN training is highest one also, at the same time the MSE is lowest. Thus, the number of neurons at hidden layer nodes is set to 22.

Step 3.2.3 : *Transfer function:* Log- sigmoid function is ideal for MLPs, the output range of this function is set to [0, 1] as NN is respond to 1 for classification and 0 for not. But, in practice it is always vary in between them.

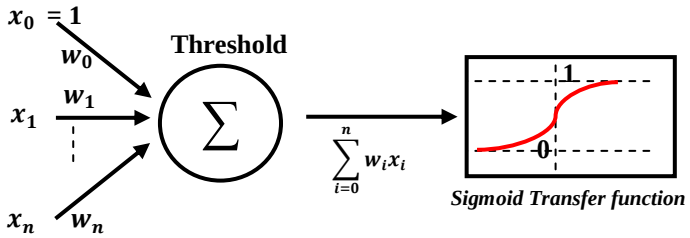


Figure 5. Sigmoid Function for MLPs

Step 3.2.4 : *Weight initialization :* There are three options to set initial weight at hidden and output layer respectively (i) Both are set to zero; which is not feasible as no such updates will be occurred (ii) Both are set to random; then the output will be noisy (iii) Set Hidden-Zero and Output-Random gives a clear appearance of output. Therefore, we have set the third combination for weight initialization.

Step 3.2.5: *Learning Rate :* Weights are updated by $\Delta w_{ji} = -\eta . \delta_j x_{ji}$

$\eta \in$ R, is called learning rate of the BACKPROPAGATION algorithm. If the learning rate is set too high then, the algorithm may oscillate and become unstable. If the learning rate is too small then, the algorithm will take too long to converge.

Momentum : $\Delta W_{ji} = -\eta \delta_j x_{ji} + \alpha \Delta W_{ji}(n-1)$

The update in n^{th} iteration multiplied by a factor 'α', called momentum where, $0 \leq \alpha < 1$. It will be helpful in speeding the convergence and avoiding local minima in the error surface.

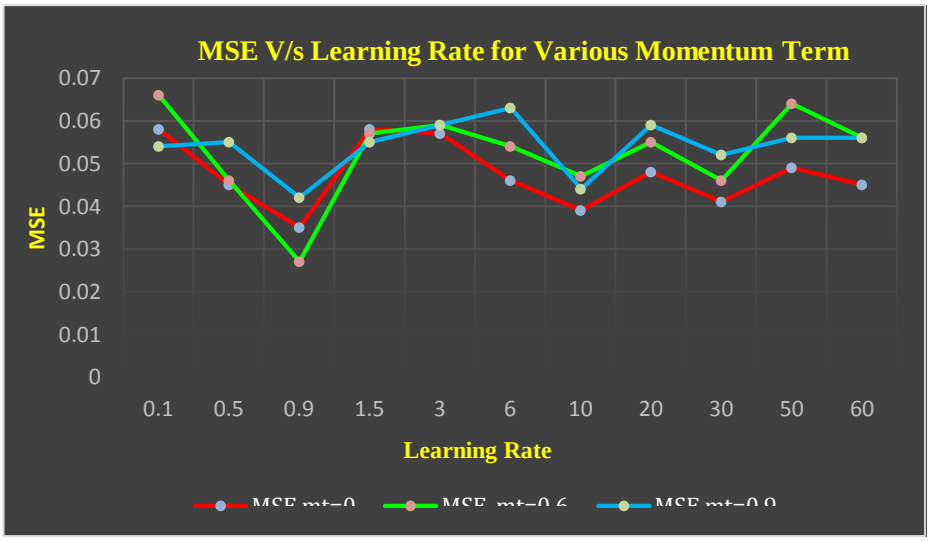


Figure 6. MSE V/s Learning Rate & Momentum

Figure 6 shows that the MSEs are obtained for various combinations values of learning rate and momentum term in which it is minimum at learning rate = 0.9 and momentum term 0.6.

Step 3.2.6 : *Training Stopping Criteria:* In training process of NN there are many ways to set as stopping criteria. Here, we are taking the termination condition as number of iterations (Epoch) to be performed at which the MSE is become minimum.

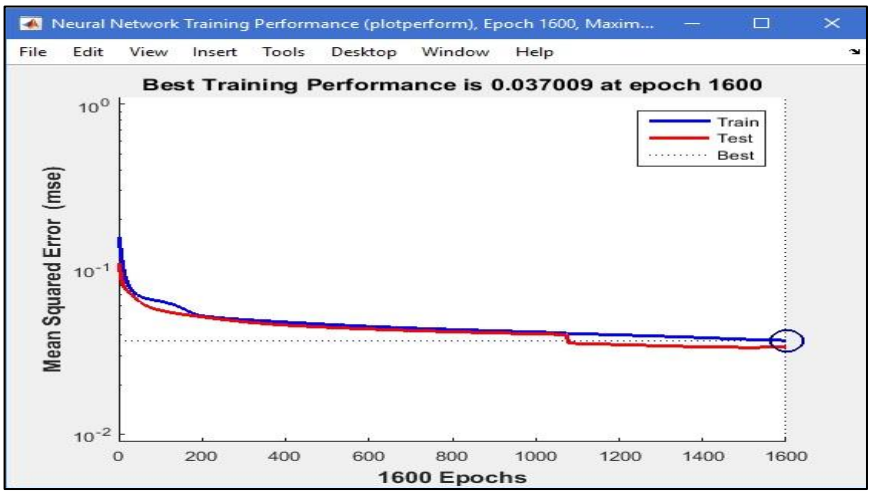


Figure 7. MSE V/s Number of Epoch

From the Figure 7, it is observed that the MSE of Train set and Test set is become minimum at 1500 epoch. Thus, training stopping criteria is set to perform maximum 1600 epoch.

Step 3.2.7 : *Number of ICA eigen images:* In the classification of an emotion of an individual human the various hand gesture images are entered to the system, from which their features (Eigen Images) ICs are obtained for classification by NN. Here, we are interested in only those eigen images which are significantly vary, and the remaining having similar nature are not considered because of to reduce time and process.

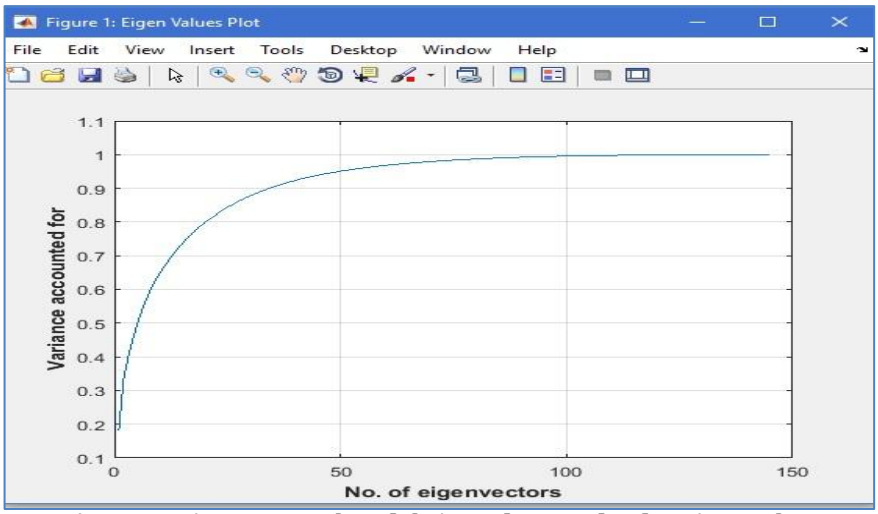


Figure 8. Eigen Vectors based their on decreased order Eigen values

Figure 8 shows that the eigenvectors of ICs are plotted according to their decreased eigenvalues and found that the eigen images are significantly vary up to 40 -50, such that only 40 ICs are considered as an input for training process.

Step 3.3 : *Set Target Matrix for input eigen image:*

P11	P12	---	P1n
P21	P22	---	P2n
---	---	---	---
Pm1	Pm2	---	Pmn

Happy – Expression Eigen Image

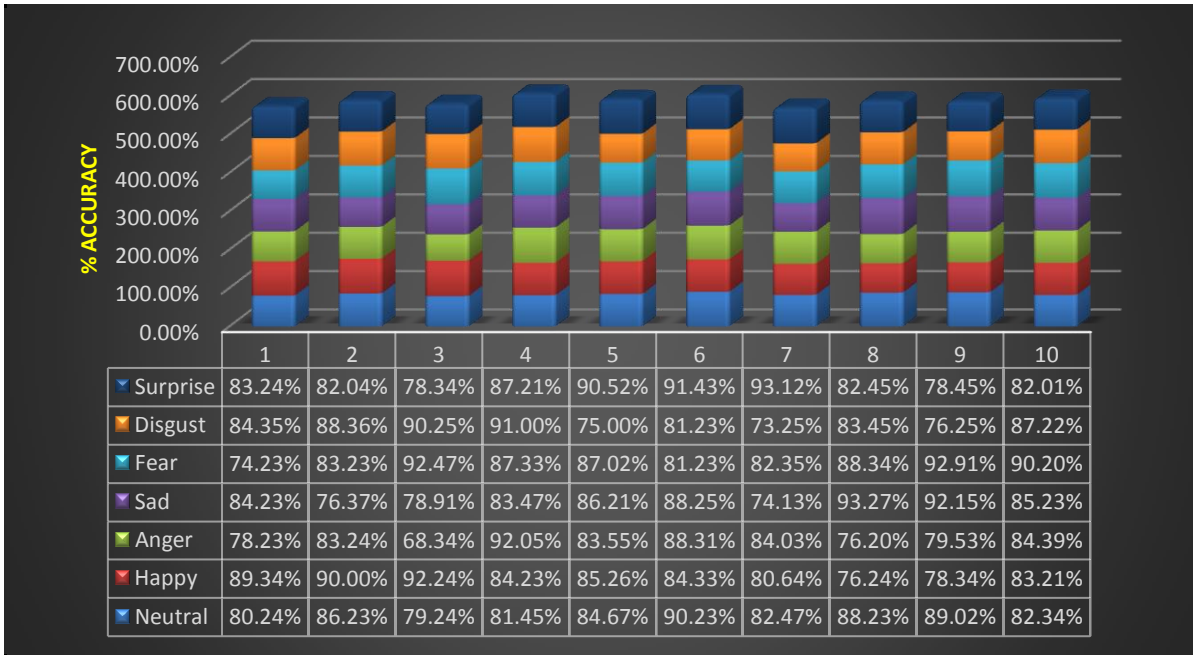
$$\Rightarrow \begin{bmatrix} 0.1 \\ 0.9 \\ 0.1 \\ 0.1 \\ 0.1 \\ 0.1 \\ 0.1 \end{bmatrix}$$

Transformed Image Matrix

Where, P_{ij} indicates the pixel value of Eigen image of size $m \times n$.
Similarly, the target matrix for all other emotions are obtained where, 0.9 is responded to classification

III. EXPERIMENTAL RESULT

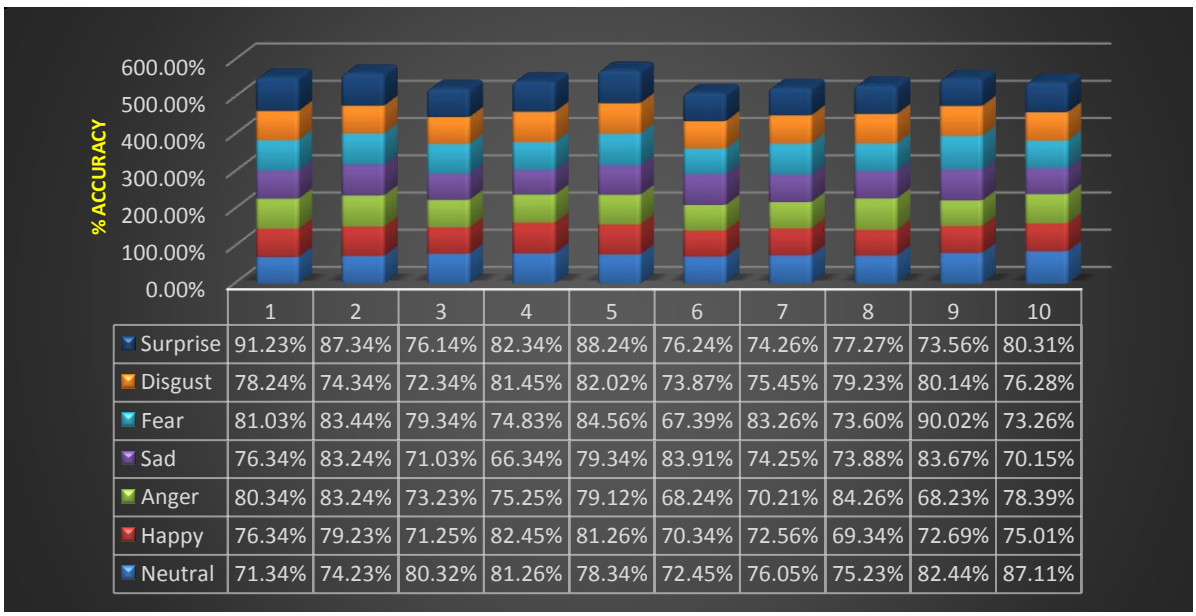
To recognize emotion using Neural Network for ICA of hand gestures of a human, 10 individual persons are taken as a sample. Their hand gesture images are captured for respective emotion and stored in database. Further, the database is divided into two sets, Training set and Testing set which consists respectively 90% and 10% of size. The test image is classified over the whole training set for an individual emotion of an individual person and the percentage accuracy of classification is measured as follows.



	1	2	3	4	5	6	7	8	9	10
Surprise	83.24%	82.04%	78.34%	87.21%	90.52%	91.43%	93.12%	82.45%	78.45%	82.01%
Disgust	84.35%	88.36%	90.25%	91.00%	75.00%	81.23%	73.25%	83.45%	76.25%	87.22%
Fear	74.23%	83.23%	92.47%	87.33%	87.02%	81.23%	82.35%	88.34%	92.91%	90.20%
Sad	84.23%	76.37%	78.91%	83.47%	86.21%	88.25%	74.13%	93.27%	92.15%	85.23%
Anger	78.23%	83.24%	68.34%	92.05%	83.55%	88.31%	84.03%	76.20%	79.53%	84.39%
Happy	89.34%	90.00%	92.24%	84.23%	85.26%	84.33%	80.64%	76.24%	78.34%	83.21%
Neutral	80.24%	86.23%	79.24%	81.45%	84.67%	90.23%	82.47%	88.23%	89.02%	82.34%

Figure 9. Percentage Train Accuracy NN with ICA Hand Gesture

The training accuracy obtained in Figure 9 indicates that, the train set is classified in the seven emotions with the overall percentage accuracy of 80-85%. Which is satisfactorily good as the variety of hand gesture with respect to variety of emotions to be classified. The accuracy can also be improved by updating training set by more precise hand gesture images of an individual.



	1	2	3	4	5	6	7	8	9	10
Surprise	91.23%	87.34%	76.14%	82.34%	88.24%	76.24%	74.26%	77.27%	73.56%	80.31%
Disgust	78.24%	74.34%	72.34%	81.45%	82.02%	73.87%	75.45%	79.23%	80.14%	76.28%
Fear	81.03%	83.44%	79.34%	74.83%	84.56%	67.39%	83.26%	73.60%	90.02%	73.26%
Sad	76.34%	83.24%	71.03%	66.34%	79.34%	83.91%	74.25%	73.88%	83.67%	70.15%
Anger	80.34%	83.24%	73.23%	75.25%	79.12%	68.24%	70.21%	84.26%	68.23%	78.39%
Happy	76.34%	79.23%	71.25%	82.45%	81.26%	70.34%	72.56%	69.34%	72.69%	75.01%
Neutral	71.34%	74.23%	80.32%	81.26%	78.34%	72.45%	76.05%	75.23%	82.44%	87.11%

Figure 10. Percentage Test Accuracy NN with ICA Hand Gesture

The test accuracy shown in Figure 10 indicates that the percentage accuracy of newly entered test image of a hand gesture into the system has over all percentage accuracy level is 75-80%. Which is expected level of accuracy can be improved by updating the training set, by taking more precise images as an input and also by more training of Neural Network.

IV. CONCLUSION

In the identification of an emotion of an individual by taking ICs of hand gestures, Neural Network has performed its vital role in the classification. The overall accuracy level obtained by NN Classification has been satisfactory, having scope of improvement. Thus, the measurement of emotion with respect to one's various hand gesture formed during communication shows the mental situation or the behavioral pattern. This is very much helpful for a negotiator to understand or to deal with counter person which makes the communication fruitful, smoother and faster. It also boost up the decision making process and the ultimate output can be achieved.

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