

ANN Based Emotion Recognition along Valence Axis Using EEG

Dr. Mandeep Singh, Mr. Mooninder Singh, Nikhil Singhal

Department of Electrical & Instrumentation Engineering, Thapar University, Patiala, India
mandy_tiet@yahoo.com, mooninder@gmail.com, nikhilsinghal.729@gmail.com

ABSTRACT

The measurement using EEG has enabled the researchers to monitor the small electrical activity arising out of the brain of post-synaptic potentials in neurons, which vary due to human reactions. In this paper we consider the ERP features which consists of event related brain potential components that are collected by the means of technique called electroencephalography (EEG) for classification of emotion into two classes namely low valence or unpleasant and high valence or pleasant. The raw EEG data is available at enterface 06 website. The ERP features selected for emotion quantification are P100, N100, P200, N200, and P300. The ERP features collected from the data of 7 electrodes namely Cz, Pz, Fz, FC1, FC2, F1, and F2 for 3 participants are then passed through Feedforward and Multilayer 2- hidden layer ANN classifier to find out the accuracy in the classification. The average accuracy obtained using Feedforward classifier is 71.27% but on analyzing the same attribute set with Multilayer 2- hidden layer Neural Network classifier a very high accuracy of 100% has been achieved. This can be considered as a novel breakthrough in the Brain Computer Interface (BCI) implementation.

INTRODUCTION

The Electroencephalogram (EEG) is considered a powerful tool in both neuroscience research and clinical diagnosis because it allows to record from the surface of the scalp, electrical signals arising from the brain[1]. In this research undertaken Event Related Potential (ERP) features have been extracted from the EEG acquired from different participants. The attributes taken into consideration from the acquired EEG are P100, N100, P200, N200, and P300 for classification of emotions in two classes along the valence axis while ignoring arousal axis dimensions. To classify the data we used inbuilt tool of feedforward (feedforwardnet) and 2-hidden layer neuron (nntool) in MATLAB R2011 version.

Jennifer Healey (2001) worked on the 8 emotional states namely no emotion, anger(High arousal negative valence), hate (Low arousal Negative valence), grief (High arousal negative valence or Low arousal Negative valence), love(Low arousal positive valence), romantic love(love for opposite sex- very high arousal positive valence), joy (high arousal positive valence)and reverence(for nature and God-low arousal and neutral valence) with the help of guidelines mentioned by Clynes [2]. To recognize 8 emotional states 5 sensors were used. The classification of these emotional states was done by using Fisher analysis and the accuracy lied between 80% and 90%. In his pioneer work Russell, J.A. (2003) discussed about the feelings like joy, happiness, fear, angry, depressed, displeasure and all were inter related. He worked on affective space model (Valence and Arousal) by representing them as a circle in a two dimensional space. He represented arousal dimension with pleased along the X-axis.[3]

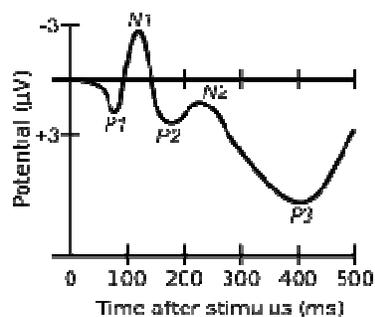


Figure 1: ERP [4]

DATA COLLECTION

The data gathered by Svran at el at the interface 06 workshop has been used for analysis. The attributes have been determined of three participants namely P3, P4, and P5 for the seven electrodes Cz, Fz, Pz, FC1, FC2, F1, and F2. The determined attributes have been used for emotion quantification into low valence and high valence states using Feedforward and Multilayer 2-Hidden Layer Neural Network classifier. The analysis has been done on the EEG data available on the Enterface website [5]. The data set provided by enterface 06 contains four files, one containing the EEG data for five participants all are male as well as right handed in 3 sessions in Biosemi Data Format (BDF) format. The second one contains fNIRS information, the third one contains the set of images shown to the participants along with their mean arousal and mean valence values and fourth file indicated the self assessments of participants along by the five subjects under observation. The emotions were elicited by using the stimulus provided by university of Florida called International Affective Picture System (IAPS) [6] in NIMH center. The participants were also asked to rate the images on the arousal and valence scale using self assessment manikin method (SAM) [7]. This work shows that images were shown to the participants after selected from IAPS based on three classes namely clam, positive exciting, and negative exciting. The data has been digitized and processed upon by using the open source software called EEG LAB [8].

The images shown for calm had a mean arousal value of less than 4 and mean valence value between 4 to 6, while the stimuli for positive exciting had a mean valence greater than 6, variance valence smaller than 2 and mean arousal greater 5, and for exciting negative mean valence should smaller than 3 and mean arousal greater than 5 [5].

calm : mean arousal < 4 ,4 < mean valence < 6

exciting positive : mean valence > 6.8

var(valence) < 2
mean arousal > 5

exciting negative : mean valence < 3
mean arousal > 5

Each image was shown for 2.5 seconds and total of 5 images were shown for evoking one emotion at a time. So to evoke one emotion the EEG data was collected for 12.5 seconds. The EEG data was collected at a sampling rate of 1024Hz in the three sessions for each participants and the images were shown in a random order. To reduce the data set, the EEG data for participants 3, 4, and 5 has been down-sampled at a sampling rate of 256Hz and also considered the seven EEG electrodes Cz, Pz, Fz, FC1, FC2, F1, and F2 to classify the emotions in two classes high valence (Pleasant) and low valence (Unpleasant).

FEATURE EXTRACTION

In the investigation done by Danny in 1999, psychological EEG signals were continuously monitored on line in order to determine the participant's functional state. We studied raw data provided by enterface 06 of three participants with 3 sessions on seven electrodes Cz, Pz, Fz, FC1, FC2, F1, and F2 [7].

Further, this information was used to adapt the task when high levels of mental emotions were detected in order to see if task performance would be enhanced or harmed. The goal of the present analysis was to determine the level of accuracy that a Feedforward and Multilayer 2- hidden layer ANN classifier could achieved using psychological variables to determine participants' level of mental emotions while they performed a complex task.

P100 is also called P1 as it is the first positive peak observed from 80 to 120ms. After the onset of stimuli, we took P100 as the maximum ERP of the subject in the time limit of 80 to 120ms. For the corresponding electrode, the P100 of the subject was determined manually. N100 is just reverses of P100. Here the minimum of ERP value was chosen as an attribute for classification. The N100 was also determined within the time limit of 80 to 120ms. P200 is

a second positive peak observed about 200ms observed between 150 and 275ms. N200 in particular is a negative-going wave that peaks 200-350ms post-stimulus and is found primarily over anterior scalp sites. P300 is a positive peak observed at 300 ms varying between 250 and 500ms. The data file pertaining features extraction contains 5 rows and 1260 columns [9].

CLASSIFICATION

Feedforward neural network is a biological inspired classification algorithm. In this network, information moves in only one direction, forward, from the input node through the hidden node and to the output nodes. Since data flows only on forward direction with no feedback they are called feedforward neural network. Feedforward neural network has been implementing using the built in function in MATLAB R2011a version. We used feefforwardnet MATLAB function to classify the emotions [10].

Multilayer neural network is feedforward neural networks trained with the standard back-propagation algorithm. Generally only one hidden layer neural network is used for classification but we used 2-hidden layer neural network. So we started with 5 neurons in first hidden layer and 7 neurons in second hidden layer for classification. In our thesis to determine the accuracy in emotional EEG data we used built in MATLAB Tool nntool of MATLAB version R2011a version [11] [12][13].

Generally in one hidden layer 10 neurons were used as an input to determine the classification rate of EEG data. In Multilayer Neural Network we used 2-hidden layer network with 5 or 10 neurons in first hidden layer and 7 or 40 neurons in second hidden layer for classification to increase the efficiency in data [14] [15] [16] [17].

RESULTS

From the Classification technique, we classified the extracted data into two classes' i.e, high valence or positive or 1 and low valence or negative or 0 using ANN network (Feedforward and Multilayer 2- hidden layer Neural Network) classifier. In this, we used the extracted features from ERP in different combinations to analyze the difference in accuracy of data. First we used the ERP features of EEG signal to get the accuracy in data of only one participant in Feedforward and used a feedforwardnet MATLAB Tool for classifier and we observed the accuracy of around **72.21%** for participant number 3. Then we worked on the attribute set of participant 4 and observed the accuracy of **65.95%**. After that we took the data of participant 5's EEG features and on classification we observed the accuracy of around **72.34%**. At last we analyzed all the 3 participant's features of EEG signal together and observed the accuracy of **76.59 %**. Table shows the accuracy using Feedforwdnet.

Participant	Error	Accuracy
Participant-3	29.78%	70.21%
Participant-4	34.04%	65.95%
Participant-5	27.66%	72.34%
Participant-3,4, & 5	23.40%	76.59%

Figure 2: Table of Accuracy of Feed forward Neural Network

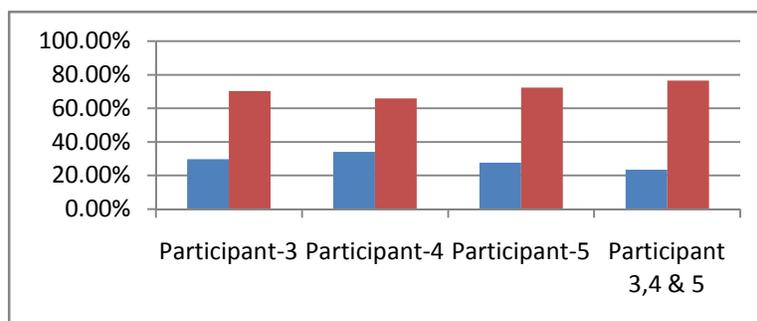


Figure 3: Graph of accuracy of feedforward

In Multilayer 2-hidden Neural Network, we used the 2- hidden layer neural network to classify the data with the help of nntool (MATLAB Tool). After classifying the ERP features of EEG signals we observed the accuracy of **100%**. When we took the data of participant 3 and of all three participants together, we used 5 neurons in first hidden layer and 7 neurons in second hidden layer. Then for analyzing feature set of participant 4 and 5 we took 10 neurons in first hidden layer and 40 neurons in second hidden layer. From these we got the accuracy of **100%** by Multilayer 2-hidden Neural Network.

Participant	Accuracy
Participant-3	100%
Participant-4	100%
Participant-5	100%
Participant-3,4, & 5	100%

Figure 5: Table of Accuracy of multilayer 2-Hidden Layer Neural Network

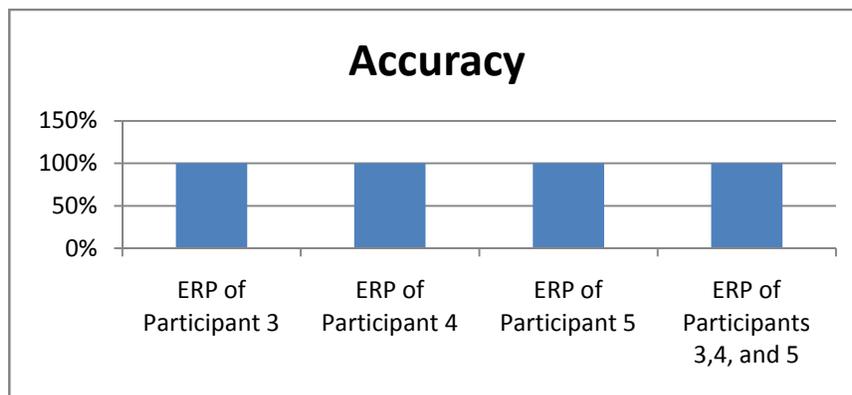


Figure 4: Graph of accuracy of multilayer 2-hidden layer neural network

CONCLUSION

In this work, we used psychological data to classify and find out the accuracy using Feedforward and Multilayer 2-hidden Neural Network ANN classifier. We used 3 participants data that is calculated at 7 electrodes namely Cz, F1, F2, FC1, FC2, Fz, Pz at a sampling frequency of 256 Hz. We observed that psychological EEG data can also be easily grouped into relative emotional classes. Using ‘feedforwardnet’ matlab tool we obtained the overall accuracy of 76.59% with single hidden layer neuron network with 10 neurons as an input to it. On using ‘nntool’ matlab tool for 2- hidden layer network we obtained the overall accuracy of 100%. In this, numbers of neurons were changed from 10 to 5 and 40 to 7 to each layer to improve the efficiency of result. So finally we observed that the 2- hidden layer neural network gave best accuracy among all the above mentioned classifiers.

For validation of very high results it is required to consider data that is gathered from more number of participants. Further quantification of emotion into more number of classes is considered as very high accuracy rate have been achieved.

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