CLASSIFICATION OF NOISY BRAINWAVES INTEGRATED WITH EMOTION CLASSIFICATION

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ABSTRACT

This paper investigates the previous systems which worked on brainwaves and achieved a little amount of brainwave filtration, the paper also reports about the project which was motivated by the predecessor of the same problem domain, which uses the concept of Artificial Neural Network, in a completely fresh manner which is different from the existing methodologies. The results achieved is the comparative study of brainwave handling which were captured and recorded via Electroencephalograph, after which the emotion classification, emotion domination calculation and brainwave filtration is done.

KEYWORDS: *Brainwave, Emotion Classification, Emotion domination calculation, Brainwave filtration Electroencephalograph*

1. INTRODUCTION

1.1. Background

The human brain is something which cannot be examined by the coherent approaches as it plays the role of the most vital organ present in the body. The entire human biological system is being manipulated by the brain, and to link it with other theatrical roles of the body spinal cord is used.

Neurons are the fundamental part of the brain, which consisted of a cell body, dendrites and an axon. For the communication in the human body electrical impulses are applied. Due to advancement in the technologies it is possible to record electrical signals produce by the impulse. The brain comprises of four different type of waves which is illustrated in table 1.

rhythm	Freq (Hz)	Amp(μV)
alpha	8-13	20-200
beta	13-30	5-10
delta	1-5	20-200
theta	4-8	10

Table 1. Waves Frequencies and Amplitudes

The recent developments in Brain Computer Interface (BCI) technologies have been experienced, emotion detection and sorting. The subjects have provided findings in several contexts, including

communication, medical, teaching and many more areas. In our research, we have employed different techniques and approaches in the process to classify different emotional state of the gathered signals and classified them into three categories such as Happiness, Sadness and anger.

1.2. Electroencephalograph, EEG

The EEG is basically a test which detects any kind of abnormalities in our brain waves, or any electrical activity of our brain, and to carry out this formality an EEG gear is needed. The EEG gear is placed over the scalp to record the signal waves. The device can either use a wet electrode or a dry electrode, depending upon the needs of what operation we need to carry out. In case of a wet electrode, an electrolyte gel is applied over the scalp. Dry electrodes are often preferred mostly as it is more convenient when compared to wet electrodes. Raw data are being collected from the EEG device to feed into the signal processing system for the training of the neural net. A headgear is depicted below in Figure 1.

Figure1. Emotive Neuroheadsets

1.3. Noise Interferences

In communication, noise interference is anything which modifies, or disrupts a signal when it travels along a channel between a source and a receiver. Few are the possibilities where noise might occur considering that the system is connected. It is often collectively made owing to the presence of the system in addition as subject artefacts. Therefore, for the maximum reduction of the noise, the NON technique is used and will be disused in the future references.

1.4. Emotion

Emotion is any conscious experience characterized by intense mental activity and a certain level of joy or displeasure it can be generally classified on the foundation of two models: discrete and dimensional. Dimensional model of emotion suggests that emotional states can be accurately represented by a low bit of underlying affective dimensions. Most dimensional models consisted of two categories valence and arousal. Valence refers to the level of ‘pleasantness’ associated with an emotion (e.g. Sad, stressed) to pleasant (e.g. Happy, excited). Whereas arousal refers to the strength of experienced motion and can range from active (e.g. Alert, elated) to inactive (e.g. Uninterested, bored), the measurement of the emotions can be either subjective or objective.

2. EXISTING METHODOLOGIES

2.1. Method I

The first methodology was purely based on classification of Alpha and Beta waves which was supported by Balkis Soiehah Zainuddin, Zakaria Hussain, and Iza Sazanita Isa. The method of knowledge assortment was wiped out associate degree isolated atmosphere wherever the experiments were done supported 2 categories of topics: the clustering of the healthy person while not neural disorder and a couple of patients with the neural disorder. Dry electrodes are placed over the head for on the patient's scalp. The regions engaged in the brain were the frontal (F), central (C), temporal (T), posterior (P), and bone (O). The experiment was through emotional encephalogram Neuroheadset that

has fourteen channels. Here the patient was asked to relax for a few times, he was asked to try to a quantity of thinking and reading was taken in each case. For reduction of dissonance, the non-inheritable knowledge was more experienced the bandpass filter so more experienced the notch filter. To decrease the amplitude, completely different classification algorithms were tested, like K-nearest (KNN) that permits build inferences concerning however distinct the emotion square measure from one another, the opposite was Naïve Bayes in this case a wave is characterized by its amplitudes which emotion square measure matched to sample waves that have the correct registers, and also the last one was Artificial Neural Network algorithmic rule (ANN) here with the assistance of neural nets by coaching the nets it helps in nonlinear relationships of options. During this feedforward net were trained to use a scaled conjugate gradient backpropagation to update the weights and live performance on the completely different size of hidden layers wherever size maximizes the coaching and determine performance. The engagement of neural web was economical because it may be trained simply and may provide satisfactory results.

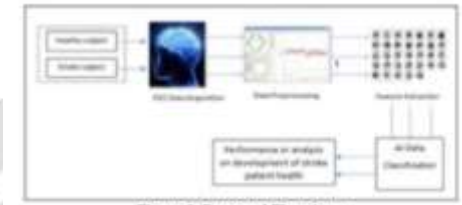

Figure 2. Proposed Flowchart

2.2. Method II

This advance was based on hardware-oriented management, which was proposed by K. Suresh, Aminath Saadha, K. Preparing and Aravind C.V. In this it was supposed that the noise produces by physical elements will only be removed from hardware minded filters. In this the experiment consisted of the people between 24-27. The experiment was directed towards 3 mental conditions: 1st is that the state of relaxation where the patient was asked to relax their mind by paying attention to some soft-core music, same in the next case the reverse was being asked i.e. to brainstorm by giving the mathematical problem and to resolve it in quarter-hour, followed by the third case within which the person was asked to 1st relax and to solve the mathematical problem. The experiment was directed towards the analogue signals and to take advantage of utilization graph. For reduction of unwanted noises a series of low and high pass filters were used, where a Butterworth filter was made by modifying the LM741 electronic equipment to attain this.

The conclusion of the subsequent experiment was down with the domination of alpha waves throughout relaxation about an hour and through the physical exertion session, the domination was seventieth that because of the brainwave. Also, the error rate of the system was found five. As a result 27% of the utilization of hardware-oriented filters.

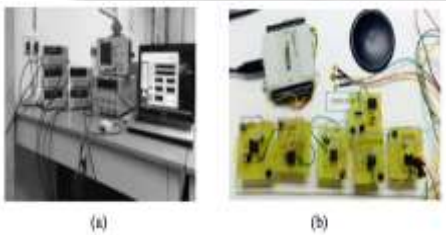

Figure 3 (a): Setup (b): Hardware Filter

2.3. Method III

The third method was approached by Tomas Matlovic based on the EEG device Emotiv EPOC and classifies emotions from the data captured by the device. Here the classification is done based on the data captured by the EEG device. The preliminary result was shown 37.72% accuracy. The multimodal data set for the analysis of human affective states which contains data from 32 participants who watched 41 minute long music videos. The EEG data were recorded with 32

electrode EEG device. The emotion was predicted from the arousal and valence values. In this experiment they used a support vector machine to classify six emotions: joy, surprise, sadness, fear, anger and disgust, and the emotion accuracy were 35.71%.

In order to evaluate the approach it was decided to replicate experiment which resulted into the dataset that was used for preliminary evaluation. In this experiment the participant was supposed to watch 31 minute music video highlights. Before every video, fixation crosses was projected for 5 seconds and after each video participants answered questionnaire with 3 questions:

How strong was the emotion that you felt? (Arousal)

How positive was the emotion that you felt? (Valence)

What emotion did you feel the most?

For managing the experiment, they used Tobii Studio, where they played their videos and displayed the questionnaires. EEG data were recorded with the EPOC Emotiv device. First analysis shows accuracy 36%, which was not sufficient, but they overcome the chance of random selection which is 14.3% (for 7 classes, i.e. six emotions plus the neutral state).

3. PROPOSED APPROACH

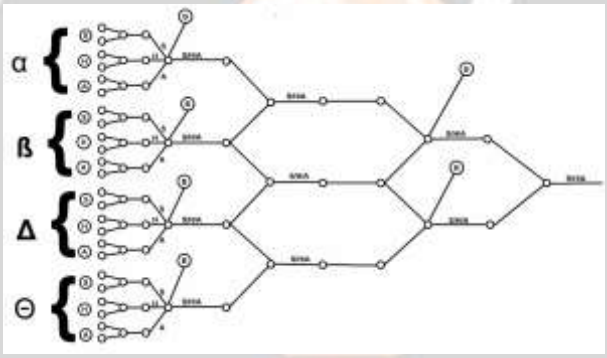

Figure 4. Network of Networks (Perceptron & Adaline)

The previously mentioned method had a noticeable impact on the quest of solving the problem, but these works became the grounding foundation to the method used in the present experiment. The proposed method uses the Artificial Neural Network (ANN) in a unique manner which has been talked about in a manner of conceptual study, the manner termed as Network of Networks, as suggested in the conceptual study it is a complex network of different sub-networks where output of one network is passed on to the other. This was developed from the Nested Neural Network which was implemented by NASA in the year 1988, where the sub-network and the main outer network were the same.

In this cumulative network, each network is connected to another network and that network is connected to another network and forms a group of nets and the net is connected to another group of nets which forms the nested net. The information and retrieval were impressed from Hopfield model. The nets that are being nested are all of the constant sorts that are analogous to the conception for nesting a for-loop within the ancient programming languages.

Originally as the concept goes the idea was to connect competitive neural networks, the connection was as follows, two Kohen Self Organizing Maps will be connected to a Maxnet, but in this paper, the approach was kept more fundamental as to demonstrate the concept only two types of nets were interconnected, namely Perceptron and Adaline.

The NoN does two actions simultaneously, the filtration of the brainwaves and the classification of emotions realized from those brainwaves. The EEG collects the brainwave signals from the subject and feeds it into the system where the noise is classified and removed and the process of emotion

classification is done. The system neither does pure classification or clustering, but a filtered classification, in other words instead of classifying raw data directly, classification of filtered brainwaves is done. The system stores the brainwaves as datasets for sake of easy computation.

Each layer has its own characteristic accuracy, hence for the requirement of calculating the accuracy of the system a slightly different approach is being deployed. In the NoN the accuracy of each net is considered and none of them is ignored and each of the nets is connected in series and has an impact over the next net in the series and two nets which are in parallel relation also have a considerable effect over one another. The calculation of accuracy will be discussed in the forthcoming sections.

Out of the six emotions namely, sadness, anger, happiness, disgusted, surprised, fear, this paper has considered only three i.e sadness, anger and happiness, as they are the most common among the six and are often seen most of the times in our day to day life. Each of the feelings have a particular brainwave signature, in other words, a particular range value for alpha, beta, delta and theta waves, which have been considered for the analysis.

4.ARCHITECTURE

Figure 5. Architecture

The system has two non-systems based component and six system based component. The non-system based components are the user and the subject, the subject is the person on the device is actually used on and the user is the person who is responsible for carrying out the procedures which comes after obtaining the analysis report from the system.

The system based components are the EEG headset, 1st Training module, the Train module, the Test module and the Analysis Report and the Storage module and finally the Graphical User Interface module. To, begin with the first module which comes in the order is the EEG headset, it is the same device about which we had discussed in the previous section. The work of this module is to capture and record the brainwaves which are produced by the subject's nerve cells in reaction to particular stimulus. The recordings are converted into a dataset collection for further computation, which will result in filtration and classification.

The next module which comes into play is the 1st Training module, where the system is trained for the first time to the response of the subject, this module may or may not use the testing subject as the training material. This module is run only once when the system receives its initial dataset and it is untrained, this module set the initial weights to the different nodes of the NoN. Once the initial training is over the subsequent training is conducted by the Train module.

After the 1st Training is over the system saves the model and for further training the model, the Train module is used. This module takes the weights obtained and adjusts them as per the new training pattern. It is this module from which it can be inferred whether the network is trained to a satisfactory level or not. Next up is the Test module where no training happens, in other words, the weights are unchanged and no updating of weights take place even if the classification is incorrect and filtration is incomplete, hence it is advised to activate this module only when the network is trained to a satisfactory level, as it is in this module the real-time classification and filtration takes place. The module following Train module is the Analysis Report and the Storage module, this module stores the final classification and filtration results, the classification results are shown in the form of graph and

the filtered results are stored in the database for a further multidisciplinary application. The last module is the Graphical User Interface, like any system even this system requires to establish a bridge between the user and the system. The GUI is easy to read and understand and the display is very straightforward. The entire above-mentioned module collaborates with each other to form a unified system which can be used in multidisciplinary areas and for various purposes.

5. IMPLEMENTATION

5.1. Design

The backend of the system is designed in C and the front-end is designed on Python. The backend consists of the collected dataset collection module the 1st train module, the training module and the test module .the analysis report and storage, is partly designed on Python and C respectively. The choice is so because as the C code runs faster than Python code, as a result, it puts less pressure on the system over which it is trained and tested. The manual memory

management which is essential for the system is supported by C. Since the NoN is a new and fresh concept hence the intricate details need special attention and so the choice of C. The choice of Python is made for the GUI as it has vast and comprehensive libraries for the purpose so the choice.

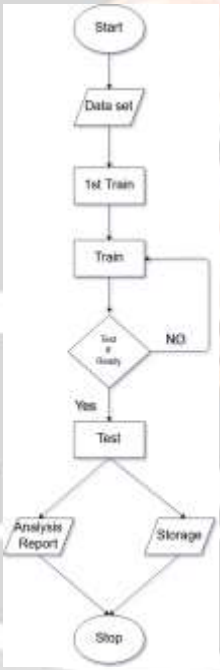

Figure 6. Algorithmic Workflow

5.2. Algorithm

The system is a mix connection of Perceptron and Adaline, the inputs from n number of perceptron's become input to an Adaline and these m numbers of Adaline's become input to a perceptron. The dataset is first transferred to the 1st Train algorithm where it trains for the first time then it is passed to the subsequent training module where the network is trained further once the choice is made then the testing starts and results are produced during the testing and after the test results are ready it is displayed as graph and filtered brainwaves dataset is stored.

5.3. Experimentation

The dataset of the already recorded brainwave was collected from the experiment conducted in Japan in the year 2015 by Dr. S.Valenzi and Dr. T. Islam, where five subjects were shown video clips from movies and the reaction to those stimuli were recorded. The project took the data of four subjects for training and the data of the fifth subject was used for training. The dataset was an open source dataset and it was raw dataset which was obtained from a headgear having channels.

The dataset was normalized for the project to be used effectively. The proposed system utilized only 24 channels' data out of the 32 channels.

5.4. Result

The overall training accuracy was seen at 85.67% which was considered the net as a whole but when the theoretical accuracy was considered which was considering the cumulative accuracy of individual nets then the value was slightly high and the overall training accuracy of individual nets varied from 85% to 89%. The training accuracy obtained at the last epoch of training of all the nets varied from 84% to 87% considering the fact that each net required a different number of epochs to reach their optimum accuracy. The testing accuracy obtained was 83.89%. The calculation of accuracy was done in a different manner, which will be discussed in the next section.

5.5. Accuracy

The accuracy calculation is done in a different manner, as we are dealing with NoN hence, there are some accuracies that are to be considered. The three being Overall Testing Accuracy, Epochal Accuracy and the Overall Training Accuracy considering the individual nets and considering the net as a whole.

$$Overall\ Testing\ Accuracy = \frac{(Number\ of\ Correct\ Classification)}{Total\ Number\ of\ attempts} \cdot 100$$

$$Epocal\ Accuracy = \frac{(Number\ of\ Correct\ classification\ in\ dataset)}{Number\ of\ dataset} \cdot 100$$

$$CumulativeAccuracy = (\sum_{i=0}^{n}(OA)_i * (m)_i) / \sum_{i=0}^{n}(m)_i$$

Where, i: The number of the net
OA: Overall Accuracy of the Net
m: The number of Epochs completed by net

Accuracy Type	Accuracy
Testing	83.89
Filtration	82.67
Training	85.67
Cumulative Training	88.23
Emotion Classification	83.23

Table 2. Accuracies

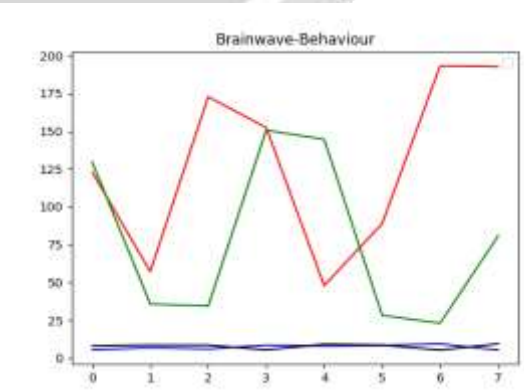

Figure 7. Brainwave Graph (red: alpha, blue: beta, green: delta, black: theta)

Figure 8. Graphical User Interface

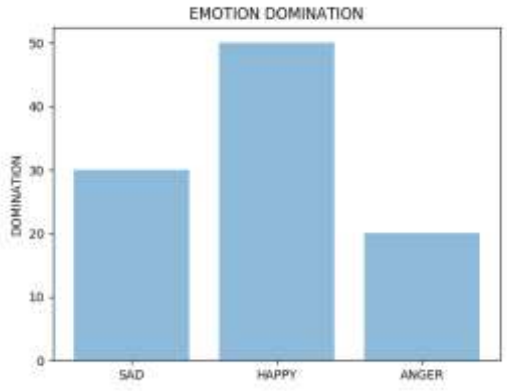

Figure 9. Emotion Domination based on Testing Data

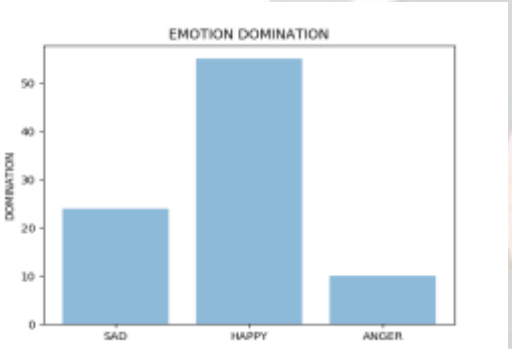

Figure 10. Emotion Domination based on Training Data

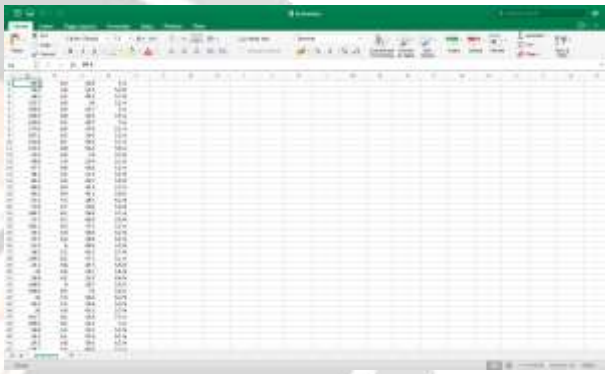

Figure 11. Filtered Brainwave CSV file

6. CONCLUSION

The obtained system had the capability of taking the brainwave input dataset and perform the filtration and emotion classification process. Although since the sample size of training is four and testing sample size was one which is very small hence the performance was as mentioned, but in case if the training sample size and the testing sample size is varied then the accuracy will also vary.

In the near future there are plans to add some enhancements to the systems which make the system more adept in terms of machine learning and provide better outputs, but taking into account that the system was a testing prototype, it performed up to its predecessors' set standards.

REFERENCES

[1].Ashwani Vaishya, Abbas Taher Bahrainwala, Preeti Kumari, Aniruddha Biswas "CLASSIFICATION OF NOISY BRAINWAVES", International Journal of Electrical, Electronics and Data Communication, Volume 6,Issue 2

[2] Balkis Solehah Zainuddin, Zakaria Hussian, Iza Sazanita Isa "ALPHA AND BETA EEG BRAINWAVE CLASSIFICATION TECHNIQUE: A CONCEPTUAL STUDY", 2014 IEEE INTERNATIONAL COLLOQUIUM ON SIGNAL PROCESSING & IT'S APPLICATIONS(CSPA2014),7-9Mar, Kuala Lumpur, Malaysia.

[3] K.Suresh, Aminath Saadha, K.Pirapaharan, Aravind C.V "CHARACTERISATION AND SEPARATION OF BRAINWAVE SIGNALS", JOURNAL OF ENGINEERING SCIENCE AND TECHNOLOGY

EURECA 2014 SPECIAL ISSUE JANUARY (2015).

[4]. Yoram Baram, Nested Neural Networks (NASA-1H-IC1032) August 1988.

[5].https://bsini.brain.riken.jp/modules/xoonips/detail.php?item_id=37

[6]. Tomas Matlovic Emotions detection using EPOC EEG Device

[7] .Matteucci, M.; Carabalona, R.; Casella, M.; Di Fabrizio, E.; Gramatica, F.; Di Rienzo, E.; Snidero, E.; Gavioli, L.; and Sancrotti, M. (2007). Micropatterned dry electrodes for brain - computer interface. Microelectron. Eng, 84(8), 1737-1740.

[8].M. Teplan, "Fundamentals of EEG measurement," Measurement science review, vol. 2, pp. 1-11, 2002.

[9] Wang, J.; Zhang, Q.; Zhang, Y.; and Xu, G. (2013). Automatic artefacts removal from epileptic EEG using a hybrid algorithm. 477-488.

[10] Bhagavatula V., Advanced Signal Processing and Machine Learning Approaches for EEG Analysis, Jun 2010.http://wwwresearchgate.net/publication/235054600_ Advanced_Signal_Processing_and_Machine_Learning_Appr oaches_for_EEG_Analysis