THOUGHT TUNES - A SMART MUSIC PLAYER INVOLVING MIND-STATE AWARENESS

A PROJECT REPORT

Submitted by

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BONAFIDE CERTIFICATE

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(EXAMINER 1) **(EXAMINER 2)** **(EXAMINER 3)**

ABSTRACT

A Brain Computer Interface (BCI) is a new communication channel allows a person to control special computer applications through the use of his/her thoughts. BCI research is based on recording and analysing electroencephalographic (EEG) data and recognizing EEG patterns associated with various mental states. A recurrent neural network involves processing nodes that has its own small sphere of knowledge, including what it has seen and any rules it was originally programmed with. It saves the output of processing nodes and feed the result back into the model. They are notable for being adaptive. A key to connect the mind - music synchronization. Usage of mind-control devices for a broader range of applications other than medical equipment's, gaming, PC's etc. Effective use of audio streaming by incorporating Neural network concepts. To train and implement a smart music player which supports the listener by enhancing relaxation and mood conversions. To provoke automation of playlist generation by means of analyzing the inputs obtained. To reduce overlap in mood extractions, maintain log of user preferences and save results of music experience.

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CHAPTER I

INTRODUCTION

Human brain is the largest and most complex organ in the human body. It is responsible for numerous tasks and functions the brain along with the spinal cord and associated peripheral nerves make up the central nervous system. The human brain control all aspects of life such as interpreting senses, initiating body movement, controlling behavior, logical thought and memory. The central nervous system control every part of a person's daily life from blinking, breathing and walking. The human brain communicates with specialized nerve cells known as neurons by transmitting electrochemical signals generated by neurotransmitters. These transmissions create voltage changes that give rise to both electrical and magnetic fields that can be measured outside the skull through an Electroencephalogram (EEG). The brain can be subdivided into four structures each with a different set of functions. These four structures are the cerebral cortex, cerebellum, brain stem, hypothalamus and thalamus. Moreover since each section of the brain is responsible for its own set of functions, different areas of the brain become more active than others depending on the person's state of mind or physical activities. Through this the EEG potentials for the location of this area of the brain will be higher and the observed frequency will be different based on the type of brain wave that is most prominent. There are five different band limits for the brain wave, namely delta, theta, alpha, beta and gamma. The presented work aims to contribute to the design of a portable device, capable of acquiring brainwaves, analyzing then and displaying the different bandwidths that the wave comprises of in real time. This device is aimed to making the process of obtaining, analyzing and evaluating the brainwaves faster and easier so that it may ultimately provide a better understanding of the patient and provide better patient care.

CHAPTER II

LITERATURE SURVEY

2.1 REAL-TIME EEG-BASED EMOTION RECOGNITION FOR MUSIC THERAPY

Authors : Olga Sourina ·Yisi Liu ·Minh Khoa Nguyen Received:

Published in: 19 April 2011 / Accepted: 19 November 2011 © Open Interface Association 2011

Literary analysis: An EEG enabled music therapy plays music to the patients which helps them to deal with their problems

2.2 EEG-BASED EMOTION RECOGNITION

Authors : D. Bos

Published in: http://hmi.ewi.utwente.nl/verslagen/capita-select a/CS-Oude_Bos-Danny.pdf

Literary analysis: An EEG based web-enable music player-it plays the musical video as per their current emotion analyzed by the system. Real time happiness detection system-it detects the state of happy emotion when it has positive valence and low arousal.

2.3 HIGHER ORDER SPECTRA ANALYSIS OF EEG SIGNNALS IN EMOTIONAL STRESS STATES

Authors :S. A. Hosseini, M. A. Khalilzadeh, M. B. Naghibi-Sistani, and V. Niazmand,

Published in : 2nd International Conference on Information Technology and Computer Science (ITCS '10), pp. 60–63, ukr, July 2010. H. Zhang, S. Zheng, and J. Yuan, “A personalized TV guide system compliant with MHP," IEEE Trans. Consumer Elec-tronics, vol. 51, no.2, May 2005, pp. 731-737.

Literary analysis: Higher order spectra analysis of EEG signal in emotional stress states- it extracts the EEG signals which produce the classification accuracy from different EEG time series

2.4 REAL TIME ANALYSIS OF EEG SIGNALS ON ANDROID APPLICATION

Authors : Prabhakaran.M, Vaishali kulkarni.

Published in : the international conference on advances in Electronics, computers and communication (ICAECC), 2014.

Literary analysis:Combining Spatial Filtering and Wavelet Transform for Classifying Human Emotions Using EEG Signals-In this, they used three different wavelets functions, in which they extracts statistical features for classifying emotions using EEG signals

2.5 EMOTION ELICITATION USING FILMS

Authors : J.J. Gross, R.W. Levenson

Published in: Cognition and Emotion, Vol. 9, (1995), 87-108.

Literary analysis: Emotion Elicitation using films-it shows selected film clips to elicit the emotions like amusement, anger, contentment, disgust, fear, neutral, sadness, surprise using support vector machine (SVM)

CHAPTER III
SYSTEM ANALYSIS

3.1EXISTING SYSTEM

This work presents an idea to reform the existing access control system of detecting medical conditions related to brain and getting timely response from doctors in case of a medical emergency and hence this paper ensures that people can get good quality of healthcare facilities from doctors worldwide. Using brain waves one can detect the abnormal behavior of brain and these waves are recorded using EEG electrodes and the obtained artifacts can be analyzed to predict the mental wellness of the patient. These artifacts can be uploaded to cloud hub for easy access from all over the world.

3.2 PROPOSED SYSTEM:

Electroencephalography (EEG) which is an electrophysiological monitoring method to record electrical activity of the brain. The electrical signals are converted into digital format using EEG data collection. These data are then uploaded to firebase using wifi connected to node mcq. Then retrieved in mobile phone using an app. This is then converted into 3D model using VAD (Valence, Arousal, Dominance) identification. The dimensional model is the most commonly used model for the classification of emotion because all discrete emotions can be represented in dimensional model by proposing that each discrete emotion represent the combination of several dimensions.

The data is filtered using the fuzzy rule.The filtered information is then analyzed and a report is generated to perform the required action such as playing music. according to the user’s emotions. The profile is then updated for the user's analysis of his own emotions.

CHAPTER IV

PROJECT DESCRIPTION

We generally use the word "stress" to describe when we feel everything seems to have become too much, strain or under pressure. However, there is more to that, the effect of stress can lead to many psychological illnesses, such as depression, sleep disorder and anxiety. Early detection of stress can therefore reduce the risk of mental illness by taking appropriate stress relief therapies. Stress is also an important factor in mental illness, as it can worsen symptoms of mental illness and lead to relapses, thus, the decrement of stress can speed up mental illness recovery rates.With the wide applications of EEG, all it is vital to identify the unique patterns of such brain waves correspond to various mental states. Through EEG monitoring, an individual's stress level can be detected and quantified in an efficient manner. It focuses on evaluating to what extent a single-electrode EEG headset – NeuroSky Mind Wave is able to classify brainwaves in terms of the subject's stressor level. By reducing the number of electrodes needed, it also means cheaper EEG headset can be used to diagnose various mental disorders. This would then allow the public and financial infeasible individuals to gain access to mental state diagnosis. With its optimistic outcome, access to chronic stress diagnosis would then be much affordable and easy to implement.

The human brain is the most complex part of the human anatomy, in which Depression is the most prevalent mental health disorder, atits worst can lead to suicide. A systematic approach to predict the depression level of a patient and diagnosing depression in the early stage which is very important. EEG is a brain signal processing technique that allows understanding the complex inner mechanisms of the brain and abnormal brain waves which is associated with particular brain disorders. Primarily the EEG signals were read using EDF browser software and the signals are loaded into an mobile app to get log Power Spectral Density from EEG bands. The results obtained from the app. The evaluated outputs are helpful to distinguish alcoholics and various sleep disorders like insomnia, narcolepsy, bruxism and nocturnal frontal lobe epilepsy.

CHAPTER V

SYSTEM ARCHITECTURE

Electrodes in headwear are used to sense the brain waves and the collected data are transmitted to application viaBluetooth for signal analysis. After signalAnalysis, alpha/beta ratio is calculated. This ratio helps in analyzing the emotions which will further generate the report and update the profile of the user. As per the report produced it performs certain functions like playing video,music or making calls and passing a message.

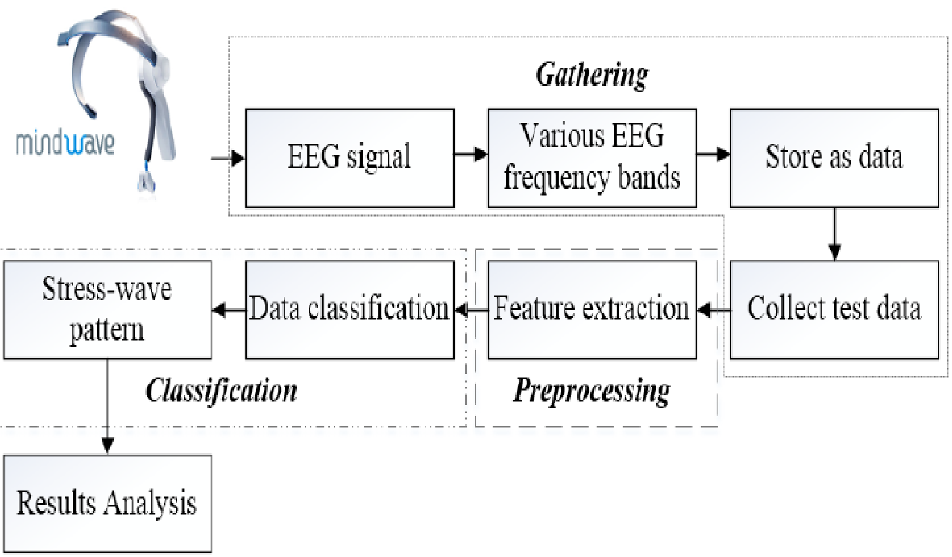

Fig 5.1 system architecture

5.1 CLASSIFICATION OF EMOTION

Several measures have been devised for classifying the human emotion. Such classification is generally divided into two perspectives namely Dimensional and Discrete perspectives. Discrete perspectives analysis emotion in a way that every specific emotion (e.g. fear, sad, happy, etc.) maps to its own unique parameter of environment, physiology and behavior. In a Dimensional perspective, human emotions are organized in few fundamental dimensions. The most commonly assumed dimension is arousal and valence proposed by Russell in his bipolar 5 model of emotion classification. In this dimension, valence represent from negative to positive whereas arousal represent from not excited to aroused or dull to intense. The dimensional model is the most commonly used model for the classification of emotion because all discrete emotions can be represented in dimensional model by proposing that each discrete emotion represent the combination of several dimensions. For example anger can be represented by negative valance and high arousal. The figure 5.2 shows the Arousal/Valence dimension in a diagram.

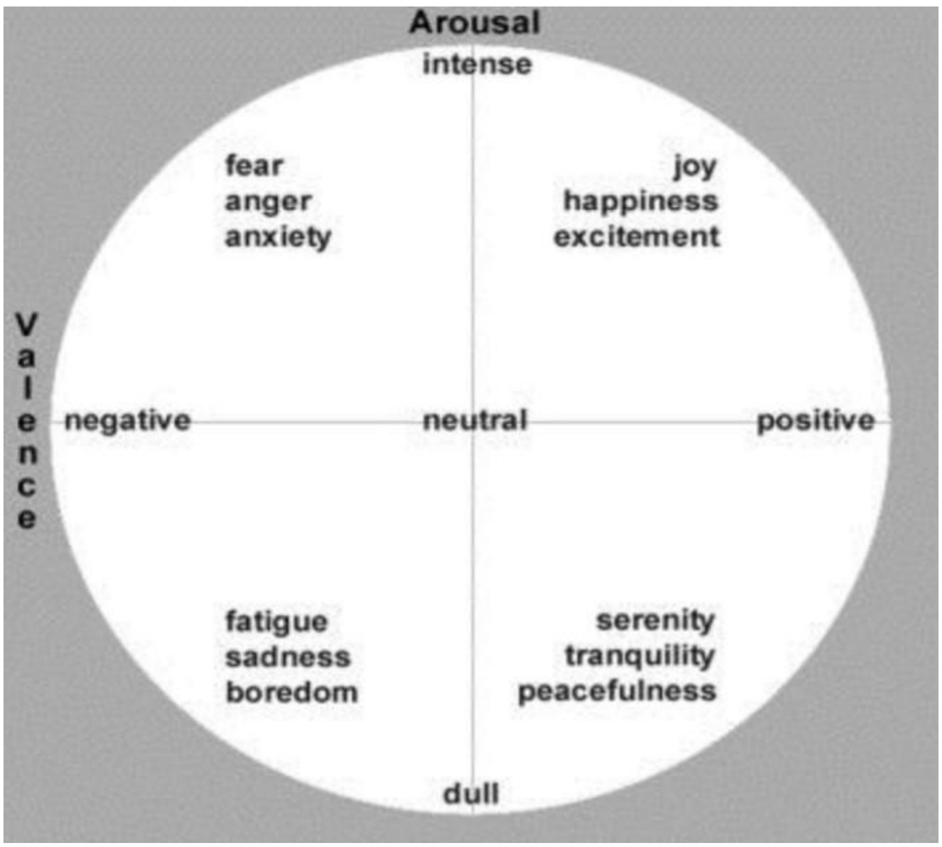

Figure 5.2 – Arousal/Valence model

5.1.1 Machine Learning Technique to Classify EEG Data

Machine Learning is the branch of artificial Intelligence which deal with the development and study of the system where known data samples are used to learn the machine in order to learn the unknown data samples. There are different Machine learning techniques to classify the EEG data with their own pros and cons. Currently, Support vector Machine, Artificial Neural Network and K-nearest neighbor (KNN) are commonly used to classify the EEG data.

5.1.2TEST DATA

Using arduino software scripts developed, we were able to read and store EEG data in a firebase environment from the NeuroSky Mind Wave headset. All 25 Sunway University students‟ EEG data were collected for a duration of 90 seconds each. With beginning 30 seconds allocated for on-screen instruction reading, followed by 60 seconds of Stroop test. All subjects‟ self-perceived stress level responses are summarized. It is assumed that all subjects‟ psychological stress were reflected in the EEG data collected, within a comparative features model that correlates to Subjects self-perceived stress level.

5.2 DATA RECEPTION AND IMPLEMENTATION

The application logic intention is to control the person to overcome the emotions. The application do some task when it recognizes that person is not in normal state, application logic automatically play the favorite music of him/her, make call to their care taker, Playing the voices of their loved ones to overcome from the emotional states. Analog signals received from the headset are converted to digital which is saved in the backend server FIREBASE SERVER database.

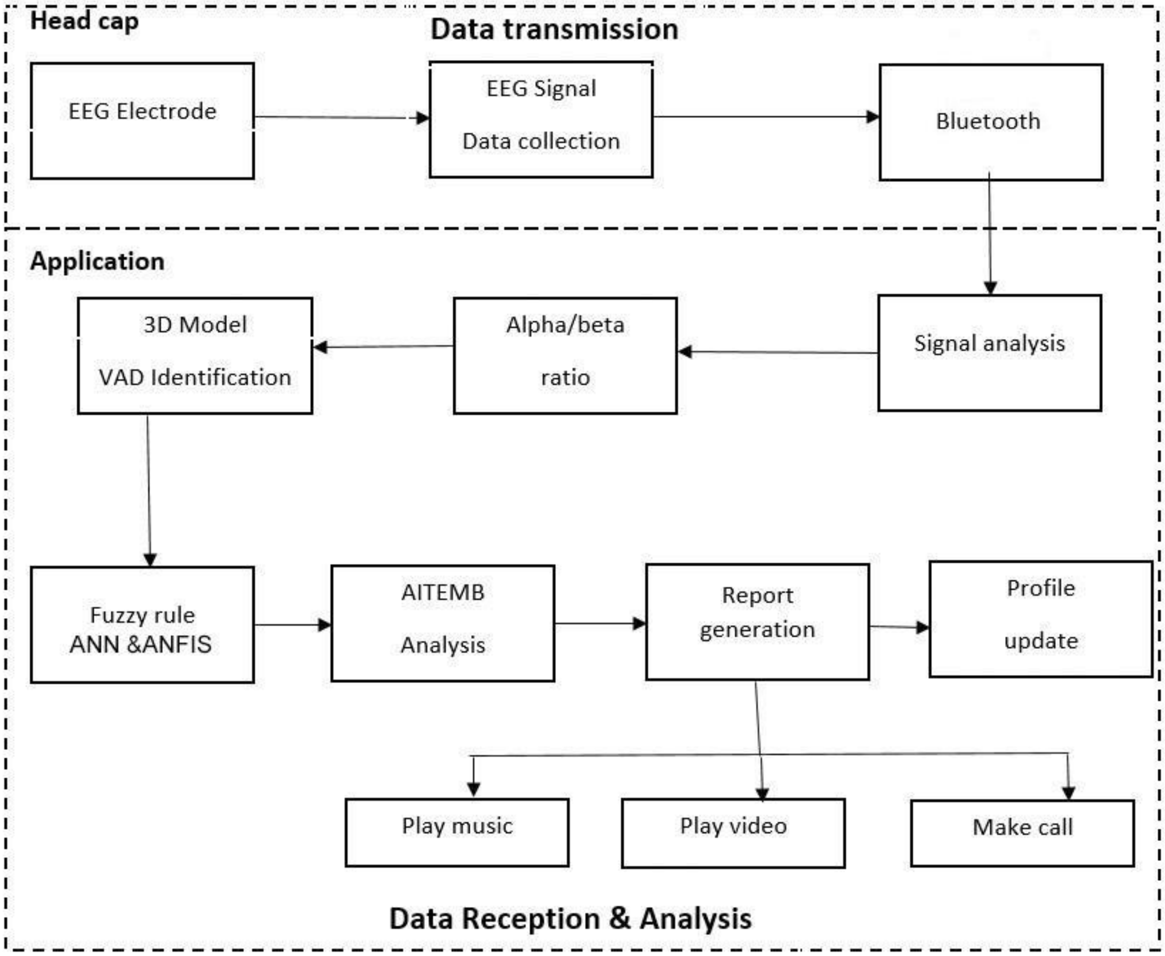

Fig 5.3 data reception & analysis

CHAPTER VI

EEG DATA PROCESSING

The recorded signals as described in above section need to be further processed to get rid of noise (chapter 1.3) embedded in it. The signals thus obtained are again used to extract only signals that were generated on each subject when the IAPS picture was shown from total length of signal. Finally, we extract a number of features from those signals. So, all these processes are described under different heading in following steps.

6.1 EEG VALUE ANALYSIS

Writing the Arduino Code for the Project was a difficult task because numbers had to be modified to provide the utmost efficiency and to account for the noise from the signal when determining which command to make. The Arduino code was written to read the code as fast as possible in order to increase the sampling rate of the system for the data acquisition part off the project. For the second part of the project to control a robot using EEG signals, the data was averaged over 20ms and compared to data that it had read over the preceding approximately 20ms to determine whether to proceed or not. If the data difference was above a certain level, then the program would average data for the next 160ms to determine whether the change in the signal was positive or negative. If the data difference was negative, then the signal would 24 command the Boe-bot to turn left; if it was positive, then the signal would command the Boe-bot to turn right. It was not greater than a certain amount, then the program would send a Null command to account for noise. The program would then wait approximately 300ms before trying to collect data again. This process would repeat continuously and occur in a single second or however long it took to pick up a reading. The Reading EEG

Signal/Sending Command Arduino Code can be found in Appendix A, and the Boe-Bot Control/Receiving Command Code can be found in Appendix B.

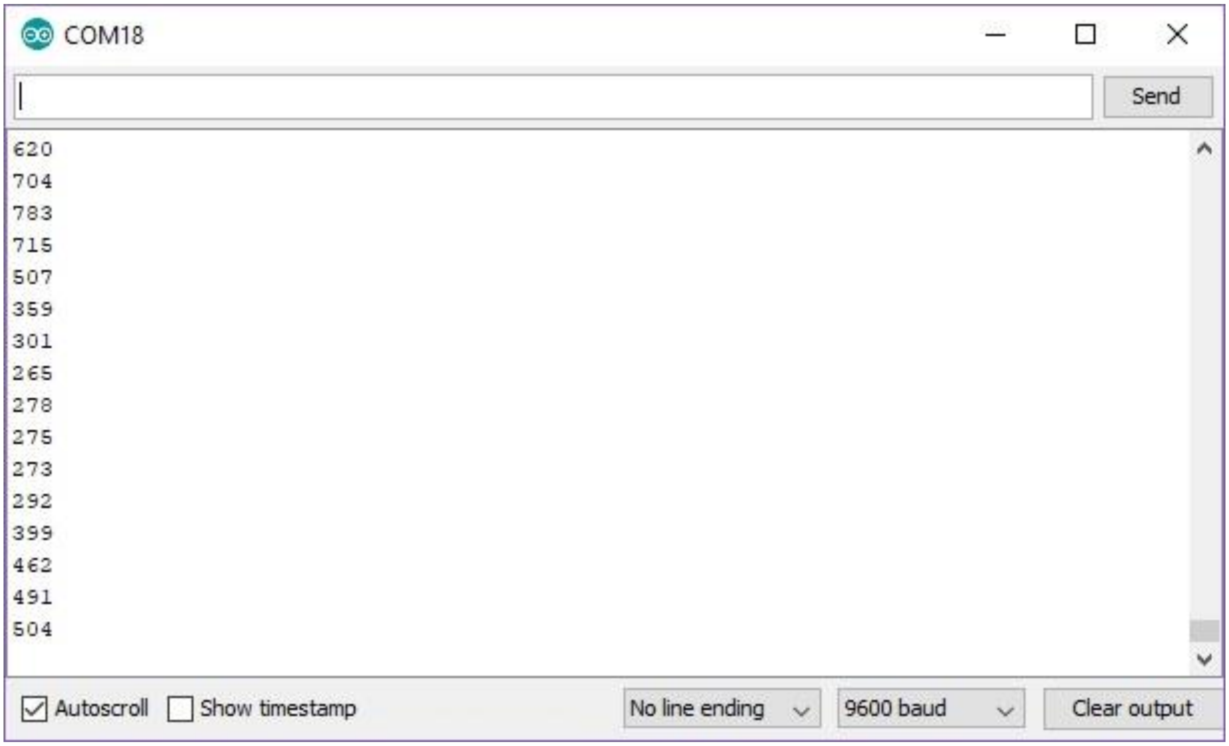

Figure 6.1 digital output screen

6.2 EEG band pass filtering

As far as the noise embedded in the recordings is concerned, such as superimposed artifacts from various sources, they can be effectively reduced by appropriate band pass filtering. More particularly, the influence of eye blinking is most dominant below 4 Hz; heart-functioning causes artifacts around 1.2 Hz, whereas muscle artifacts affect the EEG spectrum above 30 Hz. Non-physiological artifacts caused by power lines are around 50-60 Hz.

Another reason to choose the band pass filtering is due to particular interest in the area of EEG frequency range. As we have already described in section 1.2.1, EEG signals can be isolated in 5 different frequency bands where each specific frequency band is more prominent in certain states of mind. Based on this fact, the two frequencies we choose that are most important in this paper are Alpha (8-12 Hz) and Beta (12-30 Hz).

So to cater the need of both removing the artifacts while retaining the signals within the particular band of interest, i.e. frequencies within the Alpha (8-13 Hz) and Beta (13-30 Hz) bands, we apply the 10th order “Butterworth band pass filter”. Consequently, by extracting the Alpha and Beta frequency bands only from the acquired EEG recordings, we make sure to remove most of the physiological and non-physiological artifacts. We chose 10th order because high order filters provide greater roll off rates between pass band and stop band, and can be necessary to achieve the required levels of stop band attenuation or sharpness of cutoff. The lists of below are some advantages of Butterworth filter which leads us to choose it

- Maximally flat magnitude response in the pass-band.
- Good all-around performance.
- Pulse response better than Chebyshev.
- Rate of attenuation better than Bessel.

In EDFbrowser by choosing the filter from the top menu we are able to apply the filter we would like to have on our signal as being depicted in the figure 6.1.

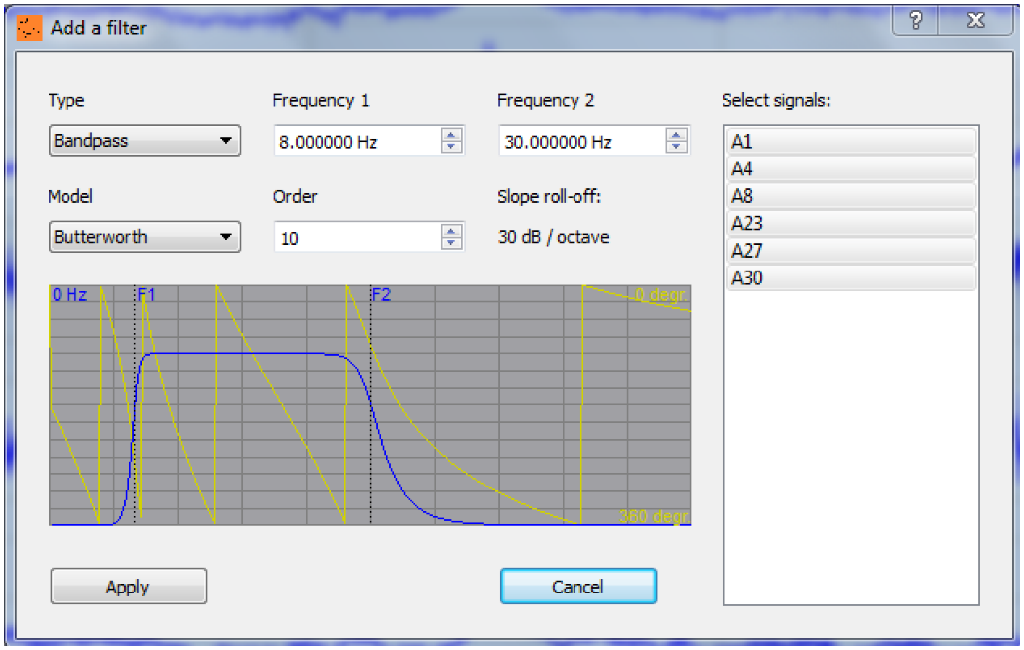

Figure 6.2 – Applying a filter [29]

The result of this filtering will be new signals with frequencies between 8 Hz and 30 Hz like the figure 6.2.

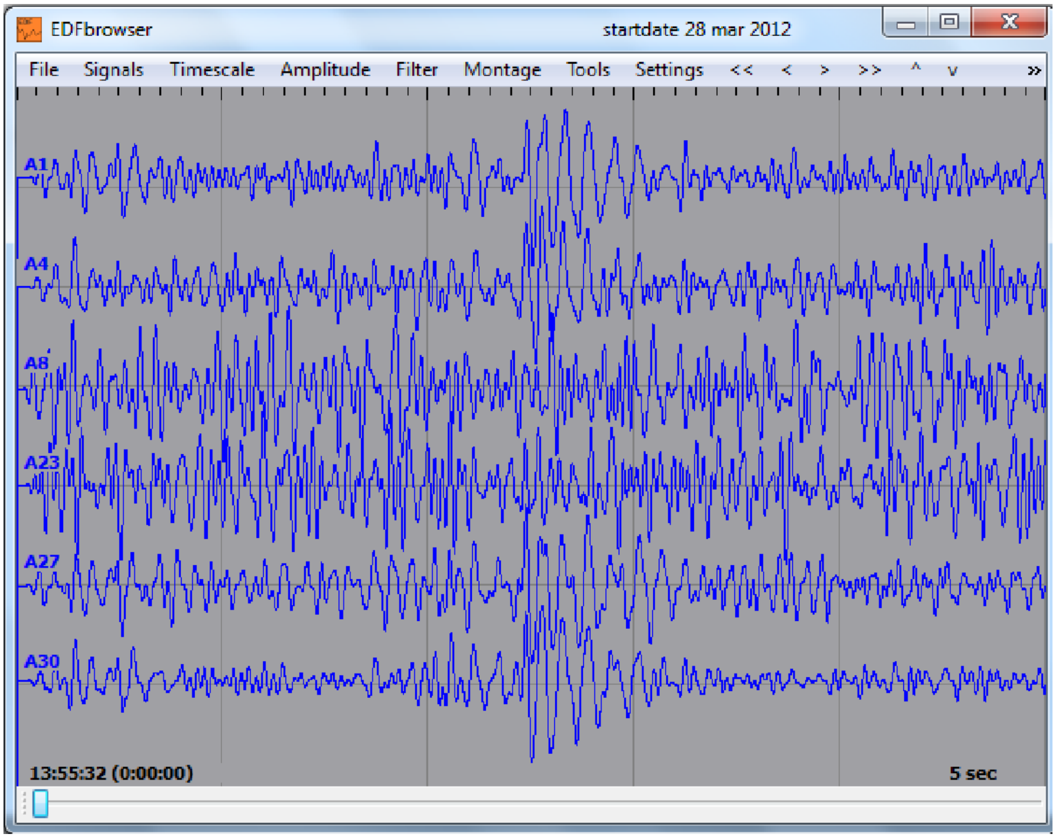

Figure 6.3 – Sample filtered signal

6.3 EEG data segmentation

The filtered signals we get from above step is further needed to be processed in order to get the signals that are generated when stimuli is shown to subject from whole length of signal. That is, we are here motivated in retaining 30 segments of signals each of length 5 seconds for each subject for which IAPS picture are shown. While segmenting the signals, we take the signals only from 6 sensors.

So the procedure is like that the file which has been saved as BioSemi data format (BDF) is opened by EDF browser then according to the electrodes mapping on the BioSemi layout, Six channels A1, A4, A8, A23, A27, and A30 are selected as shown in figure 6.3.

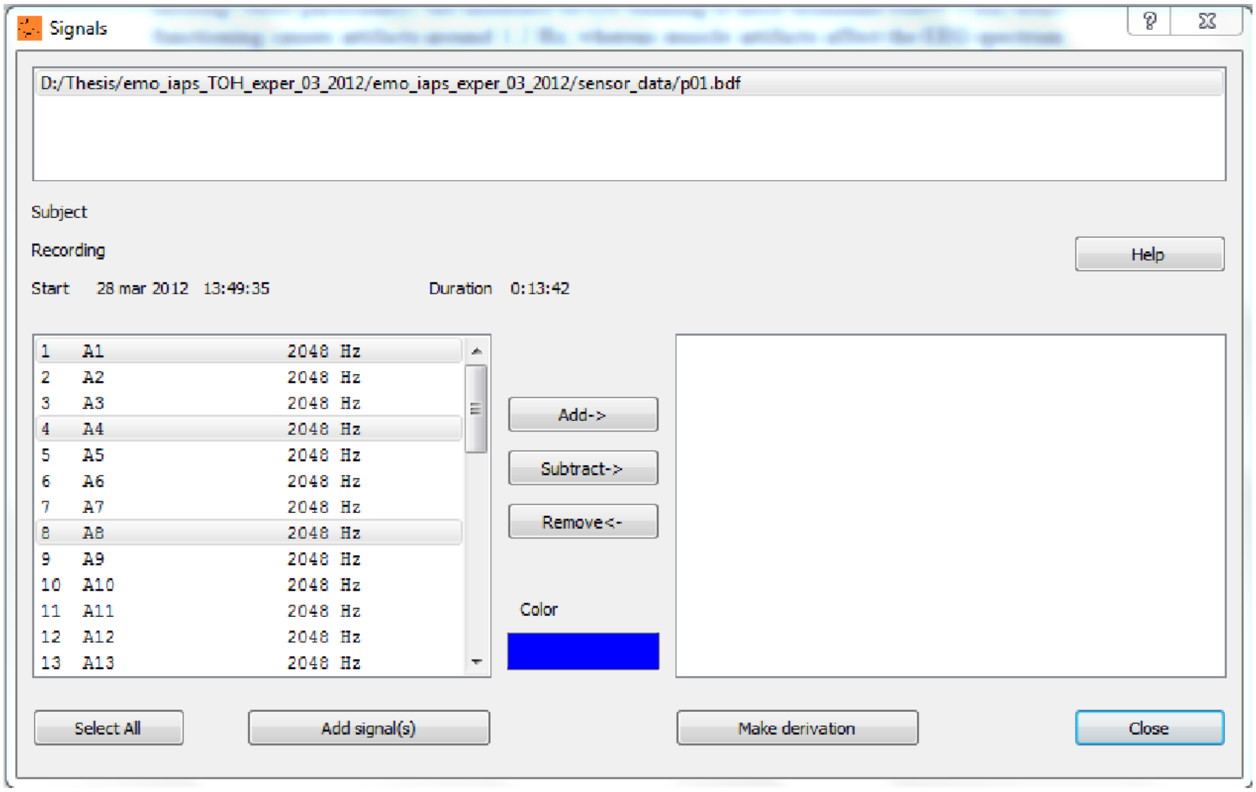

Figure 6.4 – EDF browser, Signal dialog

Then selected channels are added for further processing. By fitting the pane the recorded signals can be seen on the screen. The following figure shows the raw signal of the experiment of one of the subjects which whole of the experiment is 13 minutes and 42 seconds and each page shows 10 seconds of the signal.

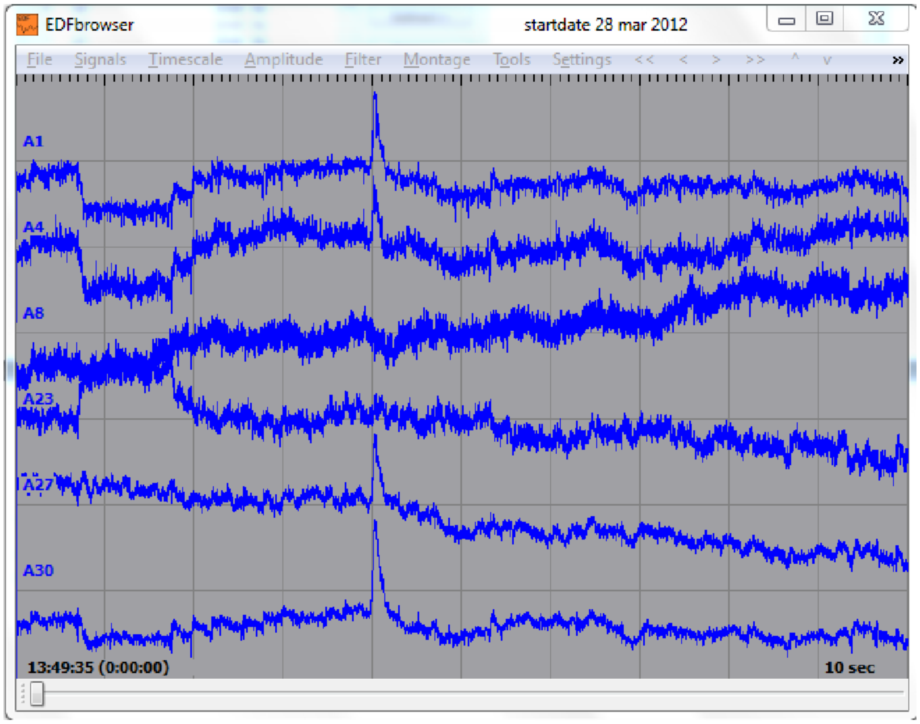

Figure 6.5 – Sample of selected signals

Each subject"s recording time slot is available and have been logged on a text file, so we know the timing of each second of the experiment. For example for this particular experiment the base line is started at 13:54:22 and has been finished at 13:55:21 for the duration of 59 seconds (when we talk about a baseline, in essence, we are talking about the duration of signal for which subject are not shown any picture before actually starting the experiment). Then cross shape projection is started at 13:55:29 to attract the sight of the subject and at 13:55:32 the first IAPS picture is displayed for the subject for the duration of 5 seconds that means the picture is ended at 13:55:37 and after that the cross is started again and this process is repeated until 30 pictures are completed that are displayed for the subject.

The data of 5 seconds of picture is what we are looking for and is essential for further processing and extracting the features for making data set. So now, we must take out the 5 seconds of the signal according the time of displaying the pictures. By using the tools in the top menu and choosing reduce signals, duration or sample rate we are able to have the exact data while the picture was showing to the subject. The channels which had been used in the experiment are selected and then by calculating exact seconds of begins and end time of displaying picture we have the 5 seconds of the signal. For example, this subject‟s first picture had been displayed from the second 358 to 362. The figure 6.5 shows how to obtain the signal for the first picture.

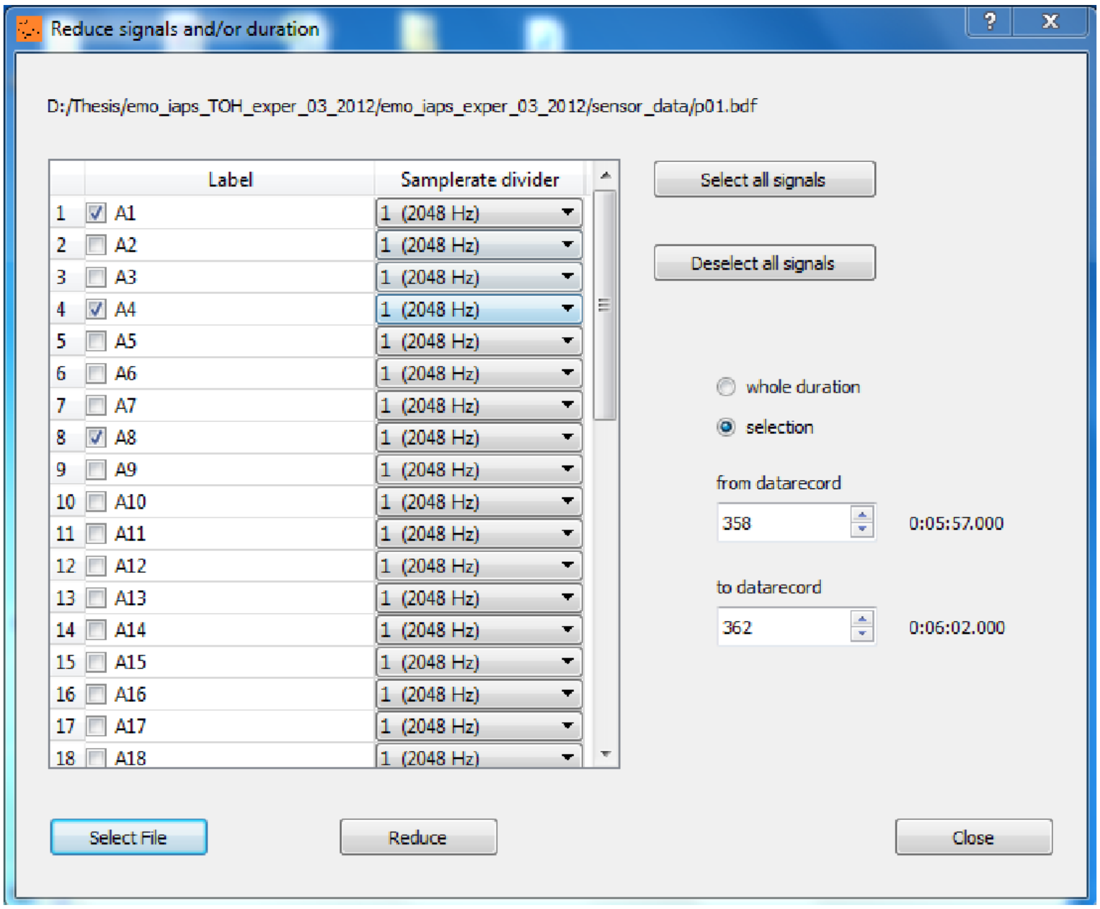

Figure 6.6 – Reduce signals or duration

By pushing the „Reduce‟ button, the 5 seconds of the signal is saved and then it can be reopened for further processing. Figure 6.6 depicts this signal as well. It shows that start time of the signal is at 13:55:32 and the whole duration is 5 seconds.

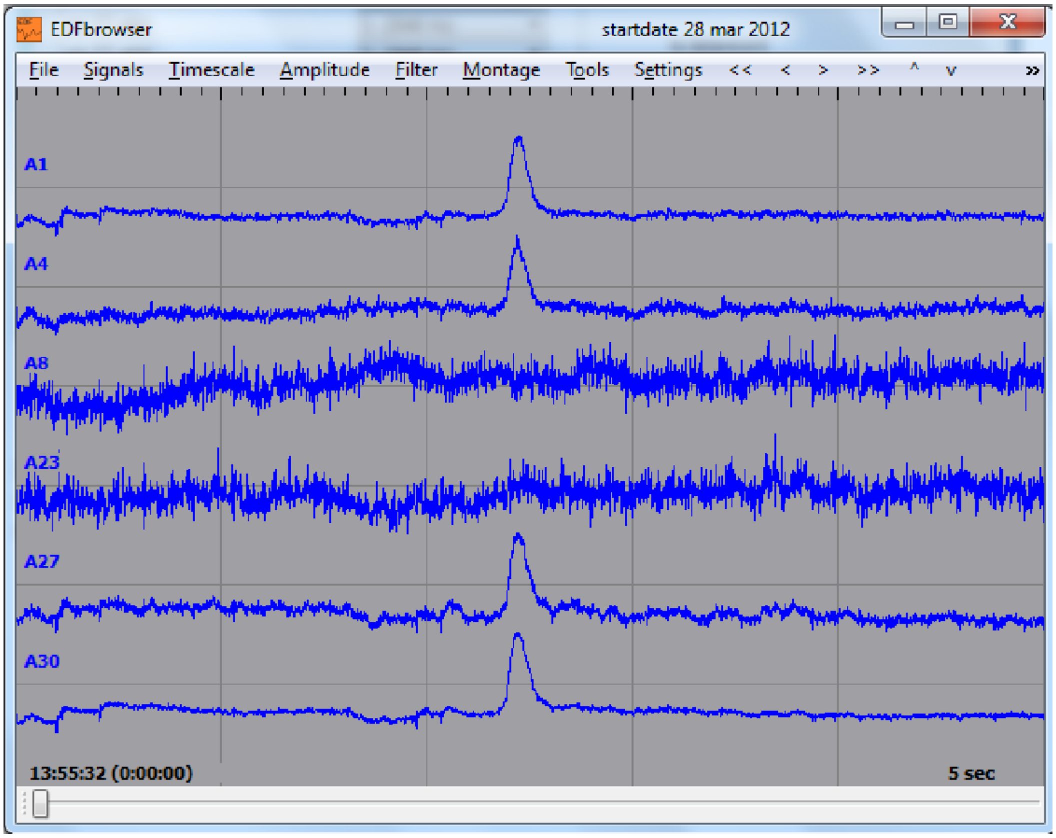

Figure 6.7 – Reduced signal

CHAPTER VII

EEG FEATURE EXTRACTION

Now, we have the signals in which the noise and artifacts have been removed from it and we should make decision which features to be extract from this signal in order to make some data sets which will be used as input of machine learning tool to learn the machine what kind of emotion is depicted by these signals.

At the first stage, the six features which are listed as below were decided to be extracted from each 5 seconds segment of the filtered signals.

- The maximum value
- The minimum value.
- The difference of the mean value of the baseline from the mean value of the raw signal (filtered signal).

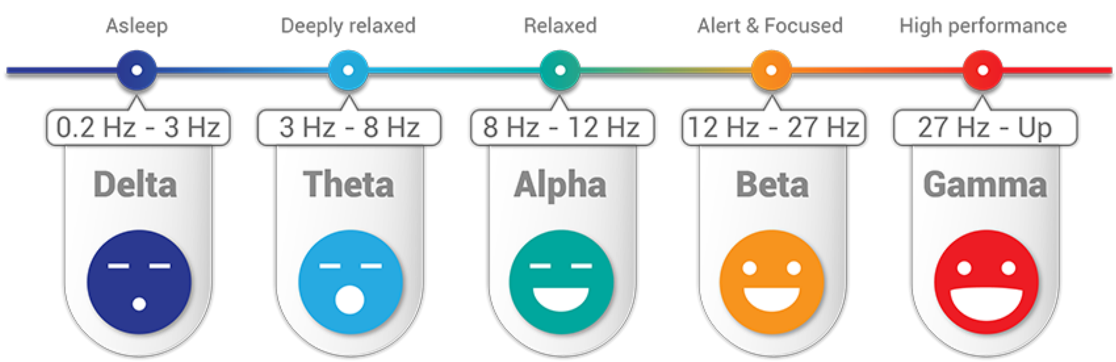

Figure 7.1 Frequency Classification

CHAPTER VIII
EMOTION RECOGNITION

8.1 Model of emotion

The research on emotion classification has been controversial and inconclusive. People's emotions are ever-changing. Whether each emotion exists independently or there are correlations among different emotions is a question that scholars still discuss.

Two types of models are used to describe the general state of emotion: One is the discrete emotion model, which includes the basic emotions such as sadness, anger, fear, surprise, disgust and happiness. However, there is controversy regarding the selection of basic emotions. Different researchers have different views. The other is a multi-dimensional emotional model. Initially, it is a two-dimensional model of valence and arousal. Valence represents the degree of delight of the individual and varies from negative to positive. Arousal represents the degree of activation of emotions and varies from calm to excitement. Later, a three-dimensional emotional model appears, which include valence, arousal and dominance.

8.2 KNN classifier

The K-nearest neighbour (KNN) method is a simple statistics-based classification method, which is commonly used in mature classification algorithms. Its core strategy is to identify the K samples that are closest to the unknown sample points and determine the category information of the unknown samples from the majority of the K samples.

8.3 Temporal window

The EEG acquisition time is usually longer than the accurate recognition time of the emotional state. To accurately identify the emotional state, EEG signals are usually divided into segments by windows. However, the length of the windows is a controversial topic. Kumar et al. use a window length of 30 s for EEG signals.

8.4 Classification

We used KNN to classify the emotion in the valence and arousal dimensions, for 32 subjects, and we divided the data generated by viewing each video into 29 windows, and the total number of samples is 37120 ($32 \times 40 \times 29$). We used 10-fold cross validation method for classification, taking the average of 10 tests as the final classification results. The training and testing process is as follows: First, we divided the total samples equally into 10 parts, of which 9 parts were for training and 1 part for testing. 1 part sample for each test is different, the remaining 9 parts were used for training, and the total training and test were 10 times, and the samples of training and test were not overlapped each time. In addition, the value of K was set 3.

CHAPTER IX
TECHNICAL DESCRIPTION

9.1 HARDWARE SPECIFICATION

The hardware requirements may serve as the basis for a contract for the implementation of the system and should therefore be a complete and consistent specification of the whole system.

9.1.1 Electroencephalogram (EEG)

The electroencephalogram (EEG) is a recording of the electrical activity of the brain from the scalp. The recorded waveforms reflect the cortical electrical activity.

Signal intensity: EEG activity is quite small, measured in microvolts (mV).

Signal frequency: the main frequencies of the human EEG waves are:

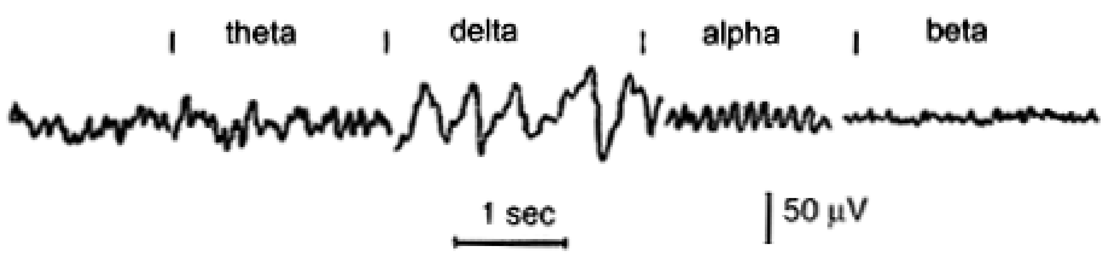

Fig 9.1.1 types of brainwave signals

9.1.2 EEG HEADBAND

The electrical activity inside a person's brain is sensed by mind reading EEG headband using a technique called Electroencephalography. The working of this technique is electrodes are placed on the scalp of patients head and these electrodes measure the electric signals which is induced by the neurons in the brain through the scalp. These electrodes are placed according to the morphology of the individual. These signals are analyzed as waves. Channel sampling rate of headwear is 250 Hz. The interface is used for connection is Bluetooth le. The minimum continuous usage of headband is 15 hours. The measurable voltage range is 0,4v.

BRAIN WAVES	FREQUENCY	AREA OF WAVE GENERATION
Delta	(0-4)Hz	frontal lobe
Theta	(4-7)Hz	median, temporal
Alpha	(8-13)Hz	frontal, occipital
Beta	(13-30)Hz	frontal, central
Gamma	(30-100+)Hz	-

Table 1: Brain waves

Figure 9.1.2 EEG BrainWave Headband

9.1.3 NodeMCU

NodeMCU is an open source firmware for which open source prototyping board designs are available. The name "NodeMCU" combines "node" and "MCU" (micro-controller unit). The term "NodeMCU" strictly speaking refers to the firmware rather than the associated development kits. Both the firmware and prototyping board designs are open source.

The firmware uses the Lua scripting language. The firmware is based on the eLua project, and built on the Espressif Non-OS SDK for ESP8266. It uses many open source projects, such as lua-cjson[10] and SPIFFS. Due to resource constraints, users need to select the modules relevant for their project and build a firmware tailored to their needs. Support for the 32-bit ESP32 has also been implemented.

The prototyping hardware typically used is a circuit board functioning as a dual in-line package (DIP) which integrates a USB controller with a smaller surface-mounted board containing the MCU and antenna. The choice of the DIP format allows for easy prototyping on breadboards. The design was initially was based on the ESP-12 module of the ESP8266, which is a Wi-Fi SoC integrated with a Tensilica Xtensa LX106 core, widely used in IoT applications (see related projects).

Figure 9.1.3 NodeMCU Board

9.2 SOFTWARE SPECIFICATION

TOOLS USED

In order to process the recorded signals, we need to use some softwares as a platform. In this chapter we present a brief introduction to the softwares we used throughout this project.

9.2.1 EDF BROWSER

EDF Browser is a free open-source, multiplatform viewer and toolbox for time series storage files like EEG data. European Data Format (EDF) is a standard file format designed for exchange and storage of medical time series. It offers a graphic visualization of the signal, as well as an integrated list of trigger marks present in the file. It also provides filtering functionalities, power on the frequency bands computation, as well as the possibility of down-sampling the signal. This program converts all the signals in an EDF to a plain ASCII text-file. Internally it includes a header and one or more data records. The data records contain consecutive fixed-duration epochs of the poly-graphic recording. The header contains some general information (patient identification, start time…) and technical specs of each signal (calibration, sampling rate), coded as ASCII characters. A screenshot from EDF browser is shown in figure 9.2.1.

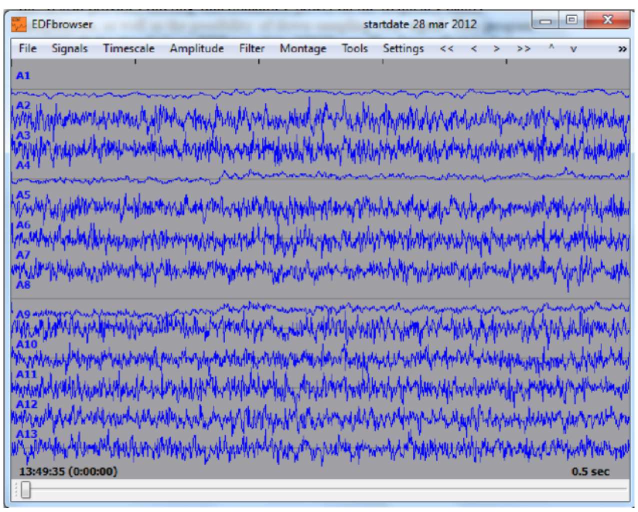

Figure 9.2.1 – EDF browser

9.2.2 ANDRIOD STUDIO

Android Studio is the official integrated development environment (IDE) for Google's Android operating system, built on JetBrains' IntelliJ IDEA software and designed specifically for Android development. It is available for download on Windows, macOS and Linux based operating systems. It is a replacement for the Eclipse Android Development Tools (ADT) as the primary IDE for native Android application development.

Android Studio was announced on May 16, 2013 at the Google I/O conference. It was in early access preview stage starting from version 0.1 in May 2013, then entered beta stage starting from version 0.8 which was released in June 2014. The first stable build was released in December 2014, starting from version 1.0.On May 7, 2019, Kotlin replaced Java as Google’s preferred language for Android app development. Java is still supported, as is C++.

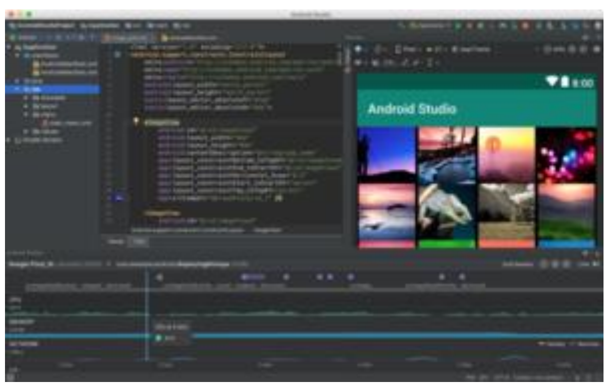

Figure 9.2.2 Android Studio

9.2.3 FIREBASE SERVER

Microsoft is the vendor of SQL Server. We have different editions of SQL Server, where SQL Server Express is free to download and use. SQL Server uses T-SQL (Transact-SQL). T-SQL is Microsoft's proprietary extension to SQL. TSQL is very similar to standard SQL, but in addition it supports some extra functionality, built in functions, etc.

T-SQL expands on the SQL standard to include procedural programming, local variables, and various support functions for string processing, date processing, mathematics, etc. SQL Server consists of a Database Engine and a Management Studio (and lots of other stuff which we will not mention here). The Database engine has no graphical interface - it is just a service running in the background of your computer (preferable on the server). The Management Studio is graphical tool for configuring and viewing the information in the database. It can be installed on the server or on the client (or both).

SQL Server Management Studio can also be used to create a new database, alter any existing database schema by adding or modifying tables and indexes, or analyze performance. It includes the query windows which provide a GUI based interface to write and execute queries.

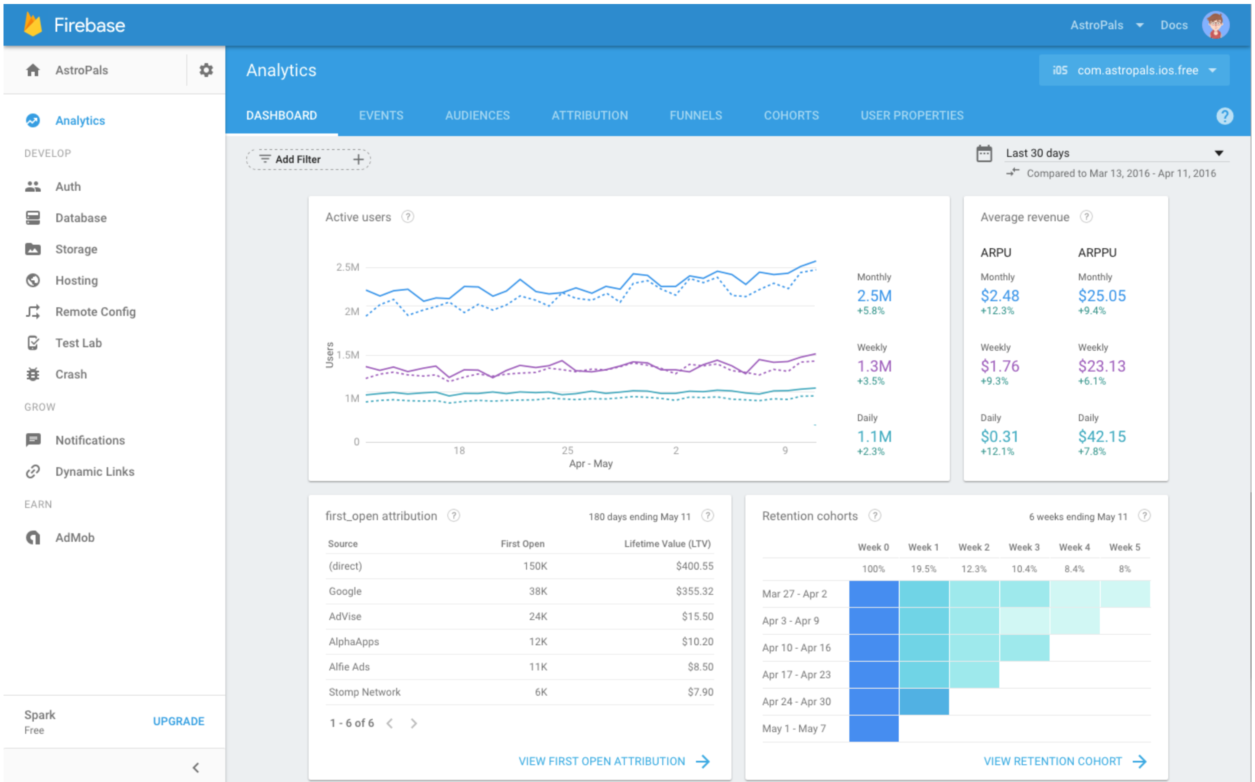

Figure 9.2.3 Firebase Server

9.2.4 Arduino Software

Arduino is an open-source hardware and software company, project and user community that designs and manufactures single-board microcontrollers and microcontroller kits for building digital devices. Its hardware products are licensed under a CC-BY-SA license, while software is licensed under the GNU Lesser General Public License (LGPL) or the GNU General Public License (GPL), permitting the manufacture of Arduino boards and software distribution by anyone. Arduino boards are available commercially from the official website or through authorized distributors.

Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards ('shields') or breadboards (for prototyping) and other circuits. The boards feature serial communications interfaces, including Universal Serial Bus (USB) on some models, which are also used for loading programs from personal computers. The microcontrollers can be programmed using the C and C++ programming languages, using a standard API which is also known as the "Arduino language". In addition to using traditional compiler toolchains, the Arduino project provides an integrated development environment (IDE) and a command line tool (arduino-cli) developed in Go

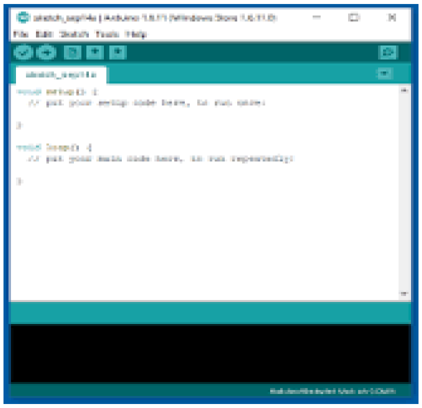

Figure 9.2.4 Arduino Software

CHAPTER X

MODULE DESCRIPTION

10.1 Brainwave Measurements

The implementation stage aims to acquire the brainwaves, separate them into different components and analyze them based on the activity of the subject. Experimental conditions are created which will stimulate the brain to produce a type of brainwave and the results are then obtained. Two studies are to be conducted, under the condition of the subjects (test models) being relaxed with the eye closed and the other when the subject is in deep mental thought. Both these studies are tested for the repeatability and reproducibility of the brainwave that is acquired. The subjects used in the study are of the age range 24-27 with no gender bias, where by two of them are male and the other is female. Three case studies are conducted to obtain the brain wave and analyze which signal is most prominent while conducting that particular activity. Three components of the brain wave namely alpha beta and gamma are measured. This is to because theta and delta rhythms are mainly found in babies and in very deep sleep modes.

Case 1: Relaxed mode

The subject is given 15 minutes to listen to some relaxing music and sit in a relaxed position in an office ergonomic chair with a good back subject enough time to properly relax, calm their thoughts and empty the mind. After the fifteen minutes readings are taken from the subject while sitting down and with eyes closed.

Case 2: Intense mental thinking

The subject is given a mathematical question with fifteen minutes to complete it. Brainwaves are acquired 5 minutes into the exercise while the subject is still answering the problem. The duration for completing the exercise in order to ensure that the subject does not slack off and is really into thinking on solving the problem.

Case 3: Changes in brainwave when going from relaxed to intense mental thinking

In this experimental setup the subject is at first allowed to relax and then after 10 minutes of relaxation a mathematical problem is given to subject to solve. Brainwave readings are taken every five minutes to measure the alpha and beta waves to see the changes in component brainwaves with change in mental activity.

Results

The design process involving all the filters is to be analyzed for repeatability and reproducibility. There are two main sections for the results discussion. The first is for the results obtained in the design realization section of the methodology. The second section looks into the real time brain wave results that have been obtained in the signal analysis section.

10.2 Brainwave realization

Two tests are conducted to evaluate the detection of frequency of components in signal after filtration and to check whether the intensity of the signal is detected. For test1 two case studies are conducted to since the device is intended to be used for people with different personality, meaning that the brainwaves vary from person to person. In the first case signals are all within the frequency band of the band pass filter. This test assumes that all the frequencies of brain waves are present in this signal and tests the detection of all the frequencies. In Case 2 the signal from a signal generator is changed so that it does not fall in any filter category. This signal assumes that the subject does not produce one frequency of brain wave at that moment and all other frequencies are being detected. The frequency of signal from each signal generator for the two cases. A second test is designed to check whether the intensity of the brain wave is detected by the software. For this study the amplitude of the 4 Hz signal generator is increased from the input while the amplitude of other frequencies is maintained constant.

Results of real-time brainwave analysis

Three case studies are conducted to obtain the brain wave and analyze which signal is most prominent while conducting that particular activity. Three components of the brain wave namely alpha beta and gamma are measured. In relaxed mode (Case 1), measurements are taken after the subject is given enough time to properly relax, calm their thoughts and empty the mind. Signals are acquired and analyzed for 3 different subjects and the results are tabulated. The results of the ratio of amplitude division in the component frequencies for Case 1. It shows that the alpha wave is predominant during relaxed and eye closed conditions for all three subjects. This wave is emitted in a higher intensity by the subjects during this form of activity. Also the spectrum of α, β and γ waves for the subject 1 is shown in shown in Fig. 7 for relaxed mode. Figure 7 sows the alpha wave is most predominant with 15mV amplitude corresponding to 70% intensity. The power spectrum analysis also corresponds with this high amplitude and shows a larger peak at the frequency of alpha waves between 8-13 Hz. The beta and gamma waveforms have amplitude of 6 - 6.4 mV.

CHAPTER XI
CODING AND TESTING

11.1 CODING

Once the installation procedure is complete the application enters into the coding and testing phase. The coding phase brings the actual system into action by converting the design of the application into the code in a given programming language. Therefore, a good coding style has to be taken and whenever changes are required, it should be easily screwed into the system.

11.2 CODING STANDARDS

Coding standards are guidelines to programming that focuses on the physical structure and appearance of the program. They make the code easier to read, understand and maintain. This phase of the system actually implements the blueprint developed during the design phase. The coding specification should be in such a way that any programmer must be able to understand the code and can bring about changes whenever felt necessary.

11.3 TEST PROCEDURE

Testing is performed to identify errors. It is used for quality assurance. Testing is an integral part of the entire development and maintenance process. The goal of the testing during phase is to verify that the specification has been accurately and completely incorporated into the design, as well as to ensure the correctness of the design itself. For example, the design must not have any logic faults in it. If it is not detected before coding commences, the cost of fixing the faults will be considerably higher as reflected. Detection of design faults can be achieved by means of inspection as well as walkthrough. Testing is one of the important steps in the development phase.

11.4 SYSTEM TESTING

11.4.1 Unit Testing

Unit testing is the testing of an individual unit or group of related units. It falls under the class of white box testing. It is often done by the programmer to test that the unit he/she has implemented is producing expected output against given input. Each module in the application is tested individually.

11.4.2 Integration Testing

Integration testing is testing in which a group of components are combined to produce output. Also, the interaction between software and hardware is tested in integration testing if software and hardware components have any relation. It may fall under both white box testing and black box testing. While integrating the modules we face interface problems, to overcome that tools like ANFIS are integrated in Arduino.

11.4.3 Functional Testing

Functional testing is the testing to ensure that the specified functionality required in the system requirements works. It falls under the class of black box testing.

11.4.4 Stress Testing

Stress testing is the testing to evaluate how system behaves under unfavorable conditions. Testing is conducted at beyond limits of the specifications. It falls under the class of black box testing.

11.4.5 Performance Testing

Performance testing is the testing to assess the speed and effectiveness of the system and to make sure it is generating results within a specified time as in performance requirements. It falls under the class of black box testing.

CHAPTER XII

IMPLEMENTATION AND RESULT

12.1 ARDUINO CODE:

```
#include <ESP8266WiFi.h>
#include <PubSubClient.h>
#include <FirebaseArduino.h>
#include <WiFiUdp.h>

#define WIFISSID "realme C3" // Put your WifiSSID here
#define PASSWORD "123456789" // Put your wifi password here
#define TOKEN "BBFF-HdyEfPABBStGKJeIUoV60r5glkSptf" // Put your
Ubidots' TOKEN
#define MQTT_CLIENT_NAME "1234a5d6798" // MQTT client Name, please
enter your own 8-12 alphanumeric character ASCII string;
                                        //it should be a random and unique ascii string and
different from all other devices
#define FIREBASE_HOST "eeg-monitor-4f21a.firebaseio.com"
#define FIREBASE_KEY
"MirVLIkOQA5HshwFkBONyHA70mQxTNojsPcrwTs6"
/****************************************
 * Define Constants
 ****************************************/
#define VARIABLE_LABEL "sensor" // Assing the variable label
#define DEVICE_LABEL "esp32" // Assig the device label
const int op = 4;
#define SENSOR A0 // Set the A0 as SENSOR
```

```
char mqttBroker[]  = "industrial.api.ubidots.com";
char payload[100];
char topic[150];
// Space to store values to send
char str_sensor[10];

/****************************************
 * Auxiliar Functions
 ****************************************/
WiFiClient ubidots;
PubSubClient client(ubidots);

void callback(char* topic, byte* payload, unsigned int length) {
  char p[length + 1];
  memcpy(p, payload, length);
  p[length] = NULL;
  Serial.write(payload, length);
  Serial.println(topic);
}

void reconnect() {
  // Loop until we're reconnected
  while (!client.connected()) {
    Serial.println("Attempting MQTT connection...");

    // Attemp to connect
```

```
    if (client.connect(MQTT_CLIENT_NAME, TOKEN, "")) {
      Serial.println("Connected");
    } else {
      Serial.print("Failed, rc=");
      Serial.print(client.state());
      Serial.println(" try again in 2 seconds");
      // Wait 2 seconds before retrying
      delay(2000);
    }
  }
}

/****************************************
 * Main Functions
 ****************************************/
void setup() {
  Serial.begin(115200);
  WiFi.begin(WIFISSID, PASSWORD);
  // Assign the pin as INPUT
  pinMode(SENSOR, INPUT);
  pinMode(op,OUTPUT);

  Serial.println();
  Serial.print("Waiting for WiFi...");

  while (WiFi.status() != WL_CONNECTED) {
    Serial.print(".");
```

```
    delay(500);
  }
  Firebase.begin(FIREBASE_HOST, FIREBASE_KEY);



  Serial.println("");
  Serial.println("WiFi Connected");
  Serial.println("IP address: ");
  Serial.println(WiFi.localIP());
  client.setServer(mqttBroker, 1883);
  client.setCallback(callback);
}

void loop() {
  if (!client.connected()) {
    reconnect();
  }

  if(Firebase.failed())
  {
    Serial.print("setting/number failed:");
    Serial.print(Firebase.error());
    return;
    }

 // sprintf(topic, "%s%s", "/v1.6/devices/", DEVICE_LABEL);
  //sprintf(payload, "%s", ""); // Cleans the payload
```

```
  //sprintf(payload, "{\"%s\":", VARIABLE_LABEL); // Adds the variable label

  int sensor = analogRead(SENSOR);
  Firebase.setInt("sensorvalue",sensor);
  Serial.println(sensor);
  /* 4 is mininum width, 2 is precision; float value is copied onto str_senso r*/
  dtostrf(sensor, op, 2, str_sensor);

  sprintf(payload, "%s {\"value\": %s}}", payload, str_sensor); // Adds the value
  Serial.println("Publishing data to Ubidots Cloud");
  client.publish(topic, payload);
  client.loop();
  delay(10000 );
}
```

12.2 ANDROID CODE:

```
?xml version="1.0" encoding="utf-8"?>
<androidx.constraintlayout.widget.ConstraintLayout
xmlns:android="http://schemas.android.com/apk/res/android"
  xmlns:app="http://schemas.android.com/apk/res-auto"
  xmlns:tools="http://schemas.android.com/tools"
  android:layout_width="match_parent"
  android:layout_height="match_parent"
  tools:context=".MainActivity">

  <TextView
     android:id="@+id/textview"
     android:layout_width="wrap_content"
     android:layout_height="wrap_content"
     android:text="Normal"
     android:textColor="@android:color/black"
     android:textSize="50dp"
     app:layout_constraintBottom_toBottomOf="parent"
     app:layout_constraintLeft_toLeftOf="parent"
     app:layout_constraintRight_toRightOf="parent"
     app:layout_constraintTop_toTopOf="parent" />
```

```
</androidx.constraintlayout.widget.ConstraintLayout>
```

Mainactivity.java

```java
package com.example.sultan;

import androidx.annotation.NonNull;
import androidx.appcompat.app.AppCompatActivity;

import android.os.Bundle;
import android.widget.TextView;

import com.google.firebase.database.DataSnapshot;
import com.google.firebase.database.DatabaseError;
import com.google.firebase.database.DatabaseReference;
import com.google.firebase.database.FirebaseDatabase;
import com.google.firebase.database.ValueEventListener;

import org.w3c.dom.Text;
```

```
public class MainActivity extends AppCompatActivity {

  DatabaseReference myref;

  TextView t1;

  @Override

  protected void onCreate(Bundle savedInstanceState) {

     super.onCreate(savedInstanceState);

     setContentView(R.layout.activity_main);

     t1=(TextView)findViewById(R.id.textview);

     myref = FirebaseDatabase.getInstance().getReference();

     myref.addValueEventListener(new ValueEventListener() {

        @Override

        public void onDataChange(@NonNull DataSnapshot dataSnapshot) {

           Details dt = dataSnapshot.getValue(Details.class);

           int s1 = dt.getSensorvalue();

           if(s1 ==0 && s1 <= 100)

           {

              t1.setText("Waiting For Input");

           }

           else if(s1>100 && s1<=700){

              t1.setText("NORMAL");

           }
```

```
            else if(s1>700 && s1<=100){
                t1.setText("MEDIUM");
            }
            else{
                t1.setText("HYPER");
            }
        }

        @Override
        public void onCancelled(@NonNull DatabaseError databaseError) {

        }
    });
  }
}
```

DETAILS.java

```
package com.example.sultan;

public class Details {
  int sensorvalue;

  public Details(){

  }
  public Details(int sensorvalue) {
     this.sensorvalue = sensorvalue;
  }

  public int getSensorvalue() {
     return sensorvalue;
  }
}
```

12.3 RESULT:

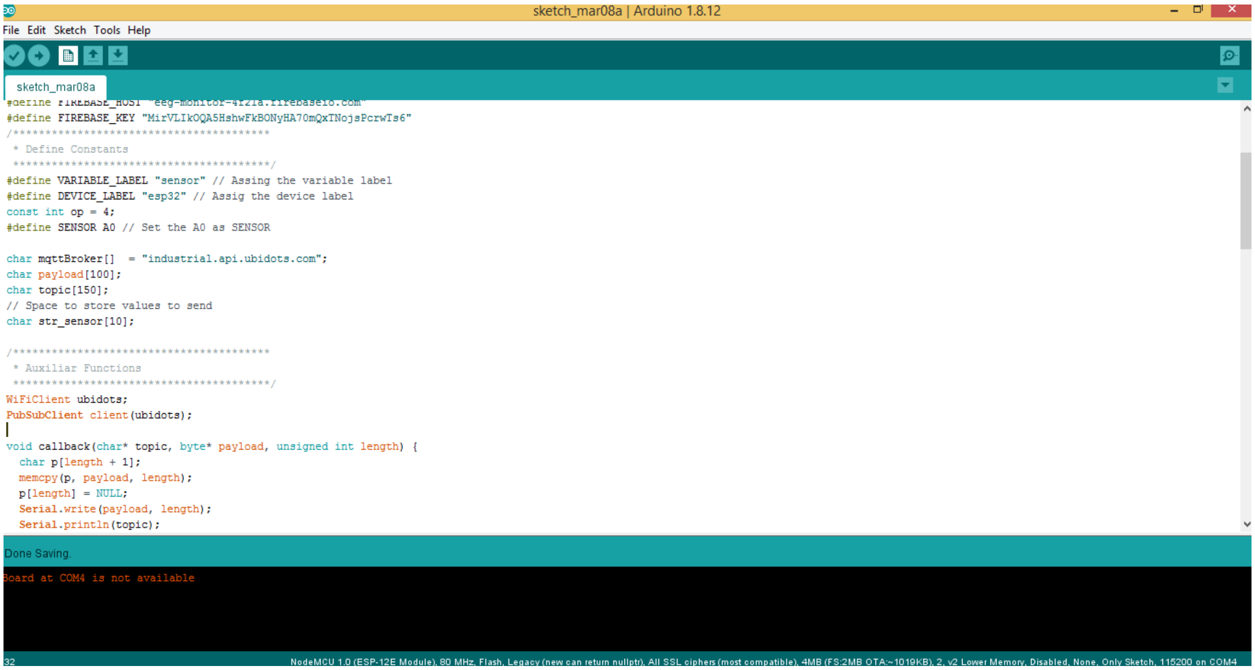

Figure 12.1 Arduino Screen

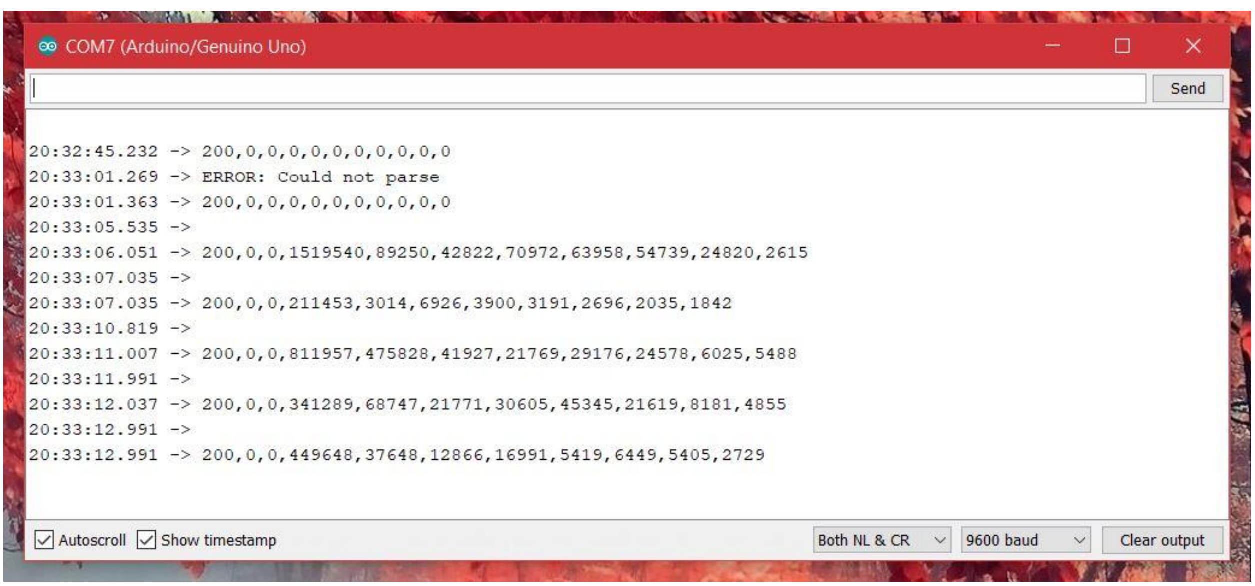

Figure 12.2 Arduino Output Screen

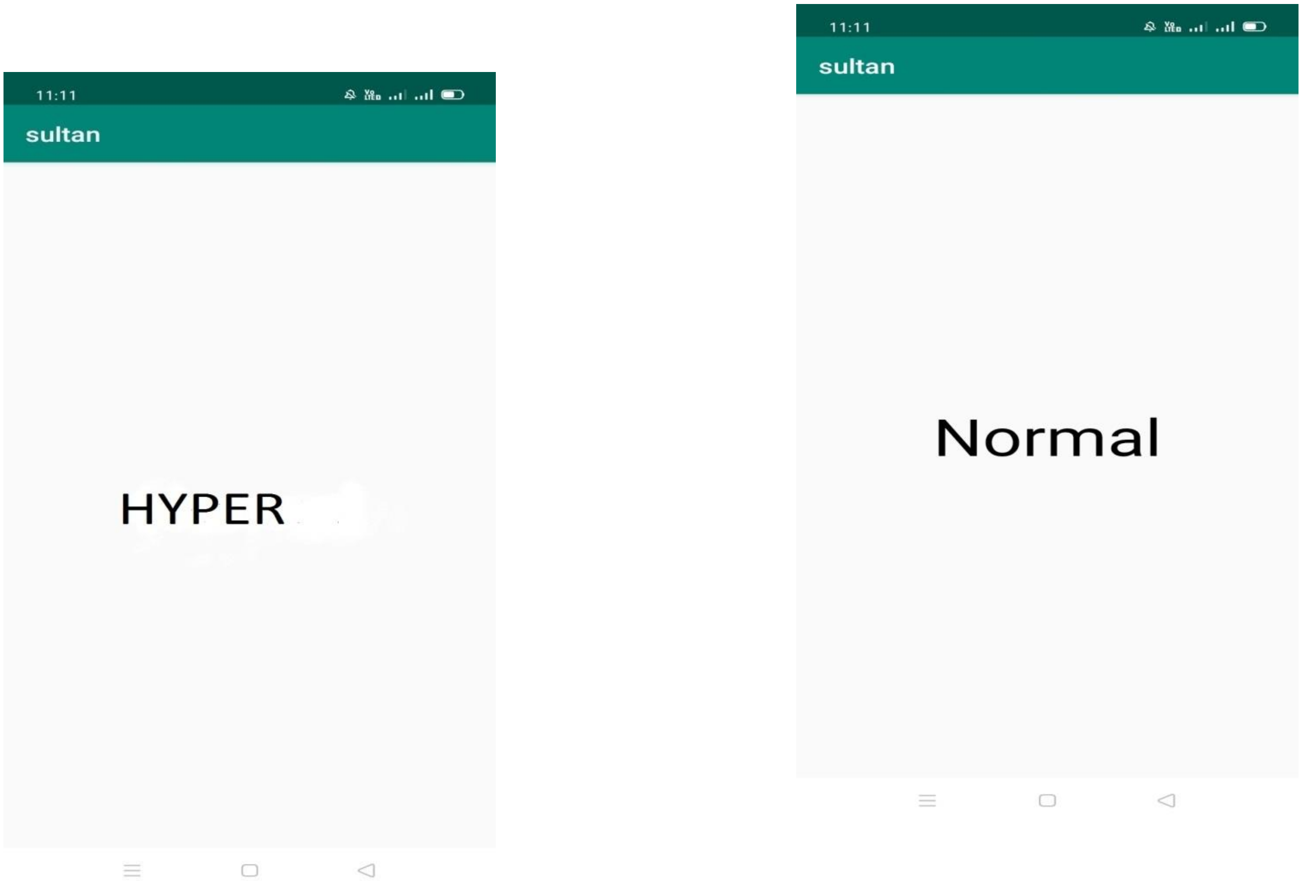

Figure 12.3 Mobile App Output ScreenShot

CHAPTER XIII

CONCLUSION AND ENHANCEMENT

In this paper, an application intervention to enhance motivated behaviour in schizophrenia affected patients (users of AITEMB).It is planned to use emotive EPOC headset to receive EEG signals. And to create an emotional database for our application. Fuzzy logic rules helps in analysing the state of emotion by classifying EEG signals and produce the resultant emotion which is further taken as an input to compute an AITEMB logic and performs the certain tasks as a final result and updated in user's profile. In future, AITEMB application is further made to be like a social media for those users, which will avoid theindividual being isolated and develops the social behaviour when it is decelerated by the effects of schizophrenia mental disorder. The proposed system will be remedy for those mental disorders like schizophrenia which has a symptoms like delusions, paranoia, hallucinations etc... It is concluded that AITEMB will be an accurate tool to assess the emotion and perform the certain task to control over it. Future work to acquire more data from users to validate the results.

CHAPTER XIV

REFERENCES

1. Haifa BLAIECH, Mohamed NEJI, Ali WALI and Adel M. ALIMI”Emotion recognition by analysis of EEG signals “Research Groups on Intelligent MachinesUniversity of Sfax, National Engineering School of Sfax (ENIS) BP1173, 3038 Sfax, Tunisia {hayfa.blaiech, mohamed.neji, ali.wali, adel.alimi}@ieee.org

2. Olga Sourina ·Yisi Liu ·Minh Khoa Nguyen”Real-time EEG-based emotion recognition for music therapy Received: 19 April 2011 / Accepted: 19 November 2011 © OpenInterface Association 2011

3. Noppadon Jatupaiboon, 1 Setha Pan-ngum, 1 and Pasin Israsena2 Real-Time EEG-Based Happiness Detection System Received 3 June 2013; Accepted 15 July 2013 Academic Editors: B.-W. Chen, S. Hsieh, and C.-H. Wu Copyright © 2013 Noppadon Jatupaiboon et al.

4. K. R.Scherer. What are emotions? And how can they be measured? Social Science Information, 44(4), (2005), 693-727.

5. E. Niedermeyer and F. L. da Silva, Electroencephalography: Basic Principles, Clinical Applications, and Related Fields, 2004.

6. Wikipedia,“Electroencephalography,”http://en.wikipedia.org/wiki/ Electroencephalography.

7. Y. P. Lin, C. H. Wang, T. L. Wu, S. K. Jeng, and J. H. Chen, “Support vector machine for EEG signal classification during listening to emotional music,” in

Proceedings of the 10th IEEE Workshop on Multimedia Signal Processing (MMSP '08), pp. 127–130, Cairns, Australia, October 2008.

8. D. Bos, "EEG-based emotion recognition," http://hmi.ewi.utwente.nl/verslagen/capita-selecta/CS-Oude_Bos-Danny.pdf

9. S. A. Hosseini, M. A. Khalilzadeh, M. B. Naghibi-Sistani, and V. Niazmand, "Higher order spectra analysis of EEG signals in emotional stress states," in Proceedings of the 2nd International Conference on Information Technology and Computer Science (ITCS '10), pp. 60–63, ukr, July 2010. H. Zhang, S. Zheng, and J. Yuan, "A personalized TV guide system compliant with MHP," IEEE Trans. Consumer Elec-tronics, vol. 51, no.2, May 2005, pp. 731-737.

10. J.J. Gross, R.W. Levenson. Emotion elicitation using films.Cognition and Emotion, Vol. 9, (1995), 87-108.

11. L. F. Barrett, J.A. Russell. Independence and bipolarity in the structure of current affect. Journal of Personality and Social Psychology, 74 (4), (1998). pp. 967-984.

12. M. Neji, A. Wali, A.M. Alimi. Towards an Intelligent In-formation Research System based on the Human Behavior: Recognition of User Emotional State. 12th IEEE/ACIS In-ternational Conference on Computer and Information Science (2013).Japan. 371-377.

13. M. Li and B. L. Lu, "Emotion classification based on gamma-band EEG," in Proceedings of the Annual International Conference of the IEEE Engineering in

Medicine and Biology Society (EMBC '09), pp. 1223–1226, Minneapolis, Minn, USA, September 2009.

14. Z. Khalili and M. H. Moradi, “Emotion recognition system using brain and peripheral signals: using correlation dimension to improve the results of EEG,” in Proceedings of the International Joint Conference on Neural Networks (IJCNN '09), pp. 1571–1575, Atlanta, Ga, USA, June 2009.

15. S. Koelstra, A. Yazdani, M. Soleymani et al., “Single trial classification of EEG and peripheral physiological signals for recognition of emotions induced by music videos,” in Proceeding of the International Conference on Brain Informatics (BI '10), pp. 89–100, Toronto, Canada, 201

16.Prabhakaran.M, Vaishali kulkarni., “Real Time Analysis of EEG Signals On Android Application,”in proceeding of the international conference on advances in Electronics,computers and communication(ICAECC),2014.