

# **BRAIN CONTROLLED INTERFACE BASED SMART SYSTEM**

*Project work submitted in partial fulfillment of the requirements for the Degree*

*Of*

**BACHELOR OF TECHNOLOGY**

**IN**

**ELECTRONICS AND COMMUNICATION ENGINEERING**

**BY**

**ABHISHEK KUMAR SINGH-141107**

**ANKIT VERMA-141095**

**UNDER GUIDANCE OF**

**DR. MEENAKSHI SOOD**



Department of Electronics and communication Engineering

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, WAKNAGHAT

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## **DECLARATION**

We hereby declare that the work reported in the B-Tech project entitled “**BRAIN CONTROLLED INTERFACE BASED SMART SYSTEM**” submitted at **Jaypee University of Information Technology, Wagnaghat, India**, is an authentic record of my work carried out under the supervision of **Dr. Meenakshi Sood**. We have not submitted this work elsewhere for any other degree or diploma.

Abhishek Kumar Singh

Ankit Verma

Department of Electronics and Communication Engineering

Jaypee University of Information Technology, Wagnaghat, India

Date:



## JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

(Established by H.P. State Legislative vide Act No. 14 of 2002)  
P.O. Waknaghat, Teh. Kandaghat, Distt. Solan - 173234 (H.P.) INDIA

Website: [www.juit.ac.in](http://www.juit.ac.in)

Phone No. (91) 01792-257999

Fax: +91-01792-245362

### CERTIFICATE

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This is to certify that the work reported in the B.Tech project report entitled “**BRAIN CONTROLLED INTERFACE BASED SMART SYSTEM**” which is being submitted by “**Ankit Verma**” and “**Abhishek Kumar Singh**” in fulfillment for the award of Bachelor of Technology in Electronics and Communication Engineering by the Jaypee University of Information Technology, is the record of candidate’s own work carried out by him/her under my supervision. This work is original and has not been submitted partially or fully anywhere else for any other degree or diploma.

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**Dr. Meenakshi Sood**

Department Coordinator

Assistant Professor (Senior Grade)

Department of Electronics & Communication Engineering

Jaypee University of Information Technology, Waknaghat,

**juit**

विद्या तत्व ज्योतिसमः

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## **ABSTRACT**

Automation is a need of today's world because of its huge scope in every major field. It gives the user easy and comfortable way to control and use devices with better precision and accuracy. We try to achieve automation by using brainwaves. Our project is based on EEG, i.e. Electroencephalography, through this technology we are able to automate the devices which a person uses in his\her daily life. The implementation and design can be controlled via. two methods i.e. Matlab and Arduino. Metallic discs of small size called electrodes are placed onto the scalp which are around 21 in number but in our device one is on forehead and one reference and ground is at ear lobe. These electrodes record the electrical signal which are very minute (in microvolts), in the human brain and sends the signals to a computer. Within the recent years many researchers have tried to make different mind controlled devices to help physically challenged people. With the help of our system everyone will be able to live in a soothing environment and with great ease. Our focus was also to create a universal system and for that we explored our device and then we created a database of 17 different test subjects. Through insight from our database we predicted the values for different moods and now we propose a system that detects the mood and reacts accordingly. We propose a system which will not only help the user to automate his personal space but will also analyze the mood of the user and make a suitable environment for user's living/working.

**CHAPTER-1**

**INTRODUCTION**



An electroencephalogram (EEG) is a medical test which was developed by “HANS BERGER” in 1924 and is being used to calculate the electrical signals in the brain. Communication of information throughout body is done via electrical impulses which travels through “Nerve cells” or “Neurons”. These neurons in brain communicate with each other through minute electrical signals\impulses. Electroencephalography (EEG) is a unique way of recording these electrical impulses and then analyze for medical anomalies like epilepsy or can be used in research work. It is typically noninvasive, with the electrodes covered with conducting gel placed on the scalp. Basically what EEG does is it measures changes\fluctuations in voltage which results from current due to ions within the neurons of the brain. In relation to medical, EEG works by recording brain's electrical activity of any patient in real-time, as recorded from multiple electrodes placed on the scalp. It is also used to diagnose sleep disorders, depth of anesthesia, coma, encephalopathies, and brain death. EEG is still a very valuable tool for diagnosis and research despite the limited spatial resolution.



Figure: 1 Human Brain and Neurons

## 1.1 10-20 SYSTEM

The International 10–20 system or 10–20 system is a unique method which is recognized internationally and describes the location of the spots where electrodes are to be applied on the scalp for conducting an EEG test. “10” and “20” suggests that there is 10% or 20% distances between adjacent electrodes of the front to back or right to left distance of the complete human skull and where letters:

“F” means frontal

“T” means temporal

“C” means central

“P” means parietal

“O” means occipital lobes

Right hemisphere of the brain has electrode positions as even numbers (Fp2, F4, F8, C4, T4, P4, T6, O2, A2), whereas left hemisphere of the brain has electrode positions as odd numbers (Fp1, F3, F7, C3, P3, T3, T5, A1, O1). Also electrode placed on the midline is referred as "z" (zero - Fz, Cz, Pz). In addition to these combinations, the letter codes Fp, A and Pg identify the frontal polar, earlobes and nasopharyngeal sites respectively.

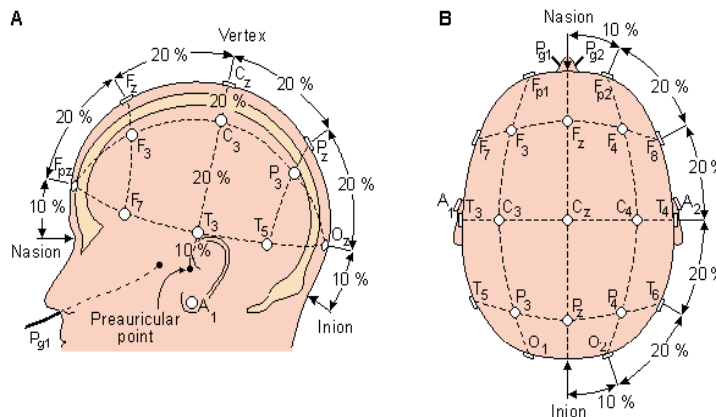


Figure: 1.1 10-20 System

## 1.2 TYPES OF BRAINWAVES

Human brain produce waves known as Brainwaves by sending synchronized electrical signals from nerve cell which help them in communicating with each other. These waves are detected by the help of sensors which are placed on the scalp of the person. Brainwaves has a unit in Hertz (i.e. cycles per second). They are further divided into bands according to the speed of the waves i.e. slow, moderate and fast waves.

### Delta Waves

**Range of frequency:** 0 Hz to 4 Hz (Slowest).

**Dominant during:** Depressants, Sleep.

These waves are the slowest brainwaves which are recorded in person. They are most common in infants and young children. As the person ages the quantity of the delta waves produced become less, even during deep sleep the delta waves are low. When Delta waves are more it is associated with highly restorative and healing sleep i.e. the person is in deepest level of relaxation. Delta waves are also involved during bodily functions that happens during unconsciousness i.e. heart beat regulation and digestion. When the delta waves are produced in adequate amount it helps in feeling completely rejuvenated and relaxed after the person wakes from sleep. If the delta waves activities become abnormal then a person may have the experience in learning disabilities and have difficulty in managing its conscious awareness which happens during the case of brain injuries.

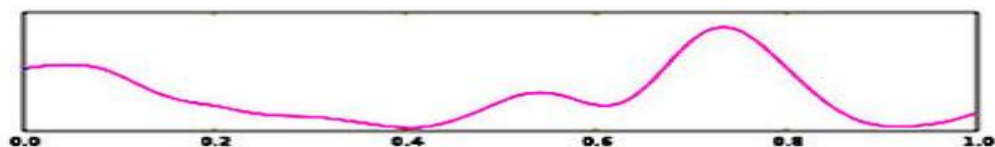


Figure: 1.2(a) Delta Brain Waves

## Theta Waves

**Range of frequency:** 4 Hz to 8 Hz (Slow).

**Dominant during:** Depressants.

When the frequency range of the brainwaves is between 4Hz to 8Hz then Theta waves are produced in brain, these waves are produce during the daydreaming and sleep. Theta waves are responsible for us to feel and experience deep emotions. When the Theta waves production is high in brain then person may feel depression, this also make the person highly gullible and they may accept and agree with any suggestions as the brain is deeply relaxed. This is also known as semi hypnotic state. If we manage to produce theta waves in sufficient amount, then it benefits and helps the person to improve their creativity and intuition. These waves are also helps in restorative sleep.

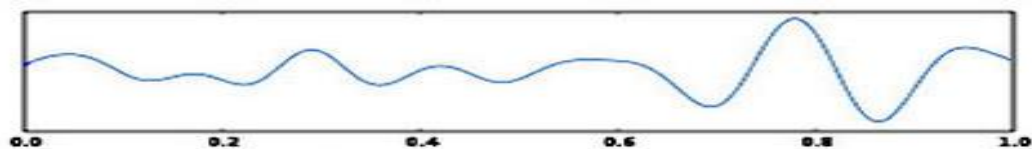


Figure: 1.2(b) Theta Brain Waves

## Alpha Waves

**Range of frequency:** 8 Hz to 12 Hz (Slowest).

**Dominant during:** Alcohol, Marijuana, Relaxants, Some Antidepressants.

When the Brainwaves speed is moderate (between the range of 8Hz to 12 Hz) Alpha waves are produced. These waves are produced when brain is neither fully conscious nor completely

unconscious. These waves help in calming down the person by generating the feeling of relaxation. “Alpha Blocking” is the phenomenon occurs when the production of alpha waves becomes very low and brain generate high beta waves which happens when the person is stressed because beta waves blocks the production of alpha waves when the person is stressed.

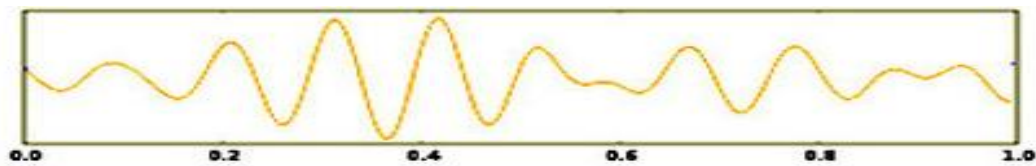


Figure:1.2(c) Alpha Brain Waves

### **Beta Waves**

**Range of frequency:** 12 Hz to 40 Hz (High).

**Dominant during:** Coffee, Energy drinks, Various other stimulants.

When the frequency of the brain waves is between 12Hz to 40 Hz Beta waves are generated. They have low amplitude. These are most common waves generated by brain as they are produced when we are awake. When the person is conscious and think logically Beta waves are prominent at that time. When the beta wave levels are normal it helps the person in focus and complete the daily tasks. When the levels increases from normal it may lead to experience stress or anxiety. Consuming any caffeine products increases Beta activity in Brain, which results in elevation in mood. These brainwaves are exhibit by the most people during their conscious daily tasks (Thinking, Writing, Reading, Socializing).

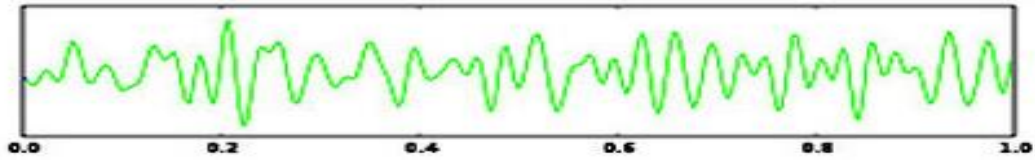


Figure: 1.2(d) Beta Brain Waves

### Gamma Waves

**Range of frequency:** 40 Hz to 100 Hz (Highest).

**Dominant during:** Meditation.

When the Frequency range of the Brainwaves are in between 40 Hz to 100 Hz then those waves are classified as Gamma Waves. These waves are very important for learning and information processing. Gamma waves are produced during high processing tasks. Low Gamma waves (40Hz-60Hz) helps in learning new things and helps in having perception of the world. Gamma brainwaves are most important in helping a person remember past events. When the Gamma waves production is less than normal then the person may become mentally challenged and may have learning disabilities. When gamma activity is normal in brain it also helps in boosting energy levels, which enables person to have peak performances both physically and mentally. Gamma waves also acts as natural anti-depressants.

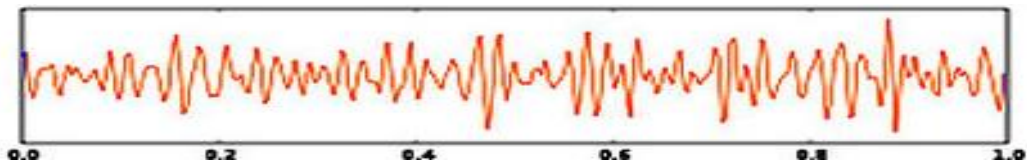


Figure:1.2(e) Gamma Brain Waves

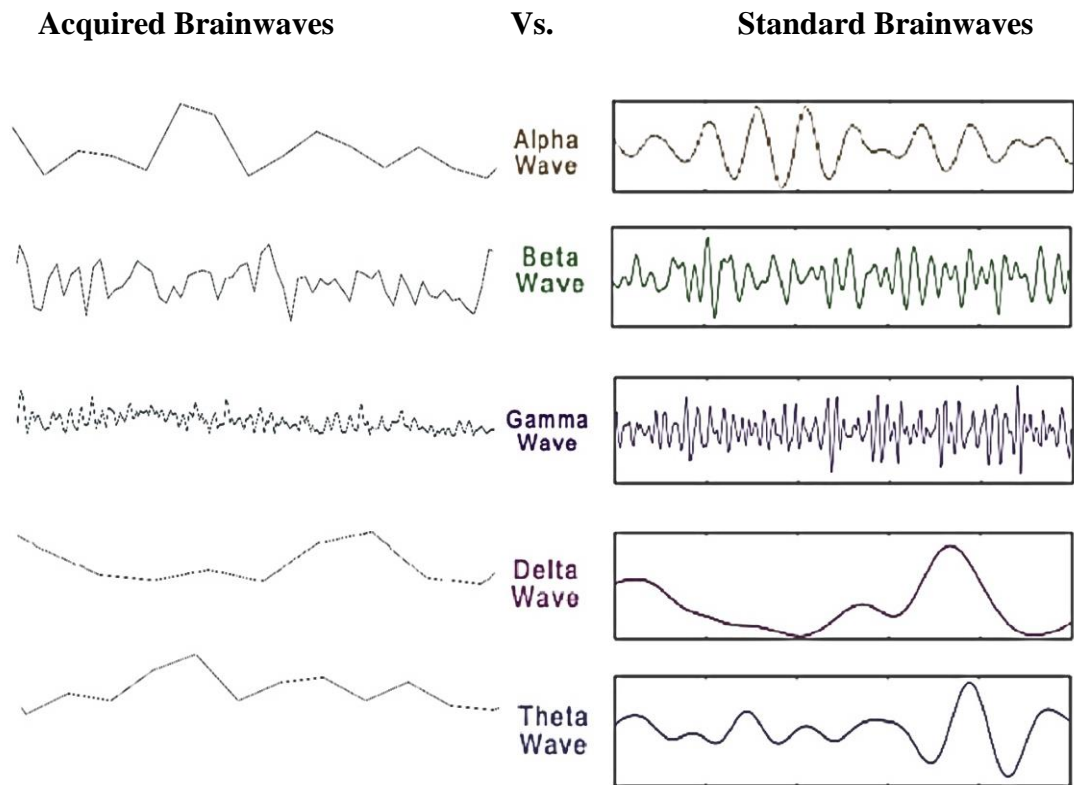


Fig.1.2(f) Comparison between Acquired Brainwaves and Standard Brainwaves

The graph (Fig. 1.2(f)) on the left is from our EEG device i.e. MindWave Mobile. We extracted raw EEG in Matlab and after taking its fft time domain signal was converted into frequency domain. We compared our graphical results and found similarities with standard graph of an EEG.

### 1.3 NEUROSKY MINDWAVE MOBILE

The MindWave Mobile is a portable and a very compact device which is used by innovators to assess and determine the outputs, the EEG power spectrums (alpha, beta, gamma, theta), NeuroSky eSense meters (i.e. attention and meditation ranging from predefined 0 to 100 values), blinking of eyes and use them for automation purposes. The device basically is a headset with a circular sensor arm that rests on the forehead and an ear clip on the ear lobe (reference and ground). The rectangular dry EEG electrode is on the sensor arm, which touches the forehead of the user above his\her left eye (i.e. Fp1 position). It uses a one AAA battery with almost eight hrs. of battery life. The outputs are Raw-Brainwaves which are of 12 bit (3 - 100Hz) with a sampling rate at 512Hz.



Figure 1.3 NeuroSky MindWave Mobile



## 1.4 INSIGHT ON ROBOT

Our four wheels robot is powered by 4 different DC motors and is capable of moving in all directions. The control signal for motors is being transmitted from Arduino, which is receiving the input with the help of Bluetooth module HC-05. Our Bluetooth module was pre-programmed to connect with only our device with the help of AT commands i.e. AT+BIND. Our EEG device which is enabled with Bluetooth is connected wirelessly with our robot. The input signal after being processed in the microcontroller drives the motors of the robot. Here L293D, a motor driver IC helps in driving motors of 9-volts by a control signal from microcontroller of just 5 volts. This IC provides 9 volts to the motors from an external power source (i.e. 9V battery) but only in accordance to the 5-volts control signal from the microcontroller.

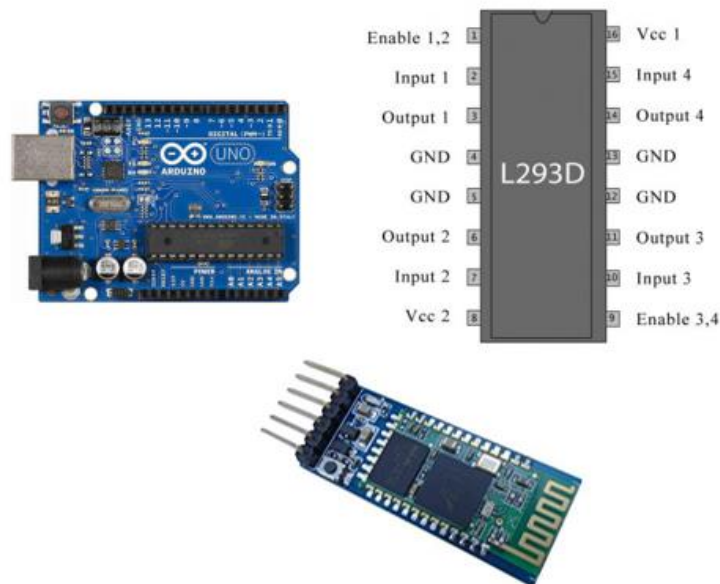


Fig. 1.4 Components used in robot

## **1.5 MOTIVATION**

In INDIA, 21 million people are suffering from one or other kind of disability and we want to provide them assistance/ease of work for sustenance living. We are ambitious to make our country Hi-Tech by providing everyone a Human-Computer interactive environment where automation is carried through mind control. This will further help in creating a stress free environment.

## **1.6 OBJECTIVE**

We are determined to target multiple aspects through our mind-control automation:

- To extract the features required to automate, from the raw EEG obtained through our device i.e. MindWave Mobile.
  
- Aid of a physically challenged person:
  - Medical devices (Wheelchair, etc.) will be controlled fully by the users through their thoughts and will enable them to perform more tasks than earlier with great ease and no/minimal assistance from others.
  
- Personal space (House, Office space):
  - By automating the basic amenities of the personal space (Fan, Lights, A.C., Music System) and provide control via brainwaves we will provide user's a highly interactive environment.

## **1.8 PROJECT OUTLINE**

The project is mainly focused on the analysis of EEG signals and designing a perfect system to create a Human-Computer interactive environment. Our focus is to make that system compatible to distinct users with very less or no changes.

In this chapter we included the introduction of EEG signal and brainwaves with its waveforms.

Chapter 2 is the literature survey, that brief study being done prior starting the research work.

Chapter 3 is Methodology which explains basic working and also a brief introduction on the work done in Arduino, Matlab and also how & what type of database we created.

Chapter 4 is Results and Discussions which depicts that what results we have achieved.

Chapter 5 is Conclusion and Future scope.

**CHAPTER-2**  
**LITERATURE REVIEW**

1. **Andreas Trier Poulsen et al 2017** This paper helps in understanding that how high-grade equipment in laboratory settings can be replaced by low cost equipment such as MindWave NeuroSky. Simultaneous recordings of electroencephalography (EEG) from multiple students in a classroom was done and measured the inter-subject correlation (ISC) of activity evoked by a common video stimulus. The neural reliability, as quantified by ISC, has been linked to engagement and attentional modulation in earlier studies that used high-grade equipment in laboratory settings. They reproduced many of the results from the studies using portable low-cost equipment, focusing on the robustness of using ISC for subjects experiencing naturalistic stimuli. Multiple students in a class can be monitored for their attention level in real time.

2. **Emotions and Brain Waves Dr. Aparna Ashtaputre- Sisode et al 2016** Emotions are directly connected to human brain. Whenever a person is happy, sad or feeling any other kind of emotion, this leads to change in brainwaves. This paper basically evaluates and proves that when a person is happy his\her alpha brainwaves tend to be more is comparison to when he is sad. For manipulating user's mood, they used two clips one sad and one comedy, from movie "3 Idiots".

3. **S. B. Mohamed, University Sultan Zainal Abidin and Zairi Rizman, University Technology MARA et al 2016** Human emotions are not always visible of the face but there is always some change in the brainwaves which can be easily analysed through EEG. They took both visible changes on face and EEG of brain into consideration. They simultaneously recorded brainwaves and recorded the face expressions of the test subjects.

Their aim was to make BCI a possibility. They finally were able to detect the changes in the brainwaves during four different moods i.e. Anger, Sad, Happy, Emotional Surprised.

4. C.Jaganathan *et al* 2015 This paper helps in understanding how to extract different types of brainwaves. For that first we record brain's spontaneous electrical activity i.e. EEG over a short period of time, usually 20–40 minutes. 250 and 2000Hz are the sampling rates generally used to record\store EEG in clinical and research and development sector, but now above 20,000 Hz sampling rate is also possible to achieve for collecting\storing data which is made possible by new technology and innovation in modern EEG data collection systems. As we know brain waves i.e. Alpha, Beta, Gamma, Theta have different frequency so they were extracted. Because of innovations and technological advancement now it is possible of diagnosing diseases that are brain related and can also be used in other fields like research and BCI.

5. Sarah N. Abdulkader *et al* 2015 Brain-computer interface is a revolutionary idea which aims to connect us with our surroundings and give us the power to control\automate just by thinking. This field is being explored to find new and efficient ways to achieve this vision in coming future. In medical fields BCI contributes in prevention to neuronal rehabilitation for serious injuries. Basically this technology can enable anyone to read mind and communicate remotely which can be used in educating people by keeping close eye on their learning rate, etc., in gaming and can be a new way of having an IoT based surrounding controlled via. User's mind\thoughts. They revealed the areas where this system has a possibility in future and be the reason for change in millions of lives. In this paper it is also discussed about the

usability and the challenges faced by this technology in practical uses and their possible solutions that helps us to limit the effects and decrease the complexity in using BCI system.

6. Wojciech SAŁABUN, 2014 This paper gives an insight of the device which is used in our project i.e. MindWave Neurosky. It gives the working on how it processes and does the spectral analysis of the raw EEG signals. Electroencephalography (EEG) is generally used in a variety of research and development area. But Earlier commercial devices that were made available were not cost effective and use to cost thousands of dollars. But now a revolutionary device is invented which is highly cost effective and costs around 200 dollars. NeuroSky inc. is the developer of cost effective portable devices and one of them is the MindWave Mobile. This device is one of the least expensive and highly accurate commercial EEG device, costing even less than 100 dollars. The paper gives methods on how can any innovator record data (i.e. raw EEG signal) and then process the data to acquire the different features needed to automate, from the MindWave Mobile in the MATLAB environment. The signal retrieved are in time domain so they used fast Fourier transform (FFT) and converted that signal in frequency domain in this research.

**CHAPTER 3**

**METHODOLOGY**



### 3.1 BASIC WORKING:

Flow graph (Fig. 3.1) below depicts the basic pre-programmed working of the device i.e. MindWave NeuroSky. The device has default function to measure and show the Attention (Beta), Meditation (Alpha) and blink. With these default values a user can control various devices by concentrating/relaxing and manipulating the attention/meditation values on his/her will. By using a simple microcontroller (Arduino Uno) the values can be interpreted according to the programmers (user's) liking.

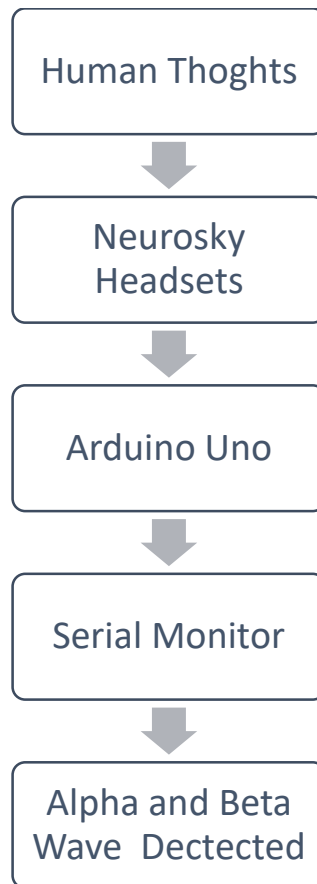


Figure: 3.1 Flow graph showing basic EEG waves detection.

### 3.2 FEATURE EXTRACTION:

To make a universal system which can be operated by any user with minimum or no changes, for this we chose Matlab environment to analyze brainwaves of different users. First establish a connection of the device (NeuroSky) with Matlab, the steps are as followed:

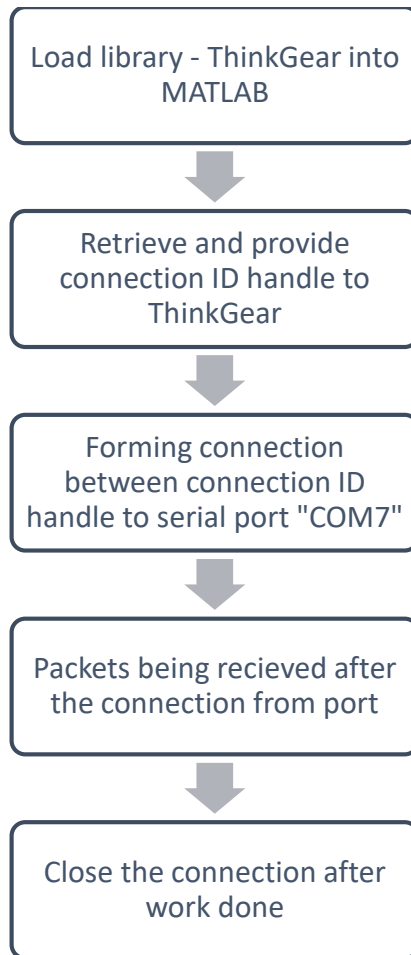


Figure: 3.2(a) The communications protocol

After the connection is established we load program in Matlab to derive raw EEG of multiple users through MindWave NeuroSky. This raw EEG is in time-domain so now to differentiate between different brainwaves of different frequencies (Alpha, Beta, Gamma, Theta) we convert this time domain signal into frequency domain. After analysing multiple wave

patterns, we take mean of the values in these graphs and we use these values to create a database which will help in providing automation through a system which is not restricted to only one user but can be used by multiple users by no/minimal changes. Additionally, we can also analyse wave patterns during different moods (Happy, Sad, Anger, etc.) for multiple users and create an environment appropriate according to the users. (Fig. 3.2(b)).

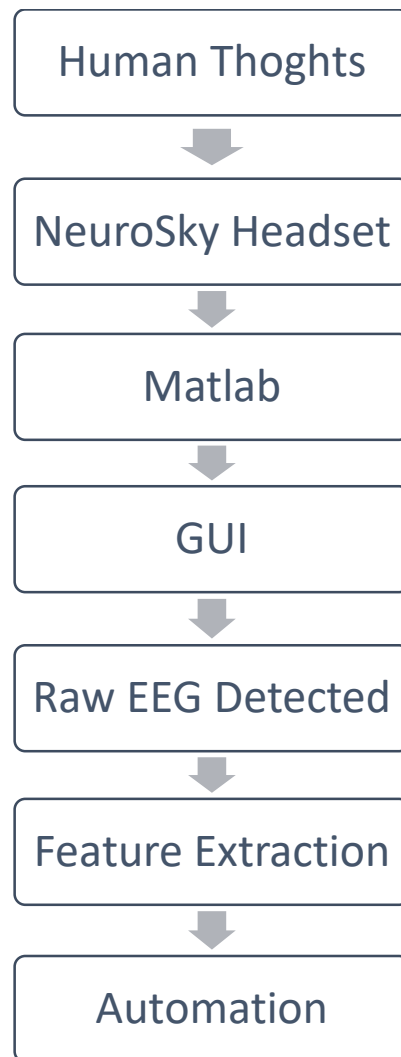


Figure: 3.2(b) Flow graph showing working on Matlab

### **3.3 DATABASE CREATION:**

To make a system that works irrespective of user and gives the desired output, we made a database of around 17 test subjects to analyze brainwaves pattern\behavior according to their change in mood. For creating the database, we first implemented a code in basic C language with pre-defined functions to extract different types of brainwaves. This code was compiled and dumped by a software called Arduino IDE (Integrated Development Environment) on our microcontroller i.e. Arduino Uno. The Arduino was connected with MindWave Mobile via Bluetooth module (HC-05). When different brainwaves input was being received into the microcontroller, they were being displayed on the serial monitor. But to manipulate this data we had to store it in a file\database. For storing this data, we used a software named PLX-DAQ v2.11 (compatible with Windows 10). PLX-DAQ or Parallax Data Acquisition tool helped us in creating a database in .xls format i.e. Excel sheets, for 17 test subjects and made manipulation of data much easier.

The flow graph (Fig. 3.3(a)) depicts the procedure we followed to make database in .xls format using PLX-DAQ v2.11.

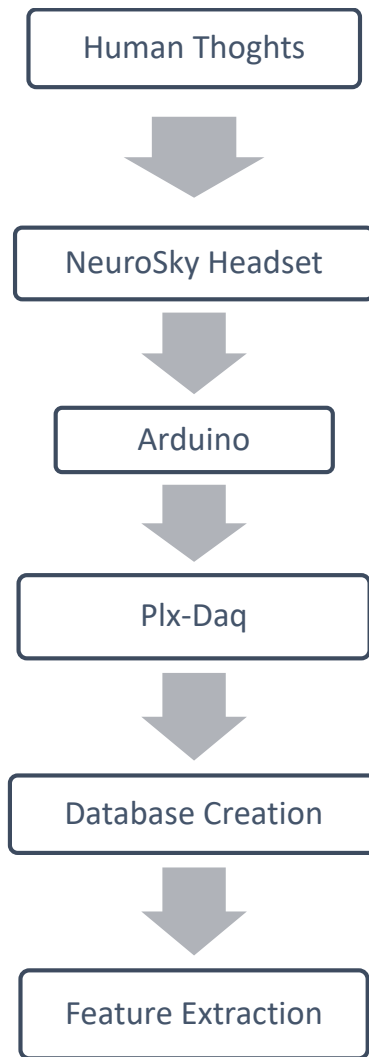


Figure: 3.3(a) Flow graph showing how database was created

Test subjects wearing our device NeuroSky MindWave on their head with metal sensor\electrode on their forehead over left eye and refence ground clip on ear lobe when their real time data was being collected as they watched videos (Fig. 3.3(b)).



Figure: 3.3(b) Test subjects watching videos as their waves are being recorded

Test subjects were shown two videos simultaneously with a gap of 3-4 minutes and were also asked for their feedback on the videos.

## **Chapter-4**

### **RESULTS AND DISCUSSION**

We analyzed brainwaves of the user to determine the correctness of the pre-programmed attention and meditation values. For this purpose, we used the software provided to us by the NeuroSky itself i.e. Brain wave visualizer (Fig. 4.1). The Brainwave Visualizer plots in a graphical, colorful, interactive manner and also provides game so that a user can learn to control his\her attention and meditation level at will. The Brainwave Visualizer includes the Brainwave Visualization, Brainwave Power Spectrum Graph, and the eSense Attention and Meditation meters.

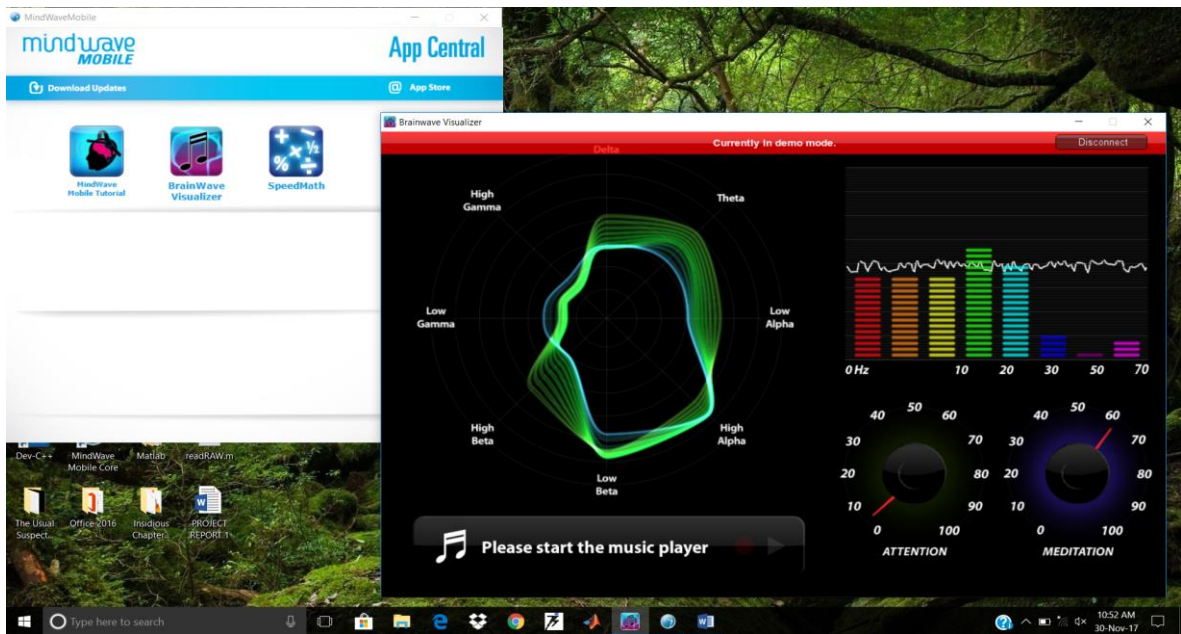


Fig. 4.1 BrainWave Visualizer

There is circular chart in Brainwave visualizer which represents different frequency bands of the brainwaves. Different brainwaves which works at different frequencies are plotted in this circular chart with fixed axis. The flow within this circular charts comes to life and changes according to the fluctuation in the brainwaves of the user. The brainwave power spectrum



graph shows the values in a graphical manner. When user achieved 100% attention (Fig. 4.2) the eSense attention meter pointed at 100. In graph the fifth (light blue) & sixth (dark blue) represents the low beta (attention in relaxed state) and high beta (attention in tensed state) respectively. When user achieved 100% meditation (Fig. 4.3) the eSense meditation meter pointed at 100. In graph the third (yellow) & fourth (green) represents the low alpha (relaxation and disengagement) and high alpha (calm body and alert & relaxed mind) respectively.

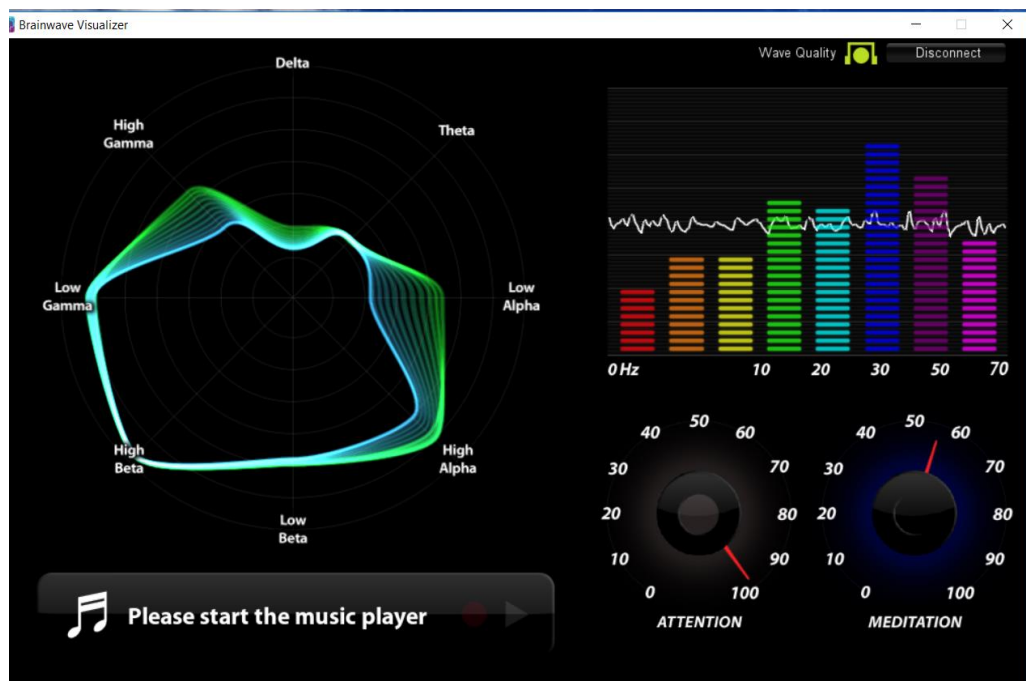


Fig. 4.2 100% Attention in BrainWave Visualizer

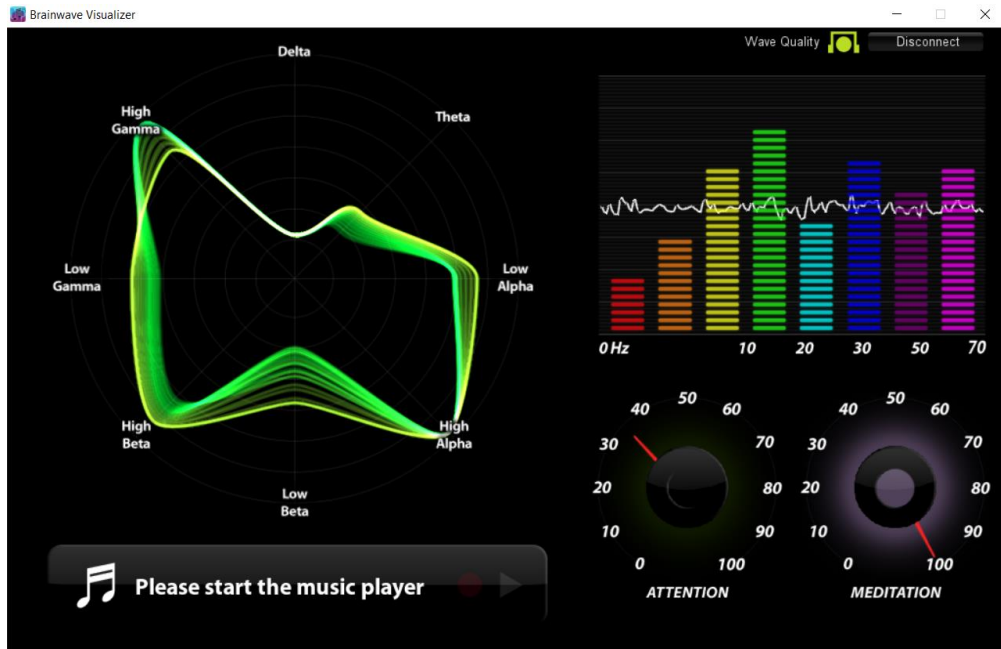


Fig. 4.3 100% Meditation in BrainWave Visualizer

We were also able to extract raw EEG (Fig. 4.4), Attention (Fig. 4.5) and Meditation (Fig. 4.6) in Matlab which will be used to make a system that will work in accordance with every single user.

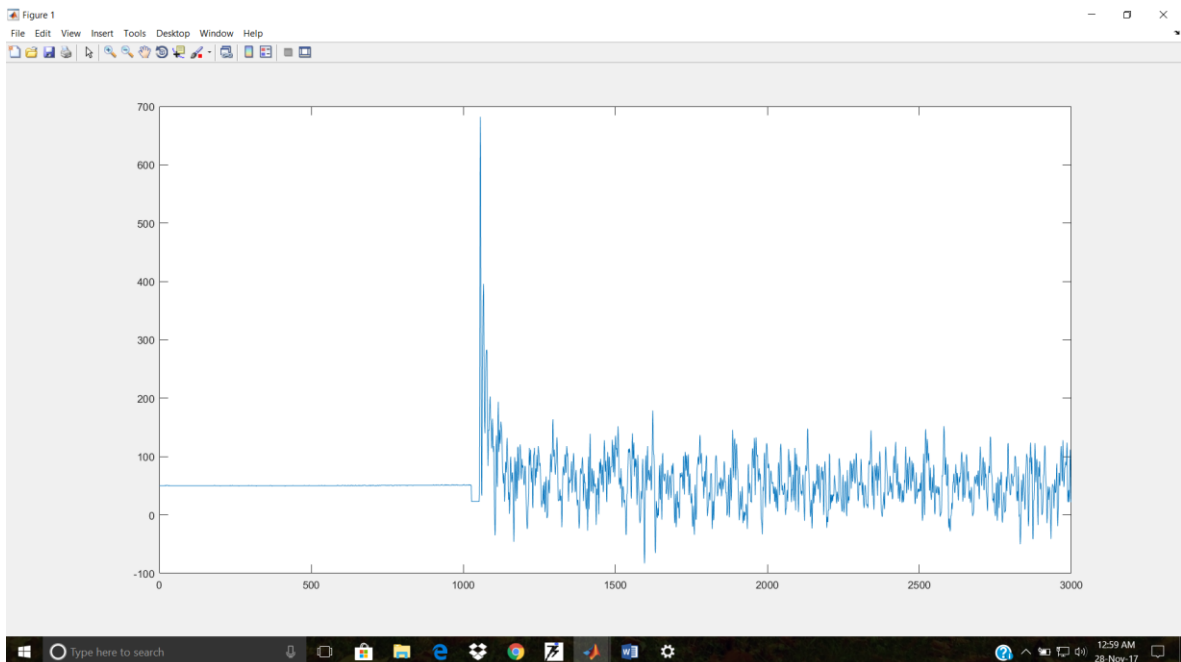


Fig. 4.4 Raw EEG obtained in Matlab

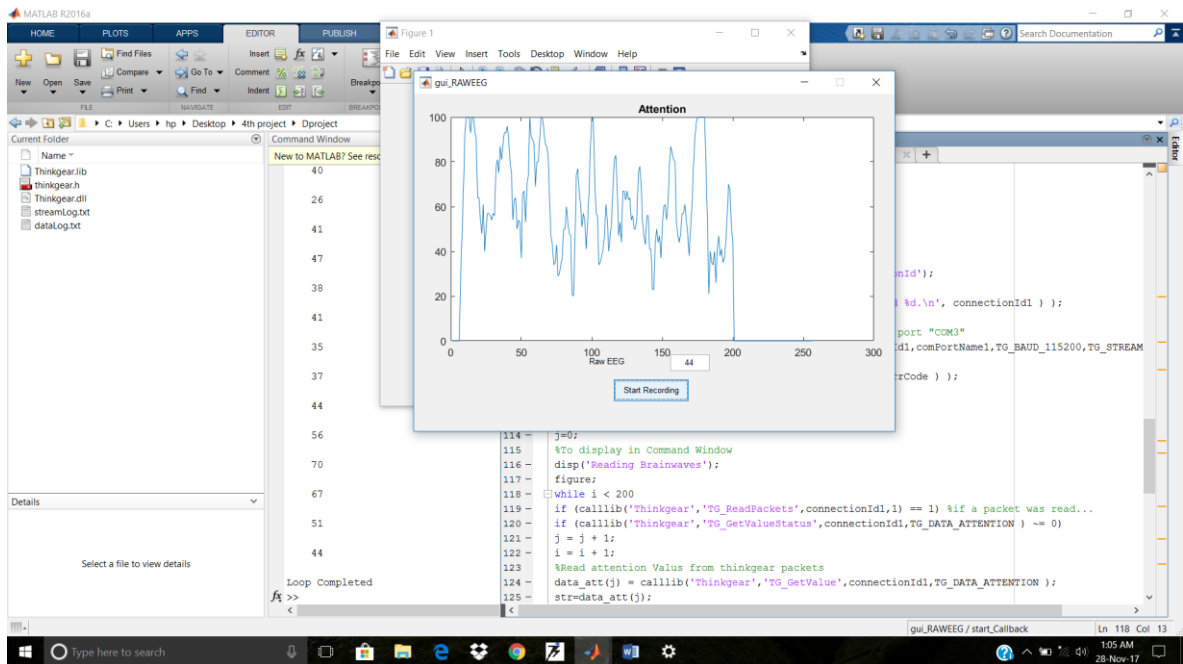


Fig. 4.5 Attention values and signals obtained in Matlab

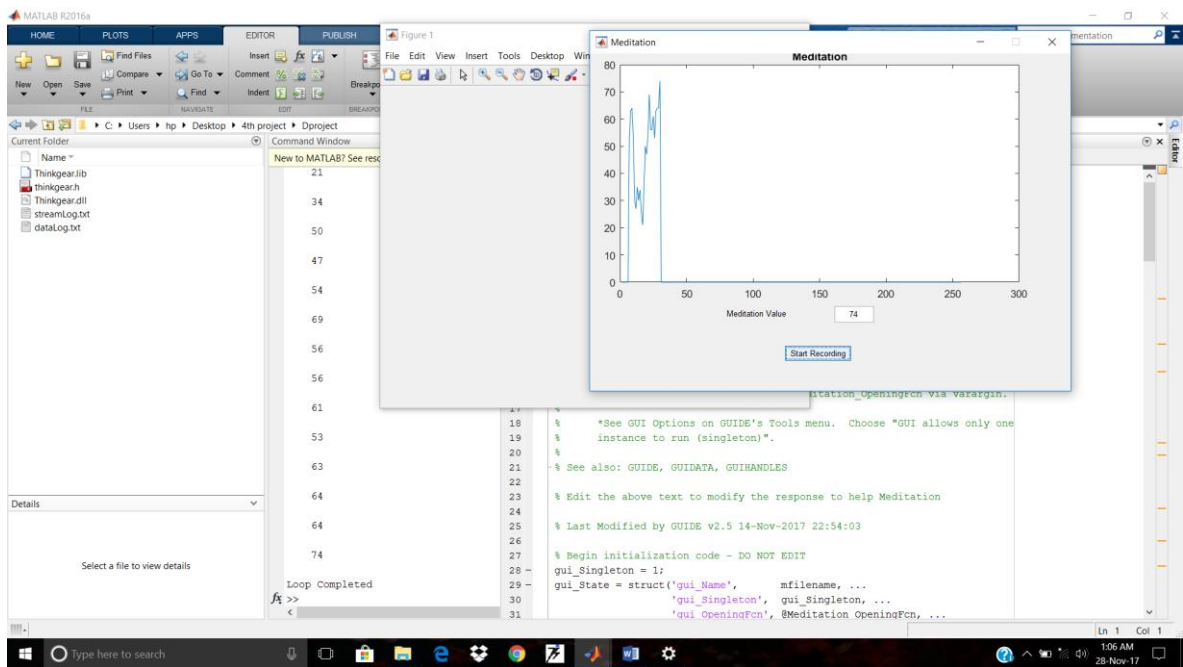


Fig. 4.6 Meditation values and signals obtained in Matlab

We have done the analysis of the device (NeuroSky MindWave Mobile) and the wave patterns in the NeuroSky Analyzer compared with the output seen in Matlab environment.

After testing from the pre-programmed attention and meditation values we were able to automate robot car (Fig. 4.7), robotic arm and basic on-off function of any device operating on alternating current.

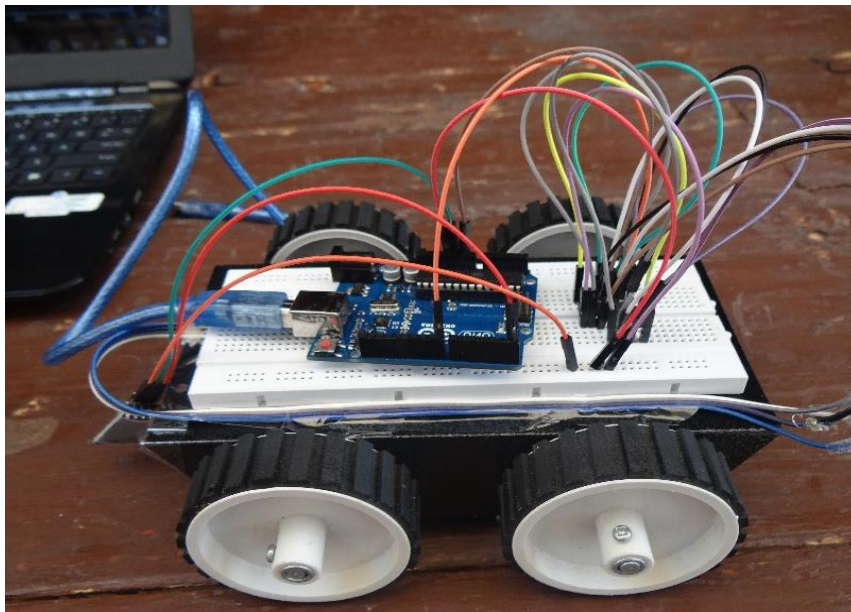


Fig. 4.7 Brain-Controlled Robot

After successfully automating a robotic car we further explored our device and extracted the raw values of different brainwaves (alpha, beta, etc.) which can be converted to corresponding voltage levels by using the formula:

$$V = (\text{raw value} * (1.8/4096))/2000$$

Where,

$$2000 = \text{gain}$$

4096 = value range

1.8V = input voltage.

Unit = Volts.

We stored raw values in an Excel sheet with the help of a software called PLX-DAQ. Then we created database by recording these values of 17 different test subjects. We recorded data while showing a comedy (Fig. 4.8) and an emotional video (Fig. 4.9) to every test subject keeping a time gap between both videos of around 3-4 minutes. Some test subjects were observed in a controlled environment and some in open environment. Then we took average of the data collected and observed that every user had higher alpha values (Fig. 4.10) when they saw comedy video as they were happy. Whereas their alpha values were comparatively lower when they saw an emotional video. We manipulated these values and created an environment that can calm\sooth any user named as “Soothing Pod”.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Time	Attention	Meditation	Delta	Theta	Low Alpha	High Alpha	Low Beta	High Beta	Low Gamma	Mid Gamma				
256	Time	53	60	22834	9150	17429	7819	9917	10662	1736	4416				
257	Time	48	60	24383	11164	17357	54528	36723	18619	16964	2941				
258	Time	34	64	3843	43855	10207	4146	2997	1670	640	756				
259	Time	27	66	53994	33565	8844	3720	3548	3205	725	883				
260	Time	14	66	58182	20220	16636	6103	5411	2758	1240	570				
261	Time	21	78	41239	1550	2993	535	1485	792	473	57				
262	Time	27	77	58892	31503	19526	25675	8310	12739	5530	5382				
263	Time	24	80	64149	28357	4328	14569	7003	2238	5513	1471				
264	Time	40	66	16507	29725	1934	8198	8060	14910	5225	1067				
265	Time	41	56	32299	63441	17621	18954	27390	18000	11514	6216				
266	Time	50	60	4461	17202	10363	3104	14204	5650	2479	1769				
267	Time	44	44	55630	19329	590	1641	827	529	93	133				
268	Time	27	60	60523	52669	13733	45932	3144	5042	6065	5626				
269	Time	21	61	18246	35309	9604	7956	12471	4445	2768	4808				
270	Time	8	56	7922	39931	7768	770	2937	1896	756	624				
271	Time	35	64	49354	15236	4529	6409	8654	15129	17526	4788				
272	Time	35	64	55777	53978	7924	43514	8769	41929	25215	14646				
273	Time	34	56	16074	32888	65412	13685	30123	8707	9263	7304				
274	Time	37	61	53561	7666	43141	14396	9134	15765	4449	1827				
275	Time	50	69	17149	12674	3333	8766	7116	5359	4693	4874				
276	Time	23	83	7997	20086	21830	5766	4879	1132	1080	950				
277	Time	30	75	37957	34913	5898	4255	15116	4324	794	824				
278	Time	20	61	27114	53468	7436	1772	3724	2186	845	408				
279	Time	10	54	59030	32784	2486	5428	1323	2137	583	927				
280															
281	Average	48.48201439	59.40647482	31068.80935	27923.91727	15613.04317	12527.51439	11086.59353	10343.07914	8661.44964	4523.16547				
282															
283															
284															

Fig. 4.8 Happy mood values of test subject

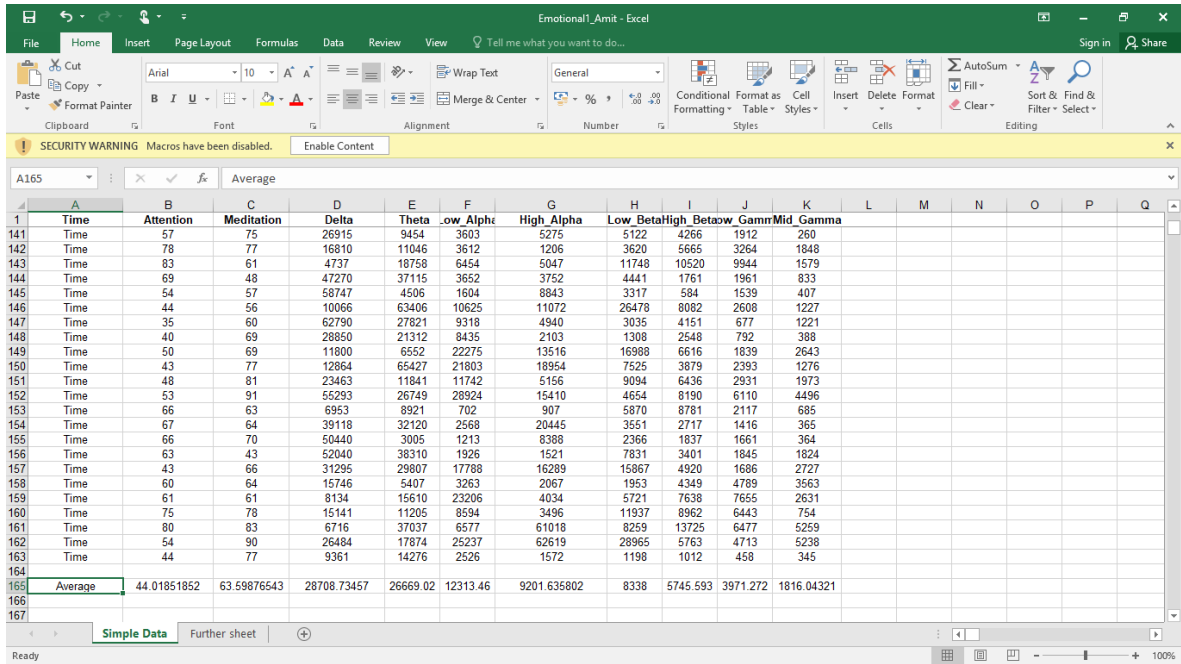


Fig. 4.9 Emotional mood values of test subject

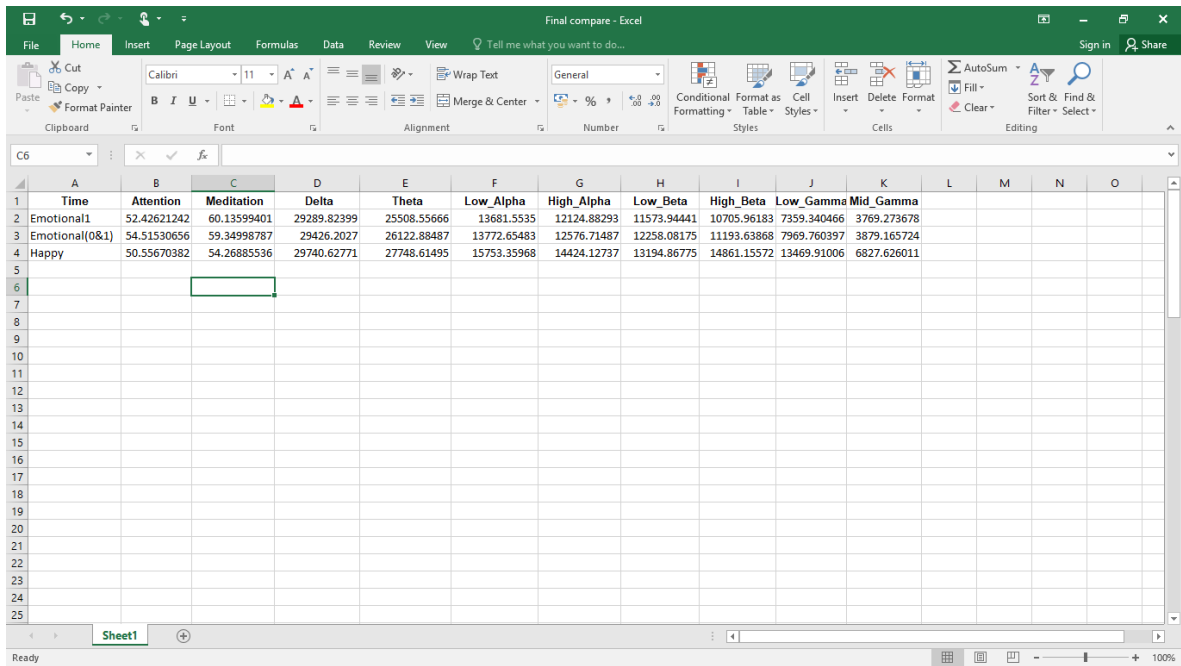


Fig. 4.10 Final comparison of average values all 17 test subjects

<b>Mood</b>	<b>Low Alpha</b>	<b>High Alpha</b>
<b>Emotional – 1</b>	<b>13681.5535</b>	<b>12124.88293</b>
<b>Emotional 0&amp;1</b>	<b>13772.65483</b>	<b>12576.71487</b>
<b>Happy</b>	<b>15753.35968</b>	<b>14424.12737</b>

Fig. 4.11 Average values of Alpha Waves for all 17 test subjects

When test subjects were shown video they were asked for a feedback about the video. Those who found video emotional were designated with number “1” and others by number “0”, who gave a complex reaction towards the video and same was done in the case of comedy video. But every test subject was happy with the comedy video so no user was given a 0. This table clearly depicts that alpha waves can be used to distinguish between users with a happy or a sad mood. There is definitely a change in alpha value when an emotional video is shown even if a user denies himself\herself.

## **Chapter-5**

### **CONCLUSION AND FUTURE SCOPE**



After taking many facts (ease of use, technology, cost) into consideration we conclude that NeuroSky Mindwave Mobile is the best device for our project work. They provide researchers with extensions that helps in using this device on various microcontrollers (Arduino, etc.) and platforms such as Matlab, LabView, etc.

Firstly, we observed the brainwave patterns in the software provided by the NeuroSky i.e. The BrainWave Analyzer and then with the help of the extensions provided by NeuroSky we further integrated our device MindWave Mobile with Matlab and generated raw EEG, Attention, Meditation. After converting the raw EEG graph in frequency domain we compared it with waveforms of different brainwaves and they were near identical (changes according to user\time\mood etc.) (Fig. 1.3).

After acquiring Attention and Meditation we were able to move a robotic car through our mind. As after a minimal practice it is easy for any user to control their Attention and Meditation level.

Then with the help of NeuroSky MindWave Mobile we created a database of around 17 test subjects for emotions i.e. “Happy” and “Sad”. They were shown two different video clips

1. Golmaal Fun Unlimited (Duration: 5:) (Funny)
2. Father’s Love for his son (Duration: 3:) (Sad)

As Alpha waves were high in happy mood than in sad mood we were able to conclude that our single electrode device is capable of analyzing the user’s mood in real time.

Now further what we did was feature extraction according to our needs to:

1. Move a robotic car with blink, attention and meditation values.

2. Make a simulated environment for users named as “Soothing Pod” to sooth and relax their body and soul by analyzing their moods in real time.

By this we have possibly worked on different aspects that can be performed through our device. And this knowledge can be used by future explorers to integrate their systems with our unique EEG based system to automate the environment in more new possible ways. Also a portable device can be invented so that brain anomalies can be detected before the condition of the person deteriorates because of late diagnosis.

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