Chapter 1

Literature Review .

In these modern times, we are looking forward to utilize the modern technology for the life of mankind. We are working on the project which can help the patients with physical disabilities. This means the patient with physical disability can use their brain to control wheelchair with the help of computer that understand the language of brain. While working on this project , we came across a few projects related to Brain control wheel chair. We are discussing here these projects, as follows:

Utkarsh Sinha and Kanthi.M [1] presented a paper which proposed a method that will based on portable Electroencephalogram (EEG) headset and Software Graphical User Interface(GUI) used for control purpose and the working of wheelchair processed by the brain activity and eye blink frequency of the person brain. Agneev Guin and Bidyut Bikash Baishya [2] proposed a method based on eyeblink . So that they use an single electrode system model based on the Neurosky Mindwave mobile headset so that the user can select the destination through eyeblink software.

Tom, Carlson and Jose del R. Millan proposed [3] a article in which brain actuated wheelchair can be contructed by combining a Brain controlled Interface (BCI) with the wheelchair via shared control layer .In this article they presented a system that fulfill the desires of the user with the accuracy of wheelchair.

Mehul patel and Rishikesh Bhavsar [4] design a brain controlled wheelchair .In this paper they have controlled wheelchair via Bluetooth module .The mindwave headset included a electrode on the front of the scalp is the reference electrode and ground electrode connected to the ear lobe .So in this paper attention parameter is used to controlled the wheel chair.

Brice Rebsamen [5] proposed a project that working on the a brain control wheelchair for the movement in the familiar environment. BCI is the best method to communicate and control the device. BCI requires a concentration effort. The movement of wheelchair totally depends on guiding path of the user.

Balamurugan Kaliappan [6] proposed a model of wheelchair that uses the Micro-electromechanical systems (MEMS) is the sensor that is used to check the movements of the head and the respective signal is given to microcontroller. After processing the signal microcontroller controls the movement and direction of wheelchair by using the motor drive circuits. This includes voice and eyeblink sensor to recoginized the voices of patients to overcome the old limitations. Collen Nelson, Nikitha S Badas, Saritha I G, Thejaswini S [7] proposed a Robotic wheelchair that uses different RF transmitter and RX receiver that can communicate with other devices in the room. They also implemented the voice recoginizing software. In their proposed work they converted the wheelchair into the bed by using different motors implemented in the bed.

S. Monoharan and N. Natarajan [8] stated that the goal of their work is to obtain attention level of brain. They will measure neurons electric activity in the brain and then by using these signal they will move a Wheel Chair. They uses EEG technique to measure the volatges of neutrons and then these voltages will be proceed to the microcontroller and they will control the wheelchair. Antoniou, E.; Bozios, P.; Christou, V.; Tzimourta, K.D.; Kalafatakis, K.; G. Tsipouras, M.; Giannakeas, N.; Tzallas, A.T [9] Stated in this paper that BCI method is used for acquiring the EEG signals from human brain by using the wireless EEG brain wear system. After getting the EEG signals from brain then by using an RF algorithm EEG recordings will differentiate into six categories. Their future work is applied this project for handFree control movement of the wheelchair in a real time.

Millan et al [10] proposed a EEG brain-controlled robots that is very useful for human technology. Different machines learning procedures were used in this project. EEG signals were captured by the Eight scalp sensors which were located at the fronto ,centro parietal positions F3, F4, C3, CZ, C4, P3, P2, and P4. The wheelchair movement can be totally depends on by mapping the eight sensor values. After capturing these eight sensory values their movement of wheelchair will be controlled.

B. Jenita Amali Rani1 and A. Umamakeswari [11] developed an EEG Brain-control wheelchair for peoples who are physically disable. Two methods were used in this project. In this project attention signals were used for making a forward/backward movements of wheelchair and Eye blink movements of the user were used for the start and stop operation of wheelchair .This prototype of Brain-controlled wheelchair developed with the help of Neurosky headset. Different techniques were used for developing this project.

K. Permana, S. K. Wijaya a) and P. Prajitno [12] proposed their model of project for wheelchair. Wheelchair movement totally depends on the motor of wheelchair whose movement obtained by Neurosky mindwave mobile 2 headset. In this mindwave mobile 2 signals from one electrode are analyze by the concentration and meditation values of the user brain. So the signals obtained from headset can be processed and analyzed then organized into five movements using the Matlab GUI,it was organize into five classes where the classes were named as default/motionless, move forward, move backward, turn right and turn left. After organized by Matlab GUI and organize data forward to Arduino Uno to control the movement of motor in the project. Muhammad Ahsan Awais [13] developed an application that is android based .The application develop using NeuroSky Android Development Toolkit to acquired the blink and attention level of user brain from the Neurosky mindwave. The working of wheelchair is design by using two features. The Four different directions are at interval of 2 seconds in the application. The disable person is used to perform double blinks in order to select a movement where he/she wants to move. Whenever the movement is locked, the user need to just focus. In meanwhile, attention level is checked. If it will goes above 60, the built in application will send a command via Bluetooth to a microcontroller to move the wheelchair in the direction where user wants..

Thair A. Salih, Yasir M. Abda [14] presented a paper that uses the Mindwave headset, which will recognize the brainwaves to form a BCI by collecting the system signals from the frontal lobe of the brain. This project also proposed an separate computer i/p device for physically challenged people. Their suggested work uses two virtual keyboard. One is QWERTY type and other is alphabets type keyboard which consists of alphabets and two other defined characters that is Delete and Space. This alphabet type keyboard has 30 cell. Each alphabet occupied the one cell and two cells for each control button. The keyboard used EEG signal from brain with also person-eye blinking for printing. The results were about (1.5-1.8 Words per minute) with an low error rate equals to (5-5.25)%. After performing the experiment the best model is the one that uses the alphabet keyboard type.

Qin, L. Y., Mohamed Nasir, N., Huq, M. S., Ibrahim, B. S. K. K., Narudin, S. K., Alias, N. A., & Ab Ghani, M. A [15] proposed a model which uses a GUI which control the home devices using BCI technology. Mind Wave headset detect EEG signals from the brain. This prototype model is developed by using Raspberry Pi 3 Model B+, 4 channels 6V relay module,televisions, light bulb and fan. The raw signals collected from brain waves is being extracted from the brain to run the home devices.

Liqiang Xin ,shang Goa , Xin Xu [16] gives the article that control the wheelchair of physically disable person. They also proposed the rotation of wheelchair controlled by the eye blinking software. Whenever person want to rotate their wheelchair it totally depends on how much times he blink the eyes. After taking the EEG signal from the brain the signal is transmitted to the STM32 to move forward the movemnet of the wheelchair. The error level of the system is kept very low and the accurarcy of the system is high.

Mohammad Monirujjaman Khan [17] proposed wheelchair that is implemented by using an Arduino-based robot that is controlled by a human brain waves using a BCI.The waves of human brain can be captured by low cost component that is Neurosky headset. Their proposed model of wheelchair is limited to a maximum speed of 5 Miles Per Hour (MPH).The battery life expectancy of proposed wheelchair is about three to four hour.This model consist of Real-time Internet of Things (IoT)based patient monitoring devices can be implemented in the wheelchair to monitor the patient medical checkup such as heart rate device, Spo2 level, ECG, and temperature etc. A short message in the form of SMS alerts can to other person in the case of any accident happens to person. Its also give alert about the any mechanical problem in the wheelchair.

Imran Ali Mirza[18] presented a model of wheelchair that extract signals from the brain and eyes and then given these instruction to the wheelchair. For EEG technique the electrode cap that is placed on the person scalp for the extraction of the EEG signals from the brain. Whenever these signals are extracted then these signal will be translated into the commands of movement by the Arduino Microcontroller which will rotate or move the wheelchair in which direction user want to move. L.annie Isabella, Aafrin Y A , Deepthi Pooja S , Dipshika R , Harini R, A. Xavier [19] in this paper proposed Robotic Wheelchair which extract the signals from the different electrodes placed at brain. There are accordingly International 10-20 electrodes setup for the EEG. The signals coming from brain are actually movement of wheelchair. In this project they uses simple unipolar electrode to capture EEG signal from the brain. The attention level and mediation level of the patient can be used to control the movement of wheelchair which they used as the control signals.

Chapter 02

Introduction .

2.1. Background/ History of Project.

Mankind has travelled from gestures communication to the modern age of wireless communication where every application is at the brink of a push button. This project is the manifestation of the idea that brings modern world and its charms closer to physically impaired people by providing them with a novel technology to communicate with machines without moving any part of body or saying a single word. The technology behind the brain control devices dated back to 2002 when researcher implemented the electrodes on the mind of monkey and used brain signals to move the cursor on the computer screen. This brain control interference technology advanced with time and many gadgets have been introduced which control by brain. In 2009, University of South Florida, Department of robotics made a wheelchair-mounted robotic arm that collect the waves of brain and make the robotic movement by using these wavs..In 2010, Duncan graham rowe at the MIT design the brain control wheelchair using 10/20 BCI system. But it was complex system. In 2016, Rahib H. Abiyev published the article "Brain-Computer Interface for Control of Wheelchair Using Fuzzy Neural Networks". In the 2018, L Xin proposed the Simple design of brain control wheelchair at the IEEE Xplore conference . In the past few years many prototype of brain control wheelchair are introduced. But that design which reached to commercial production of brain control wheelchair was designed by diwakar vaish chairperson of robotics at the SET. This commercial production of wheelchair make opportunity for common people to use BCI technology.

2.2. Brain Computer Interface (BCI)

The Brain computer Interference (BCI) generally knowns as the Mind Machine Interference (MMI) communication method which makes communication between brain and electrical devices [20]. Figure 2.1 shows the block diagram of Brain Control Interference BCI. The human mind is made up of neurons, all nerve cells are joint together by other dendrites and axons. All actions such as thinking, moving, hearing or remembering something make the senses work. Small electrical signals from neuron to neuron are moving at a speed of 250 mph [21]. Signals are produced according to the electrical potential of ions in the membranes of each neuron. Symbols can be found, translated into their meanings and used to guide the device for a specific purpose.

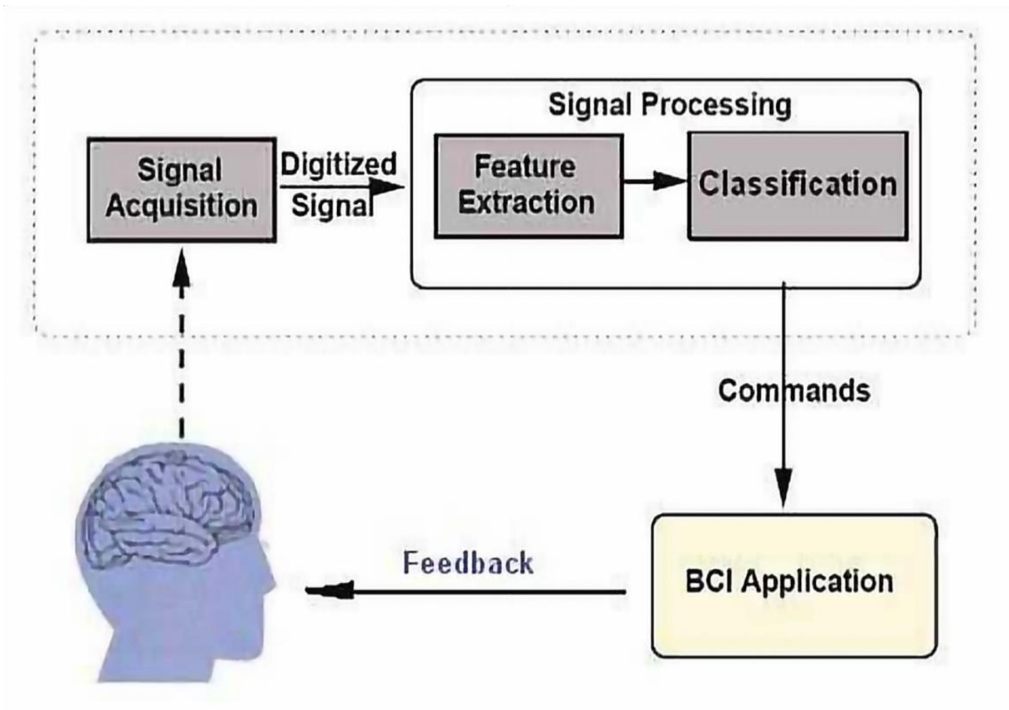


Figure 2.1: Block diagram of Brain Control Interference [22].

The immediate aim of the BCI study is to provide communication skills for people with severe disabilities who are completely disabled and living with injuries. Therefore, BCI is a system that makes communication between the brain and the computer.

2.3. Electroencephalography (EEG)

EEG is the technique used to detect and measure the brain electrical signals. EEG signals are picked up from the mind and there is some noise present due to electrical disturbances and movement of electrodes. Applying a large number of EEG channels on the brain can cause the signal to make noisy which reduce the performance of Brain Control interference BCI. That is why, usually selecting the small number of channels is prefer that gives the more accurate results and that can balance both performance and performance requirements as compared to using larger number of channels.

2.4. EEG Wavegroups

Brain wavelengths are changed with emotional states or thought patterns. Delta wave are frequency of 1-4 Hz. The waves are moving very slowly with the delta waves coming from where we are inside deep sleep. A frequency of less than 8 Hertz is considered theta waves. While this is evident in order for some of the waves to be less ambiguous, they also appear to be related with old, sensible thinking. When someone has "aha" experience it is usually when we talk.

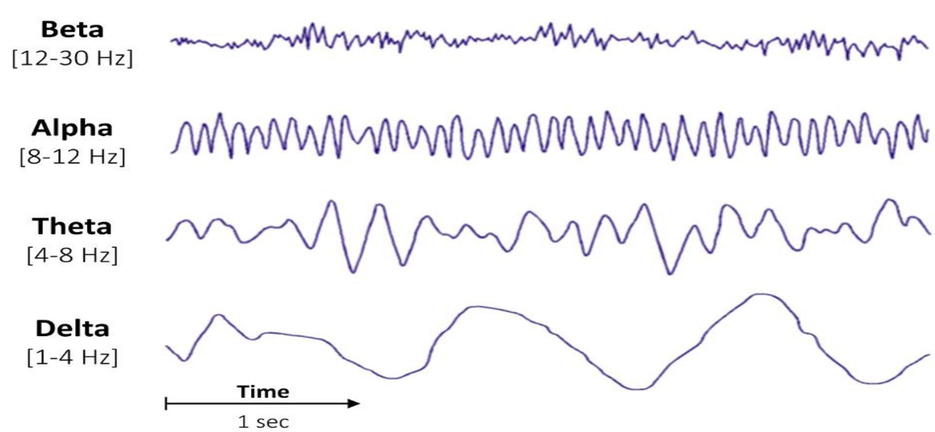


Figure : Frequency bands of EEG data signal[23]

Alpha waves have frequency from 8 to 12 Hertz and are produced in relax, meditative conditions. Most Peoples mind produced alpha waves before they time to go to bed. The alpha waves are strong during that time an evening situation when we are experience with fast sleep and awake. Beta waves are above 12 Hertz correspond to our "awakening" analytical thinking. When you solve a math problem, your brain produced beta waves. There are two types of Beta waves.

i) Beta 1

These waves are frequency of 13-20 Hz. These waves are produced by Comprehension, Thinking, Mental Activity.

ii) Beta 2

These waves are frequency of 20-30Hz, produced by tension, anxiety, excitement.

Mu waves are range of frequency of 8-12 Hz. These waves are decreased when we move. They waves are found in sensory motor cortex of mind. Gamma waves are range of frequency 26 - 100 Hz. These waves are coming to the fore. They are present in the prefrontal cortex and the temporal lobe of the left [24].

Table 2.1 shows the frequency bands and location of EEG Signal

Waves	**Location**	**Frequency**	**State**
Theta	Temporal cortex	4 – 8 Hz	Trance, Dreams
Alpha	Posterior regions of head, both sides, higher amplitude on dominat side	8 – 13 Hz	Relaxation with eyes closed but still awake
Beta	Present on both sides and have symmetrical distribution	13 – 30 Hz	Perception, Thinking, Mental Activity
Delta	Frontally in adults, posterior in children	0.5 – 4 Hz	sleep, Coma

Table 2.1: Frequency bands of EEG Signal [25]

2.5. EEG Electrode Brain Channel

In the BCI implementation locations of electrodes are selected in the skin area of brain which shows the electrical signals of the brain. The different techniques are used to pick signals from the brain and these signals can be measured, which then filters, amplifies, and recoded. Electrodes pick the voltages that are usually in microvolt levels, and then we amplify the signals. The usage of BCI technology is depend on electrode position on the brain and electrode connections. That is why, electrodes are usually made of synthetic materials, like gold or silver chloride. The gel is also used between the electrode and the head to receive desired signal. The gel that is used is conductive. The electrode system based on gel for BCI has problems to user's hair after recording. Because gel remain on skin of brain so washing hair after recording is essential. So that is why, a dry electrode system is introduced which reduce the blockage of the electrode skin for using gel. . Figure 2.2 shows the location of the electrode placing on brain according to the International 10/20 BCI system.The letters F, T, C, P and O represent Frontal, Temporal, Central, Parietal and Occipital. This System is complex and not easy to use.

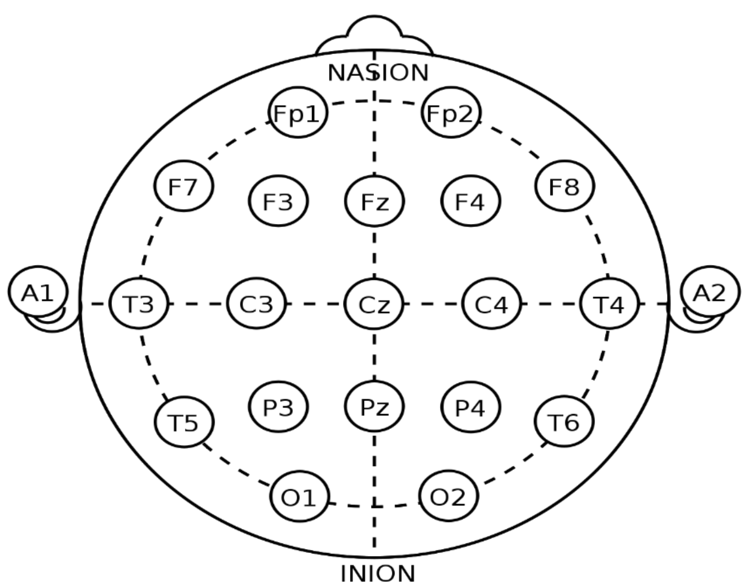


Figure 2.2:Location of EEG electrodes in Model of 10/20 BCI system[26]

2.6. Data Acquisition

Single electrode headsets are now commonly used. Neurosky Mind headset are cheaper and easy to use. Almost all of BCI devices had built in Software accessible so that user can develop the System according to requirements. Most of the headset has software and built-in hardware to reduce electrical noise, and use the embedded (chip-level) for processing of the signals and gives the output signal [27]. Dry electrodes are mostly used due to its advantages. These dry electrodes are easy to use .Figure 2.3 shows a picture of all the device data acquisition options.

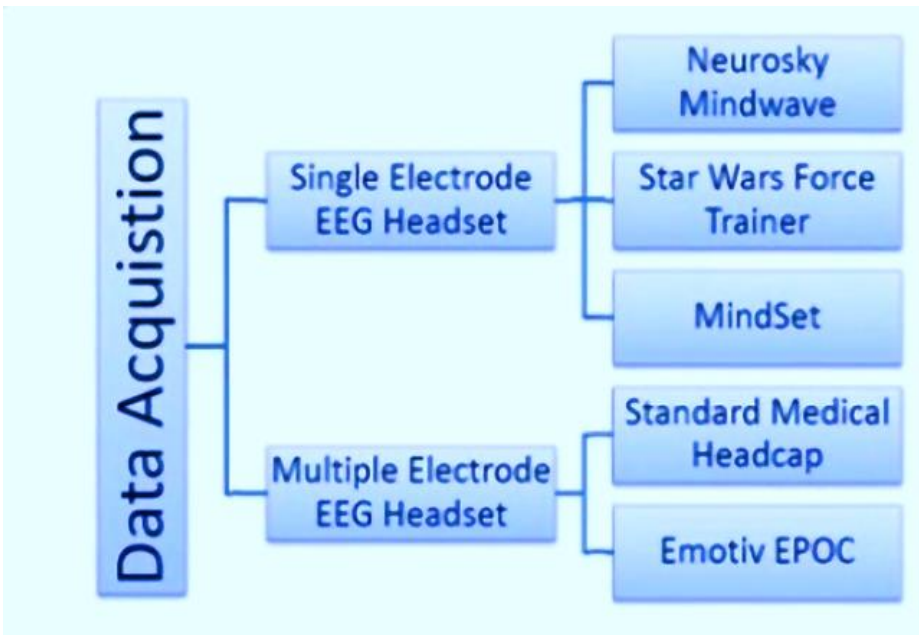


Figure 2.3: Data Acquisition options [28]

2.7. Idea behind the project

In a study that aimed to gather information from patients about the benefits of brain communication, the study concluded that 9 to 10% of patients who use electrical gadgets to interact with the physical environment are those who can walk, talk and hear on a large scale[29]. The question here is what are those patients who cannot speak, walk freely or are deaf in general. What are their challenges and how do they relate to their environment? The answer to the question is to establish something with the following features:

• It is equally effective for all types of patients (deaf, mute, blind or disabled).

• It can work in all kind of environments.

• Cost effective.

So we have to make the wheel chair that is user friendly and low cost. So that the common people with physical disabilities can use this technology.

2.8. Problem Statement

Every year around the world 250,000 to 500, 000 people experience with injuries and disability [30].Most of the injuries are occurred from sever causes. Spinal injuries and other injuries that makes the people totally disabled are top of them.In general in life , many people are living with disabilities are not enable enough to control their wheelchair. Physical disabled people's are required some person to move from one place to other. They are always looking for help to move on. In This project we will make a BCI based wheelchair that will use the EEG signal to control the wheelchair so that patients can easily move the wheelchair.

2.9 Proposed Work

In the past few years, Brain-Computer Interfaces (BCI) program are widely used for health applications. BCI is a key for making the communication between the brain and the computer. The User of BCI just think to run the proposed System. The use of BCI is outstanding for the physical disabled person. In this project an Electroencephalogram (EEG) signal will be used as a controller to give the command of the user’s intention. We will not use any gel as we are using the dry electrodes. The headset will collect data from the brain signals and process the signals and will used as the input command to move the wheelchair.

The specific objectives are:

1.Making of a Brain Computer Interface based wheelchair for people who are facing physical disabilities.

2. Receiving and processing an EEG signal from Neurosky Mind headset.

2.10 Scope and Benefits

The scope of this study is:

1. Capturing the EEG signals using the Neurosky Mind headset.

2. Making the wheelchair movement left, Right forward and backward using BCI system.

3. Analyzing the captured data.

Chapter 3

Hardware specifications and Design .

3.1. Neurosky Mindwave Headset Specifications

As Human brain contain millions of interconnected neurons. Brainwaves are basically generated by synchronized electrical pulses from masses of neurons communicating with each other. Brainwaves are sensed using electroencephalography sensors that are placed on the scalp. The brain wave signals are analyzed using Neurosky mindwave headset. The device contains a headset, an ear-clip, and a sensor arm. The Mindwave headset measures and outputs the EEG power spectrums (alpha waves, beta waves, etc) , eye blinks. The headset's reference and ground electrodes are on the ear clip and the EEG electrode is on the sensor arm, resting on the forehead above the eye. It uses a single AAA battery.

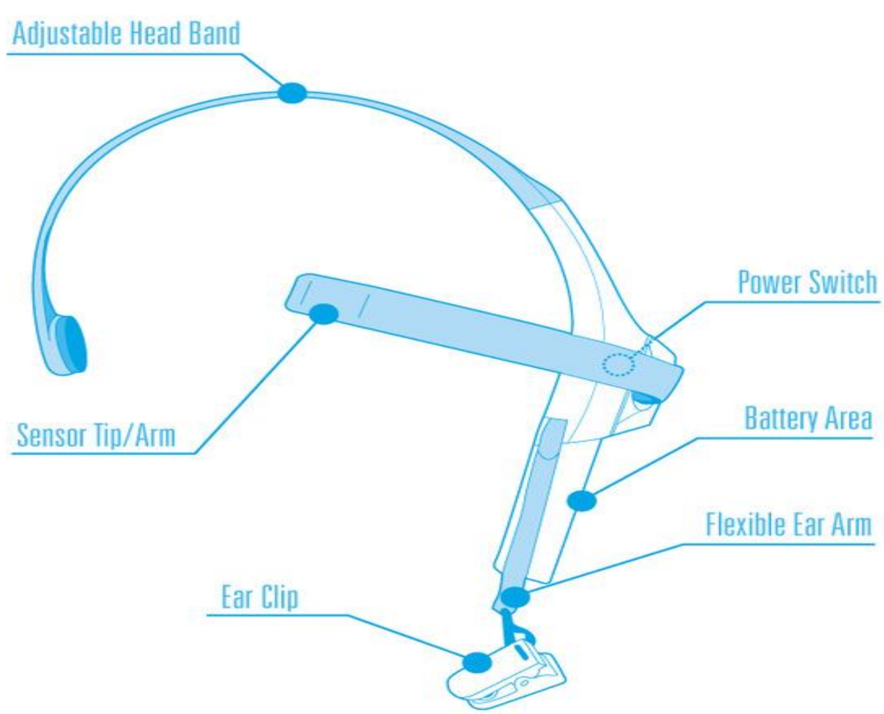


Figure 3.1 : Neurosky Mindwave Headset[31]

BCI signals are collected in the form of raw data signals(amplified data of brain) received by brain, and these signals are transferred to control different applications.

Wave-Type	Frequency	Activity
Alpha	8-13 Hz	Relexed, Reflection, closing eyes and inhabitation control
Beta	13-30 Hz	Active thinking and active attention
Gamma	35 – 100 Hz	Perception and consciousness
Delta	Below 4Hz	Deep sleep
Theta	4-7 Hz	Emotional Stress, creative inspiration and deep meditation

Table 3.1 : Brain Activity for different Wave Type[32]

3.2. Arduino UNO

Arduino Uno is called a microcontroller board because of ATmega328P . Out of 14 total digital input/output pins 6 used as PWM outputs, 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It consists of material that is needed to support the microcontroller; USB cable is used to connect it to the computer to powered it or powered by an external power supply such as battery. External power may be supplied from battery or AC-to-DC adapter. The voltage range should be in between or 6 to 20 volts for the application of the board. The board will not work if volts exceed 12V or decreased from 5V. The best range is 7 to 12 volts. The details of pin configuration are given in Fig. 3.2

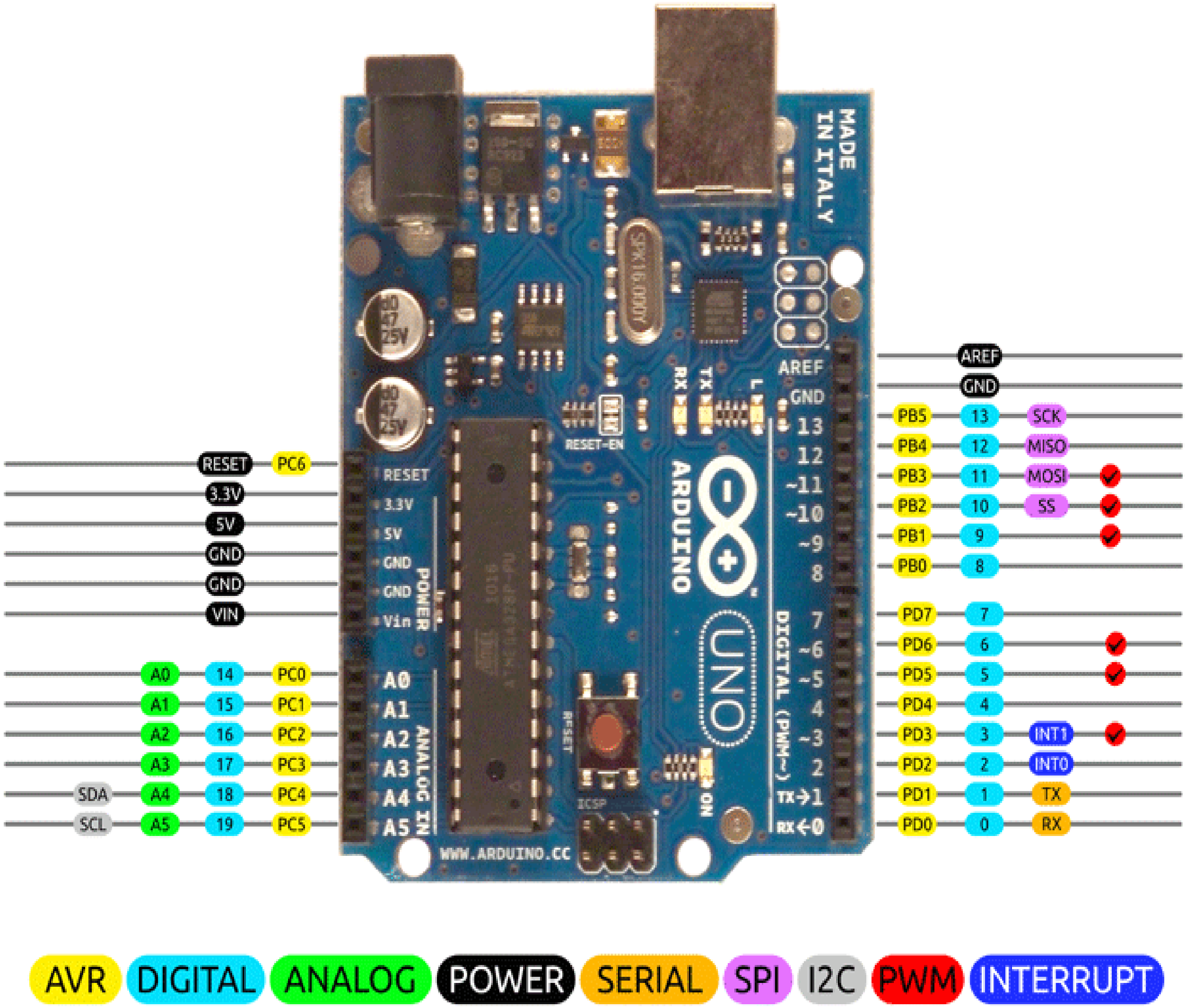


Figure 3.2 : Arduino Uno Diagram[33]

Arduino Uno consist of a polyfuse that guards our computer's Universal Serial Bus port from excessive current and short circuit. Most of the operating systems contribute as their interior safeguard. Fuse can be used as an additional coating of protection . When the applied current to the USB port was more than 500 mA the connection was automatically disintegrated by the fuse. It will be in off state until short or overload is removed.

3.2.1. Pins Description

The Table 3.2 shows the Pin’s description of Arduino UNO .

Category of pin	Name of Pin	Details of Pin
Power	Vin	The external power source is connected via Arduino‘s input pin
	+5V	A constant 5V from the board’s regulator is received by this pin
	+3.3V	A constant 3.3V that this pin outputs that is generated by on-board regulator
	GND	Ground pins that grounds the arduino
Analog Pins	A0 to A5	These pins provide’s the analog input
Digital I/O Pins	Pin 0 to 13	Input and Output Pin
Serial Pins	0(Rx) and 1(Tx)	These pins that transmit and receive TTL data
External Interrupts	Pin no 2 and 3	It can be used in triggering an interrupt
PWM	3,5,6,9,10 and 11	It provides 8-bit PWM output
SPI	10 (SS), 11 (MOSI), 12 (MISO) and 13 (SCK)	The SPI libarary act as communication between these pins
Inbuilt LED	13	The LED is in on state when pin is high , LED is in off state when the hook is low value.
TWI	A4 (SDA), A5 (SCA)	It can be used for TWI communication eith the help of Wire library.
Reset 13	13	If we bring this line LOW will automatically rest the microcontroller.
AREF	AREF	For input voltage a reference voltage is required that is provided.

Table 3.2 Pin Configurtion of Arduino UNO

3.2.2. Technical Specifications

Technical Specifications	Details
Microcontroller	ATmega328P – 8 bit AVR family microcontroller
Operating Voltage	+5V
Recommended Input Voltage	+7 to +12V
Input Voltage Limits	+6 to +20V

Analog Input Pins	6 total pins starting from A0,A1,A2,A3,A4 and A5)
Digital input and output Pins	14 pins with which 6 used for PWM
DC on input and output pins	40 mA
DC Current on 3.3V Pin	50 mA
Flash Memory	Total 32 KB out of which 0.5 KB for boot loader
SRAM	2 KB
EEPROM	1 KB
Frequency of clock Speed	16 MHz

Table 3.3 technical Specification of Arduino Uno [34]

3.3. HC-05 - Bluetooth Module

The HC-05 is used as bluetooth module that can simply add two-way wireless system. It is made for transparent wireless serial connection. It is an easiest way to interface with the computer and controller.It can simply convert through the wireless Bluetooth the UART data. The HC05 bluetooth module can work as UART serial converter module.

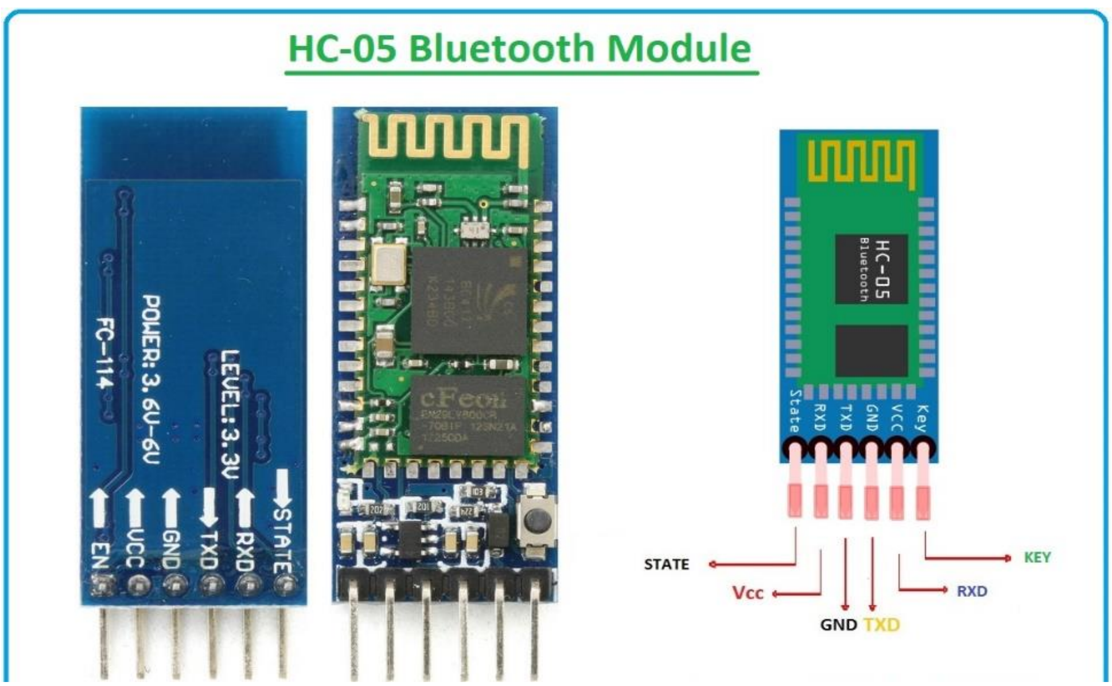


Figure 3.3 : HC-05 Bluetooth Module[35]

3.3.1. HC-05 Pinout Configuration

Pin No	Pin Name	Detail
1	Enable	For toggling between the AT command which is set high and Data mode which is set low . Automatically it will be in Data mode.
2	Vcc	This pin isa used for supplying +5V voltage.
3	Ground	This pin is used for grounding the module of system by connecting it to Ground of system.
4	TX – Transmitter	It gives the serial data that is supplied to it by the Bluetooth module so it transmit that serial data.
5	RX – Receiver	It take the data that will be broadcasted with the help of Bluetooth.
6	State	Used to check whether Bluetooth is working or not, it is connected to on board LED.
7	LED	It shows the status of Module If it blink one time within two sec: Module has entered Command Mode If it remain Blinking: It Waits for connection in Data Mode If it blink two times in 1 sec: Connection is successful in Data Mode
8	Button	Used for commanding the Enable pin

Table 3.4: Pin Configuration of HC-05[36]

3.3.2. HC-05 Default Settings

Bluetooth Name: “HC-05”

Password: The password is 1234 or 0000

Communication: Work as Slave

Mode: Data Mode

Data Mode Baud Rate: 9600, 8, N, 1

Command Mode Baud Rate: 38400, 8, N, 1

Default firmware: LINVOR

3.3.3. HC-05 Technical Specifications

- Serial Bluetooth module for Arduino and other microcontrollers
- Operating Voltage values : From 4V till 6V (basically +5V)
- Operating Current values: It operates at 30mA
- Range: It operates at range less than hundred metre
- Works with Serial communication (USART) and TTL compatible
- Follows IEEE 802.15.1 standardized protocol
- Uses Frequency-Hopping Spread spectrum (FHSS)
- Can work in Master/Slave , Master,Slave mode
- Mobile phone and Computer having Bluetooth in them HC-05 can operate with them
- Supported baud rate: 9600,19200,38400,57600,115200,230400,460800.

3.4. L298N Motor Driver Module

L298N Motor Driver Module is basically used for moving stepper and Dc Motors.It is a motor driver module. This model is basically construct of a 78M05 5V regulator and L298 motor driver IC . L298N Module can command up to four or two DC motors having direction and control the speed.

3.4.1. L298N Module Pinout Configuration

Table 3.5 shows the Pinout Configuration of L298N Motor Driver Module.

Pin Name	Description
IN1 & IN2	The input pins of Motor A. The spinning way of Motor A is controlled by these.
IN3 & IN4	Input pins of Motor B. The spinning way of Motor B is controlled by these.
ENA	PWM signal enable by ENA for Motor A.
ENB	PWM signal enable by ENB for Motor B.
OUT1 & OUT2	output pins used for Motor type A.
OUT3 & OUT4	output pins used for Motor type B.
12V	DC power source provide this 12 V input.
5V	Supplies power for the switching logic circuitry inside L298N IC
GND	These pins used for Grounding.

Table 3.5 : Pinout Configuration of L298N Motor Driver Module[37]

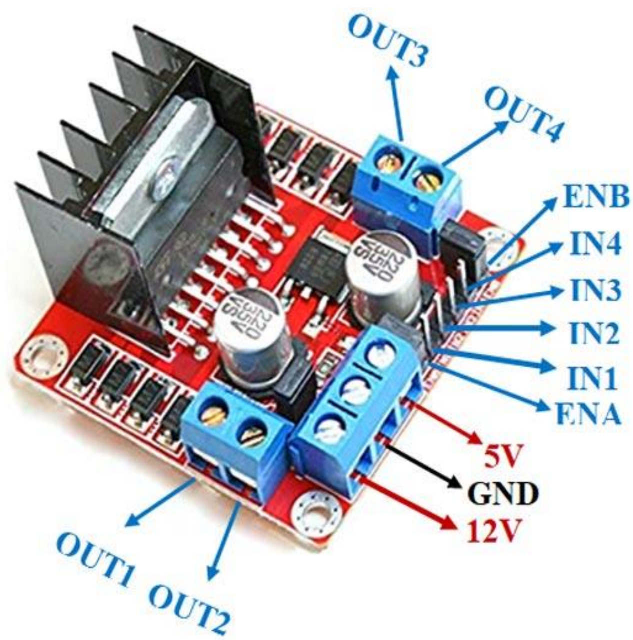


Figure 3.4 : L298N Motor Driver Module Pinout [38]

3.4.2. L298 Module Features & Specifications

- The model of Driver is L298N 2A
- Driver Chip is Double H Bridge L298N
- The maximum supply voltage to Motor is 46V
- The maximum supply current to Motor is 2A
- The total Logic voltage is 5V
- Total Driver Voltage is 5 to35V
- Total Driver Current is 2A
- Total Logical Current is 0-36mA
- Maximum Power is 25W
- Current Sense for each motor
- Power-On LED indicaton

3.5. Power Supply

By analyzing the energy consumption of all the components, we have chosen a LiPo Battery LP683072 3.7V 1600mAh for the project

3.5.1 Specifications

Specification of LiPo Battery 3.7V 1600mAh 5.92Wh is given in Table 3.7

Features	Description
Nominal Voltage	3.7Volts (V)
Capability	1600mAh

Protection circuit module (PCM)	Yes
Wat-Hou Rating	5.92Watt hour (Wh)
Maximum Operating Voltage	2.75Volts(V) to 4.2Volts(V)
Maximum Charging Voltage	4.2V±50milli Volts (mV)
Maximum Charge Current	800milli Ampere (mA)
Maximum Continuous Discharge Current	1600 milli Ampere (mA)

Table 3.7 : Features of Li-Po battery [39]

3.6 DC Motor

A DC Motor is a type of rotating electrical motors that convert the direct current electrical energy into the mechanical energy that rotates the wheel.

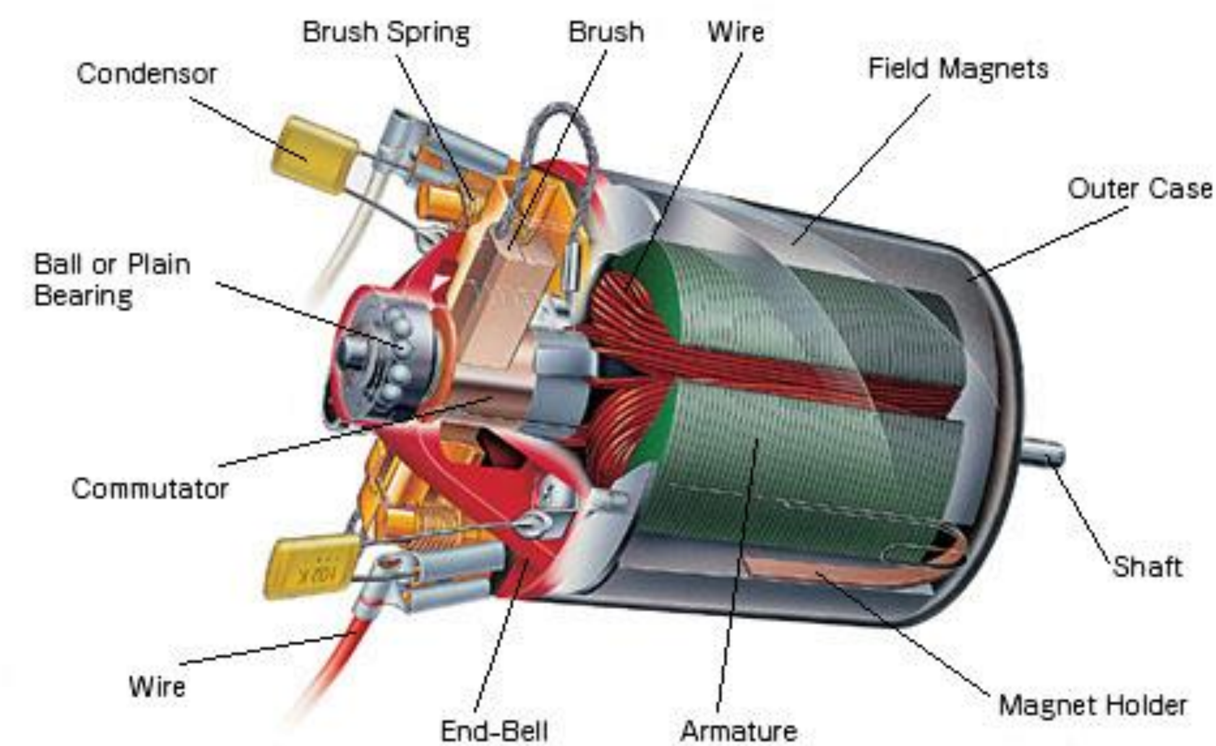


Figure 3.6 DC Motor[40]

3.7 System Design

In this project we assemble the hardware design. The hardware design is placed over the wheelchair prototype, and from there, it interacts with the external peripherals that make part of the project. As the hardware design is so tiny, it may easily be mounted on the prototype.

The steps to design the board are following:

Attach the hardware components inside Protype.

Now closely position the components so that the circuit does not become too large.

Carry out a continuity test once all of the connections have been made.

After a Successful continuity test, the circuit is now ready for the test.

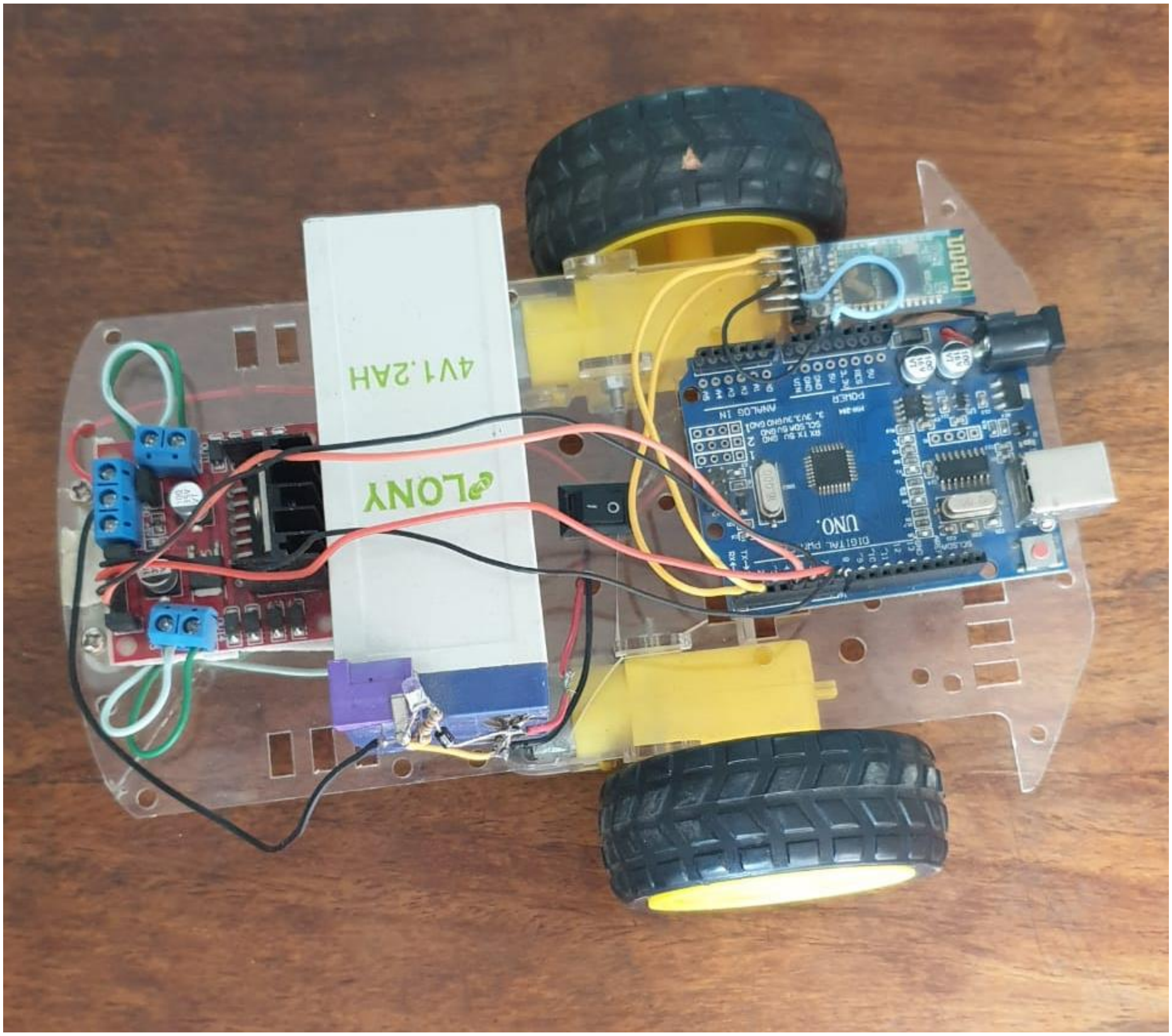
Connect the circuit to the battery

3.6.1 Circuit Connection

Table 3.8 : Circuit Connection of Brain Controlled wheelchair.

Arduino Pin	**Motor Driver Pin**
Pin no 4	IN4
Pin no 5	IN3
Pin no 6	IN2
Pin no 7	IN1
Arduino pin	**HC-05 Bluetooth Module pin**
Pin 1 (Tx)	RXD
Pin 0 (Rx)	TXD
+5 V	Vcc
GND	GND

Arduino pin	**Battery Socket pin**
Vin	+5 V (Vcc)
GND	GND
Battery Socket pin	**Motor Driver pin**
+5 V (Vcc)	+ 12 V pin
GND	GND



Chapter 04

Working and Result Analysis .

4.1. Project Working

In this project, we use Neurosky Mindwave Mobile headset device to record EEG data signals. We use this device because of its different valuable characteristics, this device process output signals easily and lower cost compared to other devices. Its features also includes: raw data(delta, theta, alpha, beta, and gamma) and power spectrum. For measuring data some devices use wet electrodes, one other aspect of this device is that its maintenance is easier because of its dry electrodes. Fig 4.1 describe the working of this project.

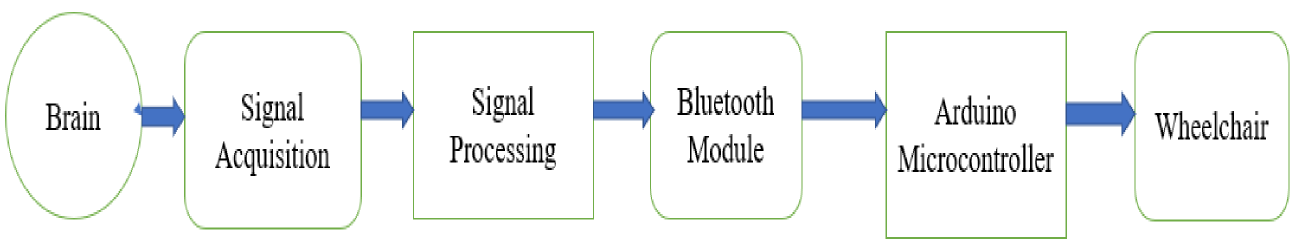


Figure 4.1 : A Schematic Explanation of designed Prototype

To process the raw digital signals in Mindwave headset we can avail different application options and programming languages, but we prefer Python software in this project. To access the features by external software we use library that is created by collaboration of Neurosky and ThinkGear. Here we will create a python program file to collect the samples. In this file we will program we have divide the direction of wheelchair and assign a number to each direction for the movement. 1 will be used for forward direction, 2 will be for reverse direction, 3 will be for right and 4 wil be used for left direction movement. When we will run this sample file it will ask us to think about number, provided by program(shown on the screen). It will collect 25 samples of direction based on raw data received by focusing brain in specific direction.

4.1.1. Signal Acquisition

A huge part of communication in the human brain is carried out by almost 85 billion cells, called Neurons. Neurons typically have a cell body(or called soma) and single or more axons shown in figure 4.2. These axons end at contact part of neurons, called synapses. These are gateways of different activities between neurons, that fires information impulses across neurons. Synaptic transmission produce neurotransmitters, that will produce a sudden voltage change across the cell membrane. An electrical field is generated by Synaptic activity, called a postsynaptic potential that typically remains for tens of milliseconds.

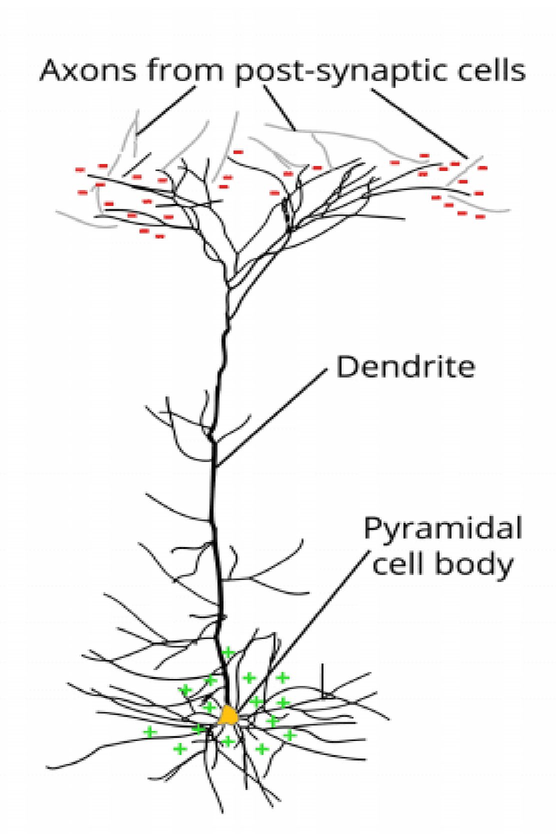


Figure 4.2 : Structure of Biological Neuron[41]

When postsynaptic potential occurs for almost 1000 or larger number of neurons , then electrical field will becomes more stronger. From researches we know that from cortical brain's regions the synchronized activity of pyramidal neurons, can be measured from the scalp outside (i.e. from EEG devices). Pyramidal cells and cortical surface are directed perpendicular to eachother[42], that creates an electrical field with a very stable orientation. Since these electrical raw brain signals are very small, hence data is digitized and sent for amplification. The raw data using Neurosky Mindwave headset from the EEG are obtained at a rate of 512 Hz[43].

After data amplification, it can be displayed as a time series of voltage values. When data is recorded then we will use decision tree classifier that will check and match the data/command sent by Mindwave headset with sample data and the will send the desired command to control circuit.

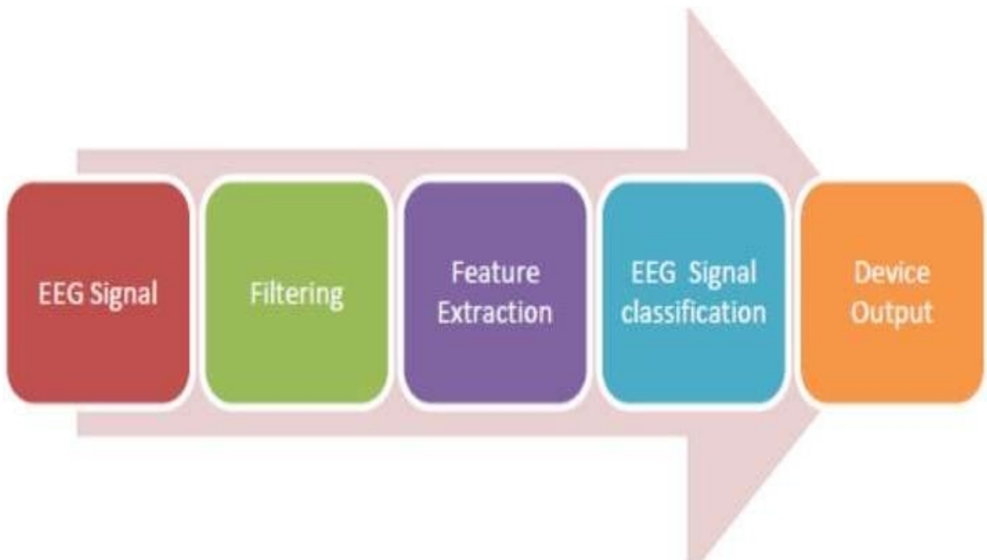


Figure 4.3 : EEG data signal Processing in Mindwave Headset

After amplification it is transferred to the operating environment, further on digital signal processing would be implemented, and then transform it to control the different applications. The type of action to be performed will depend upon the received combination of EEG signals. This technique will give us higher accuracy if positioning and contact of electrode on scalp is exact.

4.1.2. Control Circuit

In this Project, the basic control of the wheelchair is done by human brain signals. When user's brain activities reaches a certain point then motor of wheelchair will be activated. To move the wheelchair in any specific direction, the user will trigger the motor by focusing in this direction. Neurosky Mindwave headset pre-processes the detected signals and transfers them to the PC. Now received data signals will be forwarded to Python where the recorded data will programmed and through decision tree classifier data will be classified into four types of movement data. This movement data through Bluetooth module, will be sent from PC to digital microcontroller to drive the motors of wheelchair. Figure 4.4 illustrate the Flow Chart presentation for the control circuit of brain controlled wheelchair.

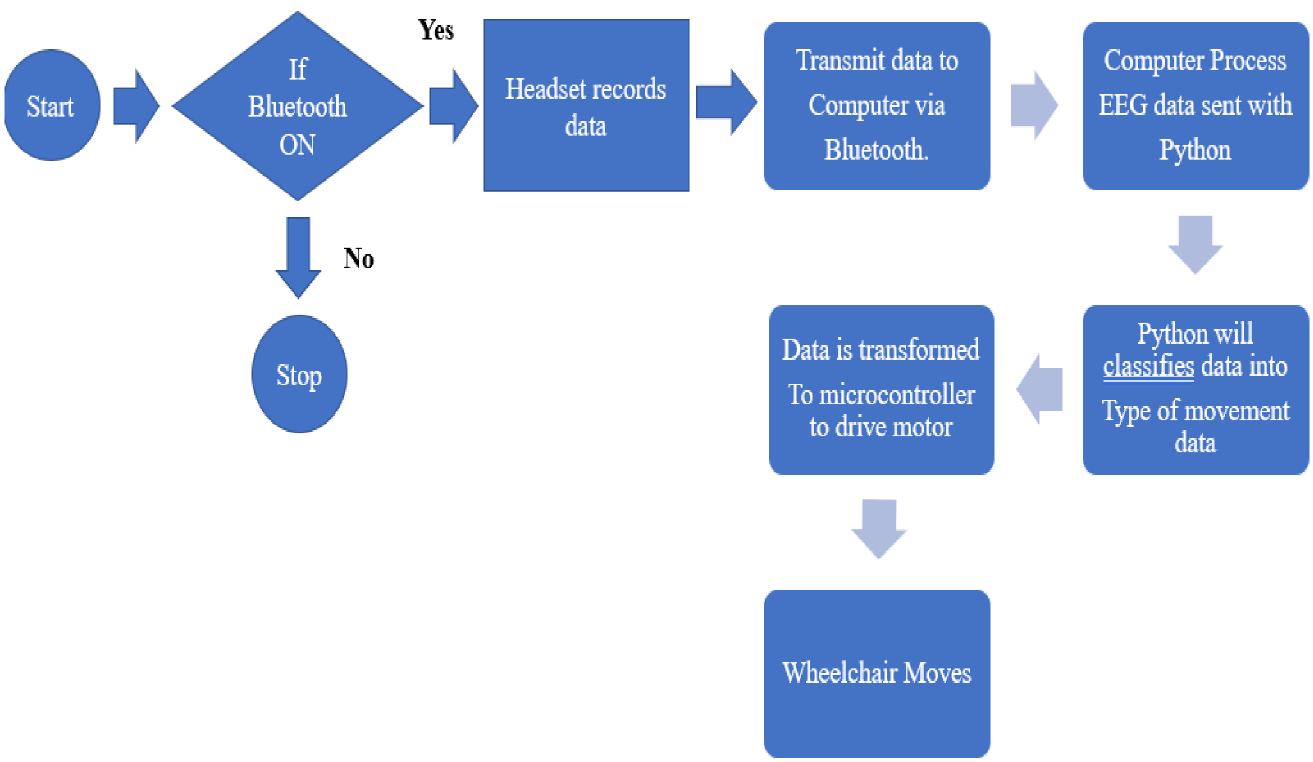


Figure 4.4 : Flow Chart presentation for the control circuit of brain controlled wheelchair

4.1.3. Wheelchair

In this project, we assemble hardware design on wheelchair prototype. Here digital microcontroller, Bluetooth module, L298N motor driver and two DC motors are used. The processed movement data signal sent from PC to the microcontroller to drive the motors in forward(defined as direction 1), reverse(defined as direction 2), turning right(defined as direction 3), and turning left (defined as direction 4) directions. In this project movement data is used in motor imagery method. We collect this data for motor imagery because it was centered to the brain's concentration, hence data results can be used for controlling wheelchair movement[44]. The classification of all possible commands are given as:

1. Forward Movement: Both DC motors will be powered and wheels will move in the forward direction.

2. Reverse Movement: Both DC motors will be powered and wheels will move in the reverse direction.

3. Right side Movement: DC motors will be powered where left wheel will move in forward direction and right wheel will move in reverse direction.

4. Left side Movement: DC motors will be powered where right wheel will move in forward direction and left wheel will move in reverse direction.

4.2. Result Analysis

When implementation of the hardware, as stated above is completed we had to turn on all devices, including wheelchair prototype, headset, PC and program from Python. All devices will communicate with each other. After doing programming on Arduino IDE Software, the code is uploaded to the microprocessor. We create a Python file and start sample collection of EEG signals for decision of direction of movement of wheelchair. The sample collection of EEG signals process can be observed in figures 4.5.

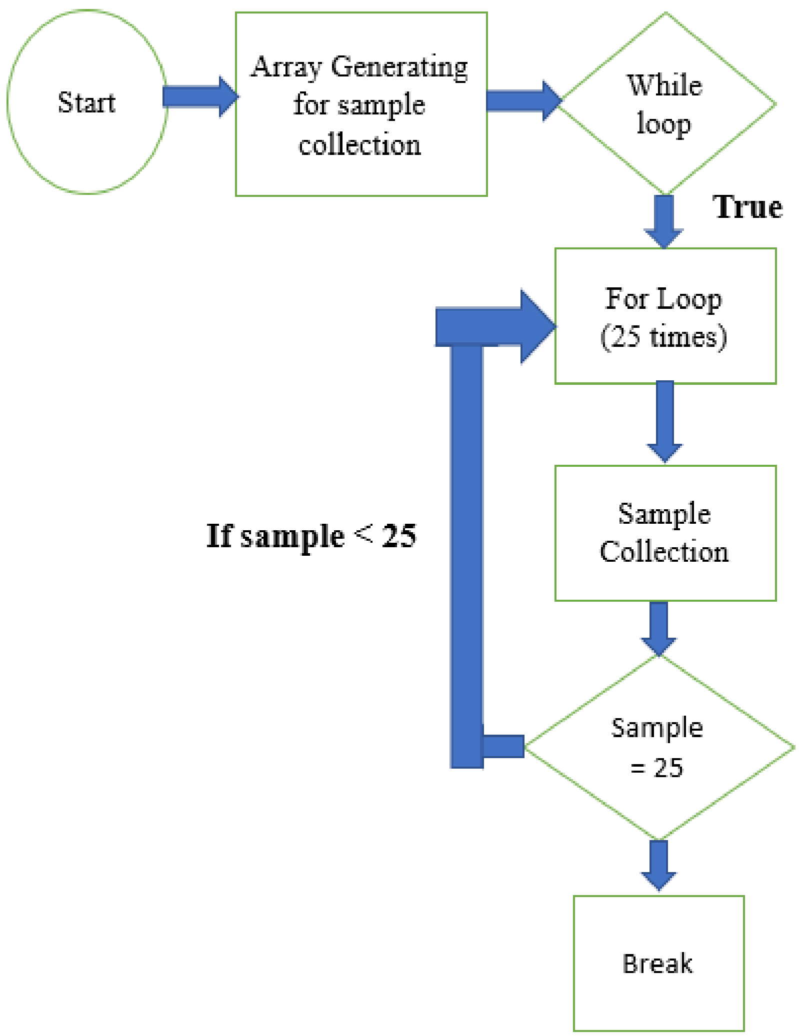


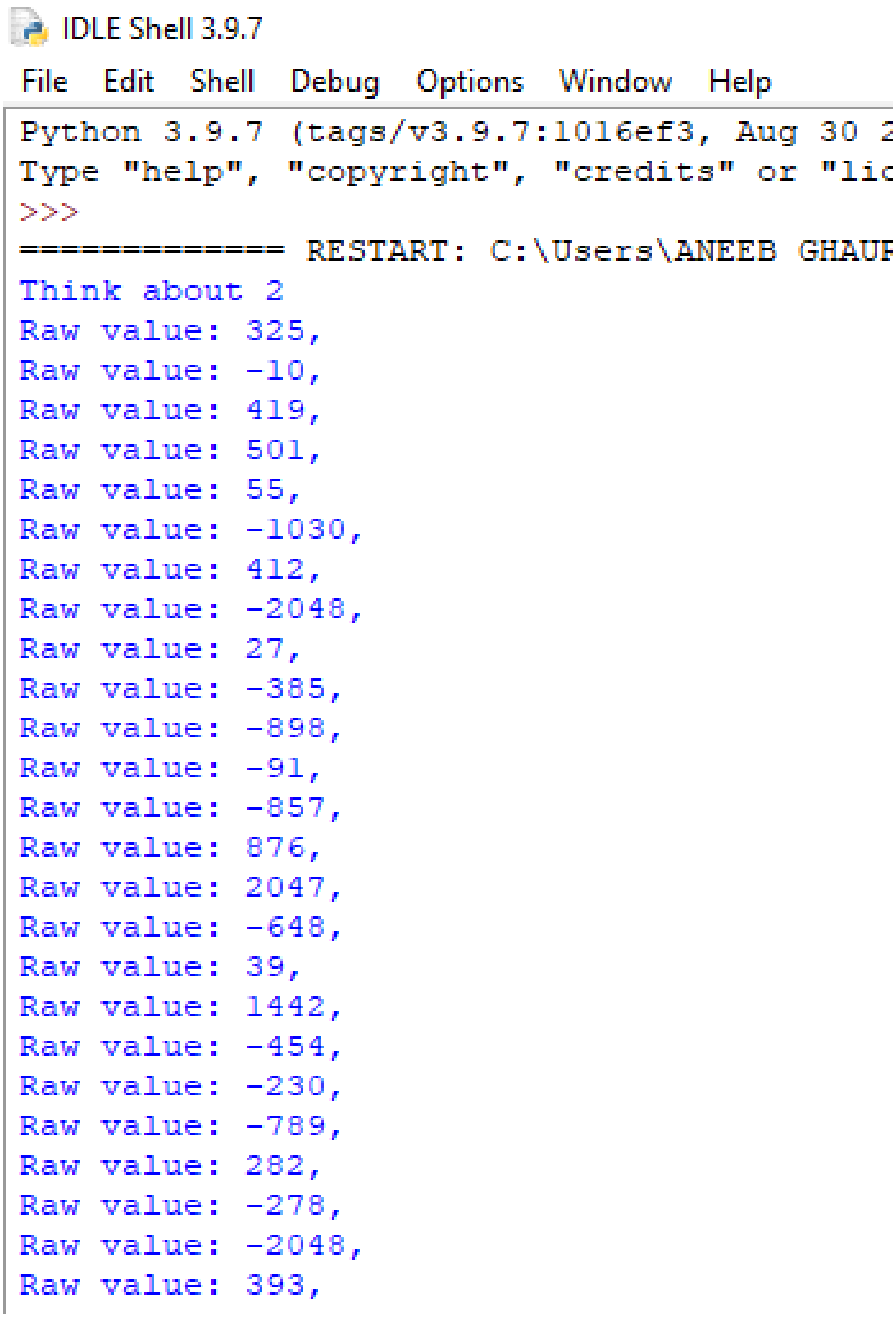
Figure 4.5 : Flow Chart illustration for the sample collection of EEG raw data

Real time implementation was done to collect sample. The figure 4.6 represent the sample collection for Forward direction.

```
Think about 1
Raw value: -474,
Raw value: 406,
Raw value: -88,
Raw value: 621,
Raw value: -2048,
Raw value: 2047,
Raw value: 920,
Raw value: 39,
Raw value: -102,
Raw value: 107,
Raw value: -57,
Raw value: -346,
Raw value: 1,
Raw value: -56,
Raw value: 122,
Raw value: -130,
Raw value: 485,
Raw value: 131,
Raw value: -390,
Raw value: 443,
Raw value: -3,
Raw value: 476,
Raw value: 133,
Raw value: 184,
Raw value: 347,
```

Figure 4.6 : Real-time raw data collected for forward direction

The figure 4.7 represent the sample collection for Reverse direction.



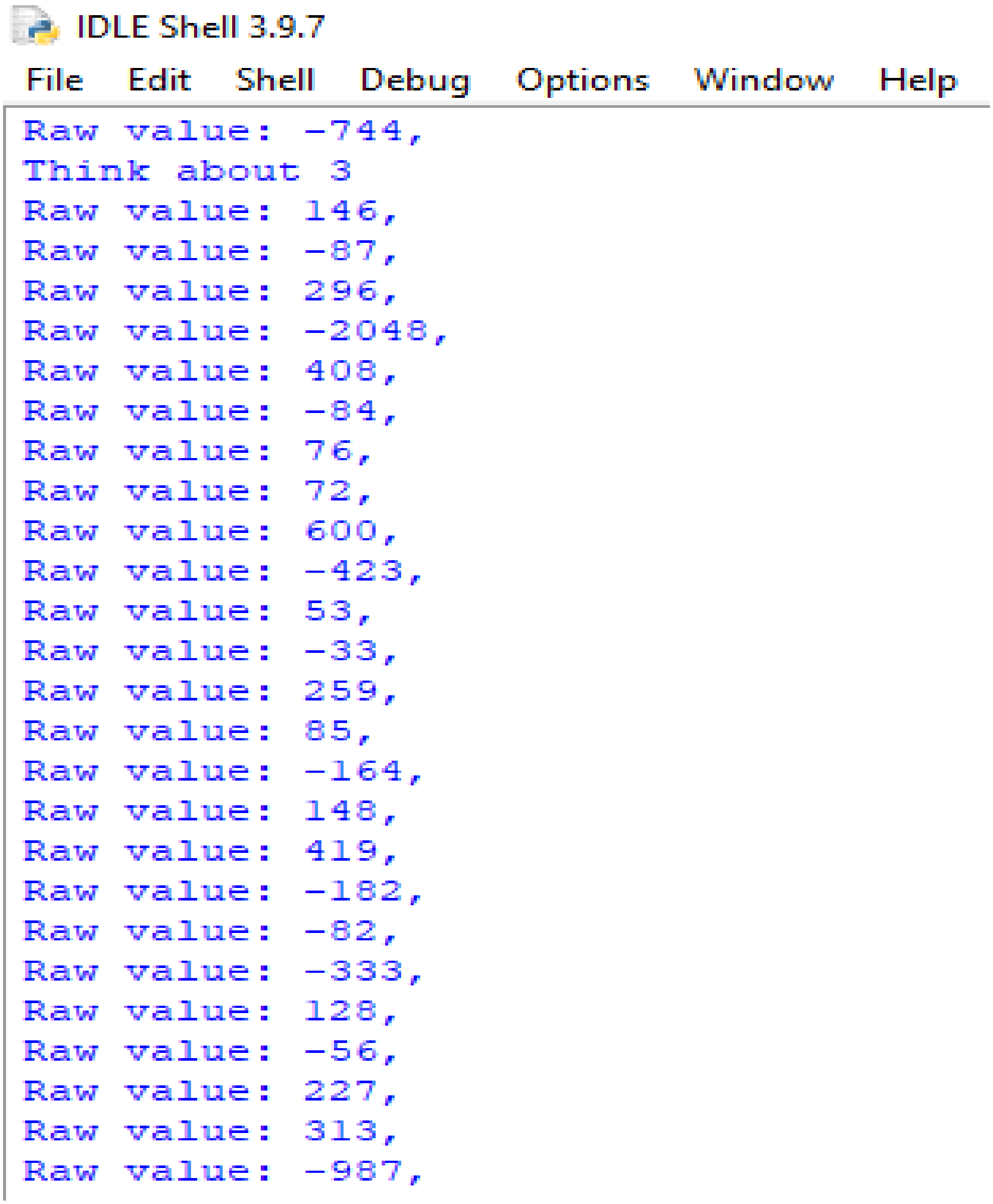
IDLE Shell 3.9.7

File Edit Shell Debug Options Window Help

```
Python 3.9.7 (tags/v3.9.7:1016ef3, Aug 30 2
Type "help", "copyright", "credits" or "lic
>>>
============= RESTART: C:\Users\ANEEB GHAUR
Think about 2
Raw value: 325,
Raw value: -10,
Raw value: 419,
Raw value: 501,
Raw value: 55,
Raw value: -1030,
Raw value: 412,
Raw value: -2048,
Raw value: 27,
Raw value: -385,
Raw value: -898,
Raw value: -91,
Raw value: -857,
Raw value: 876,
Raw value: 2047,
Raw value: -648,
Raw value: 39,
Raw value: 1442,
Raw value: -454,
Raw value: -230,
Raw value: -789,
Raw value: 282,
Raw value: -278,
Raw value: -2048,
Raw value: 393,
```

Figure 4.7 : Real-time raw data collected for Reverse direction

The figure 4.8 represent the sample collection for Right direction.



```
IDLE Shell 3.9.7
File  Edit  Shell  Debug  Options  Window  Help
Raw value: -744,
Think about 3
Raw value: 146,
Raw value: -87,
Raw value: 296,
Raw value: -2048,
Raw value: 408,
Raw value: -84,
Raw value: 76,
Raw value: 72,
Raw value: 600,
Raw value: -423,
Raw value: 53,
Raw value: -33,
Raw value: 259,
Raw value: 85,
Raw value: -164,
Raw value: 148,
Raw value: 419,
Raw value: -182,
Raw value: -82,
Raw value: -333,
Raw value: 128,
Raw value: -56,
Raw value: 227,
Raw value: 313,
Raw value: -987,
```

Figure 4.8 : Real-time raw data collected for Right direction

The figure 4.9 represent the sample collection for left direction. .

```
Think about 4
Raw value: -308,
Raw value: 247,
Raw value: 160,
Raw value: 10,
Raw value: 4,
Raw value: -252,
Raw value: 258,
Raw value: 140,
Raw value: 290,
Raw value: 66,
Raw value: -148,
Raw value: 51,
Raw value: 106,
Raw value: -8,
Raw value: 298,
Raw value: 49,
Raw value: 186,
Raw value: -119,
Raw value: 66,
Raw value: 75,
Raw value: 214,
Raw value: 276,
Raw value: 171,
Raw value: -72,
Raw value: -25,
```

Figure 4.9 : Real-time raw data collected for Right direction

The EEG data collected by Neurosky Mindwave headset from the brain is given in form of waves in Figure 4.10.

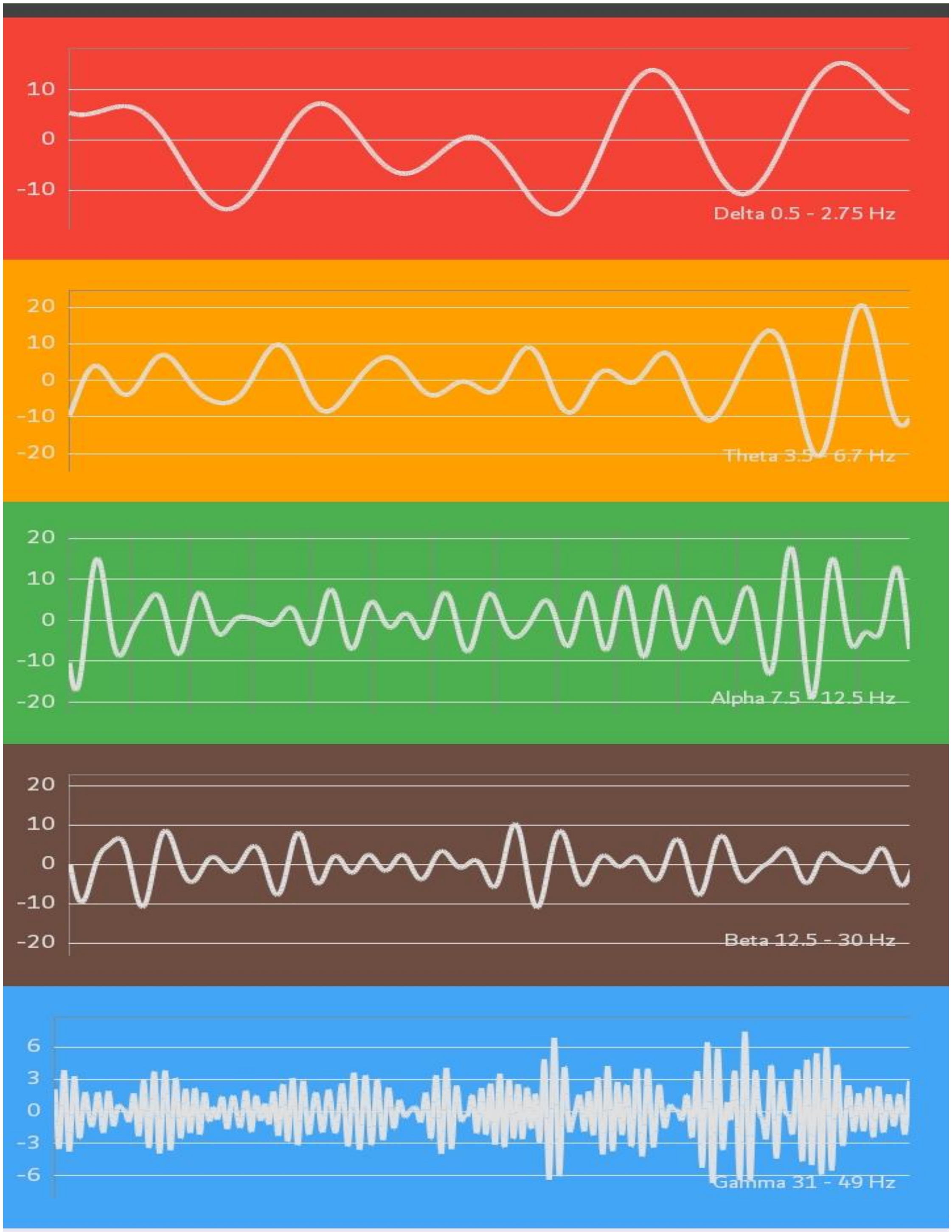


Figure 4.10 : Brain waves collected through Mindwave headset.

The real-time implementation of the project was also performed and we got the expected results that are also discussed in the report. Figure 4.11 represent the forward direction command given by human brain.

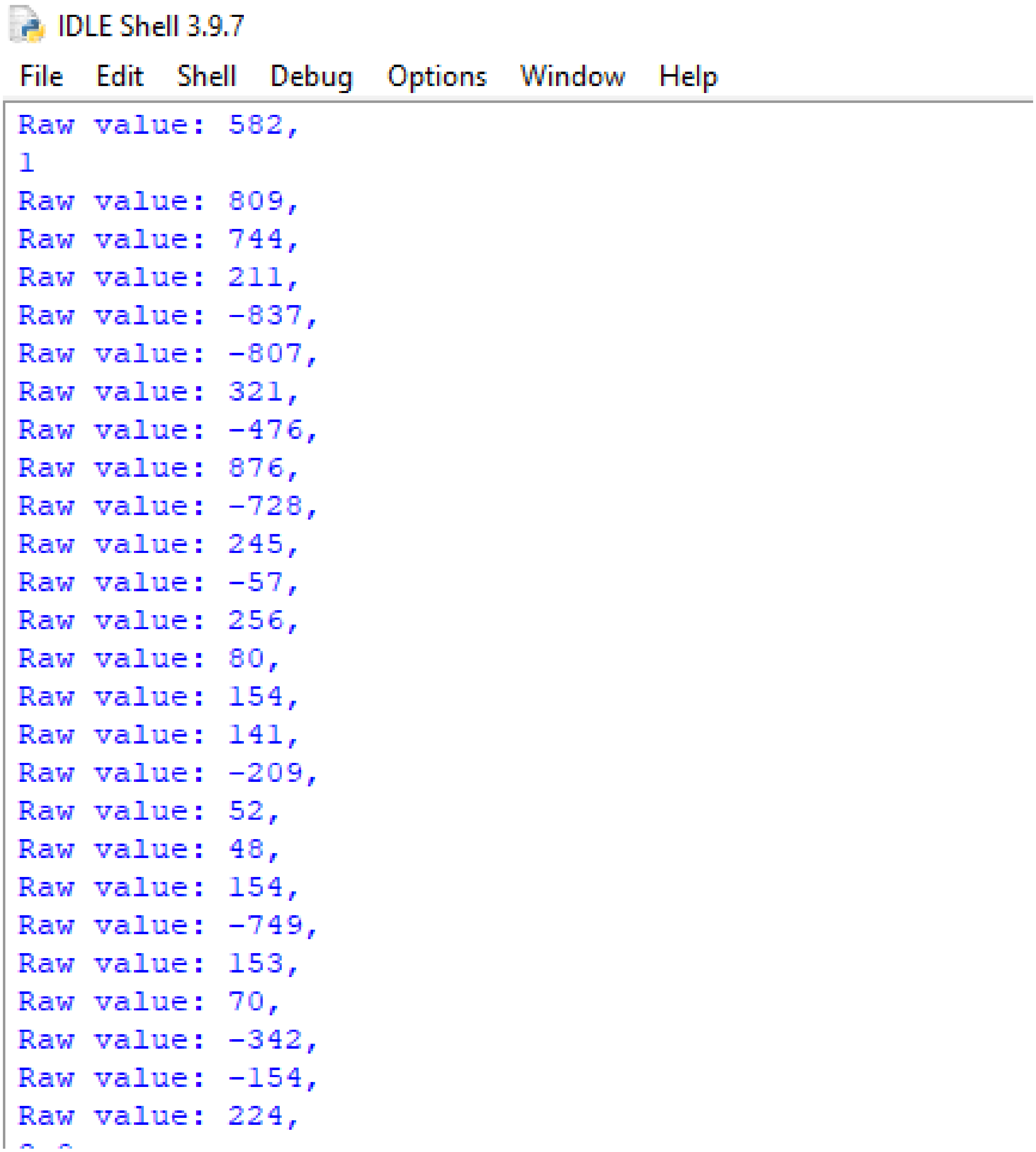


Figure 4.11 :Forward direction command data

Figure 4.12 represent the reverse direction command given by human brain.

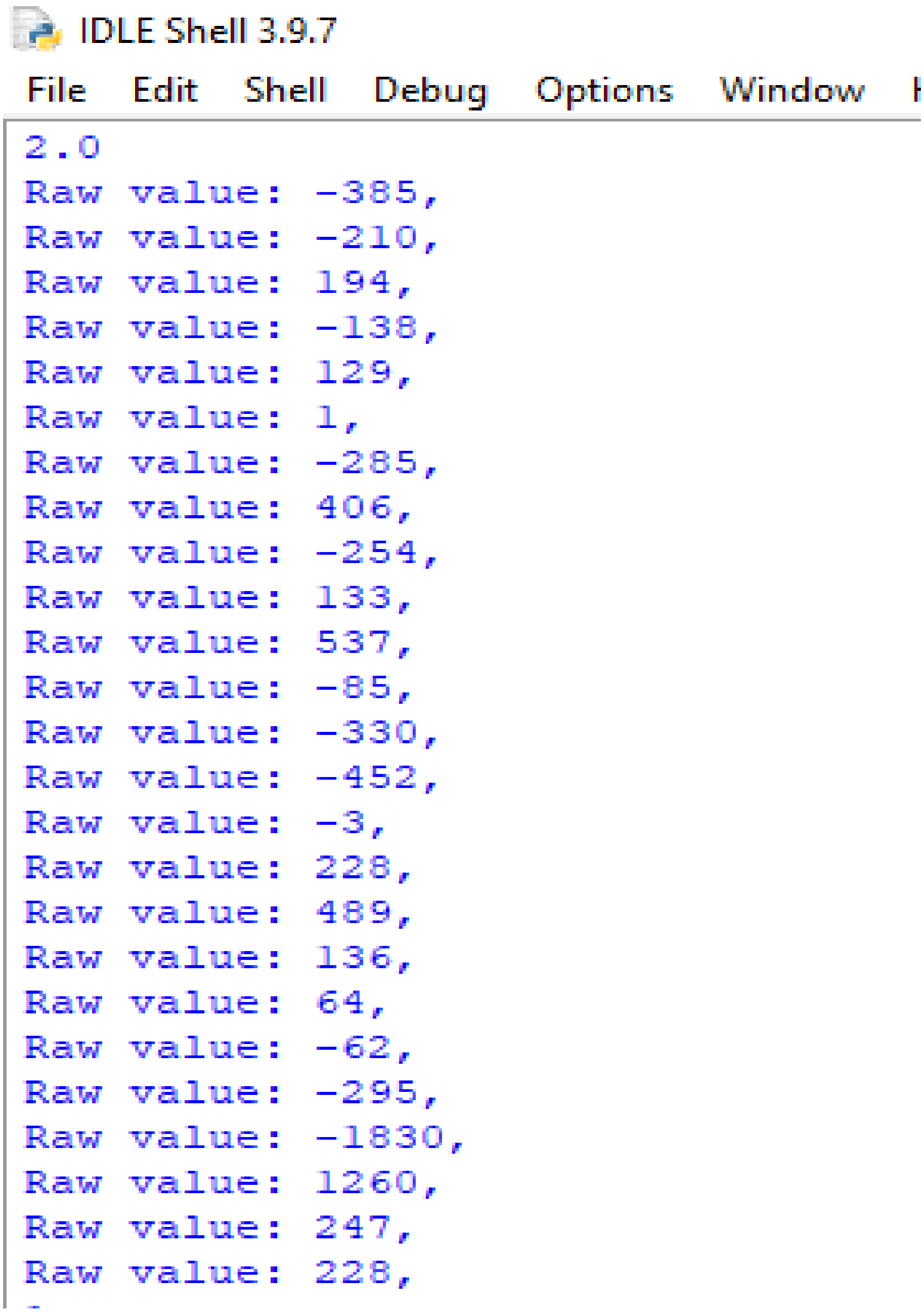


Figure 4.12 : Reverse direction command data

Figure 4.13 represent the Left direction command given by human brain.

IDLE Shell 3.9.7

File Edit Shell Debug Options Window He

```
Python 3.9.7 (tags/v3.9.7:1016ef3, A
Type "help", "copyright", "credits"
>>>
======== RESTART: C:\Users\ANEEB GHA
training....
training done
4.0 4.0
Raw value: 23,
Raw value: -2048,
Raw value: 2047,
Raw value: -2048,
Raw value: 37,
Raw value: 39,
Raw value: 39,
Raw value: -165,
Raw value: 39,
Raw value: 28,
Raw value: 39,
Raw value: 40,
Raw value: -356,
Raw value: -20,
Raw value: 55,
Raw value: 38,
Raw value: 38,
Raw value: -2048,
Raw value: 35,
Raw value: -105,
Raw value: -354,
Raw value: 37,
Raw value: 353,
Raw value: -86,
Raw value: 1185,
```

Figure 4.13 : Left direction command data

Figure 4.14 represent the right direction command given by human brain.

```
3.0
Raw value: -82,
Raw value: -252,
Raw value: -81,
Raw value: -244,
Raw value: 188,
Raw value: 161,
Raw value: 74,
Raw value: 357,
Raw value: -234,
Raw value: 87,
Raw value: 210,
Raw value: 220,
Raw value: -97,
Raw value: 193,
```

Figure 4.14 : Right direction command data

Chapter 05

SUMMARY .

Conclusion:

This paper presents a prototype model of a Brain-controlled wheelchair for physically disabled persons. The prototype model of the wheelchair has been implemented by using BCI technology. The basic control of the wheelchair is done by human brain signals. To move the wheelchair in any specific direction, the user will trigger the motor by focusing in this direction. Neurosky Mindwave headset pre-processes the detected signals and transfers them to the PC. Now received data signals will be forwarded to Python where the recorded data will programmed then decision tree classifier will check and match the data/command sent by Mindwave headset with sample data and the will send the desired command to control circuit. The processed movement data signal sent from PC to the microcontroller to drive the motors in forward(defined as direction 1), reverse(defined as direction 2), turning right(defined as direction 3), and turning left (defined as direction 4) directions. This project has an average accuracy due to limitation of stable EEG signal through the Mindwave headset.

Future work :-

Technology never ends. there are always some reforms that can be made in any project. In future, in this project we can made different improvements. The major advancement in this brain controlled wheelchair includes:

1. Reduce detection time for EEG data signals
2. Improve Speed of Wheelchair
3. Automatic Detection of hurdles and curve path
4. Brake system will be implemented.

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Appendix A

A.1. Code for Sample Collection of brainwaves in EEG

```
import mindwave, time

import numpy as np

import random

def getClassNum(max_classes):

    return random.randint(1,max_classes)



#headset = mindwave.Headset('/dev/tty.MindWaveMobile-DevA')

headset = mindwave.Headset('COM3')

time.sleep(2)

num = 1

x = 1

a = np.array([])

num_of_samples = 100

per_sample_len = 100

c = []
```

```
labels = []

sample_num = 4

while True:

    cur_class = getClassNum(4)

    labels.append(cur_class)

    print("Think about %s " % str(cur_class))

    cur_list = []

    for i in range(0,25):

        time.sleep(.3)

        rawVal  = headset.raw_value

        print ("Raw value: %s," % (rawVal))

        val = list(headset.waves.values())

        cur_list.append(rawVal)

        cur_list.append(val[0])

        cur_list.append(val[1])

        cur_list.append(val[2])



        cur_list = list(cur_list)
```

```
        #print ("Waves: {}".format(headset.waves))
    x = x+1
    if len(c)<1:
        c = cur_list
    else:
        c = np.vstack([c,np.hstack(cur_list)])
    if x> 15 :
        break;
np.savetxt('samplenum'+str(sample_num)+'.txt',c)
np.savetxt('lblsnum'+str(sample_num)+'.txt',labels)
```

A2. Code of Project

```
from sklearn.datasets import load_iris

from sklearn import tree

import numpy as np

import mindwave, time

import serial

def getProb():

    return random.uniform(0,1)

print('training....')

cc = np.loadtxt('samplenum4.txt')

lbl = np.loadtxt('lblsnum4.txt')

headset = mindwave.Headset('COM3')

robot = serial.Serial('COM5')

time.sleep(2)

clf = tree.DecisionTreeClassifier()

clf = clf.fit(cc, lbl)

print('training done');

print(clf.predict([cc[2]])[0],lbl[2])
```

```
prob_list = np.random.uniform(low=0.5, high=1, size=(4,))

alpha = 0.3

pre_predict = 0

while True:

  cur_list = []    raw_list = []

  for i in range(0,25):

    time.sleep(.3)

    rawVal  = headset.raw_value

    raw_list.append(rawVal)

        print ("Raw value: %s," % (rawVal))

    val = list(headset.waves.values())

    cur_list.append(rawVal)

    cur_list.append(val[0])

    cur_list.append(val[1])

    cur_list.append(val[2])

        cur_list = list(cur_list)

      if len(set(raw_list)) < 7:

    print('invalid sample collected')
```

```
    continue
cur_predict = clf.predict([np.hstack(cur_list)])[0]
if cur_predict == pre_predict:
    cur_predict_2 = np.argmax(prob_list)+1
    prob_list[int(cur_predict)-1]=prob_list[int(cur_predict)-1]*alpha
else:       cur_predict_2 = cur_predict
pre_predict = cur_predict
robot.write(bytes(str(cur_predict_2),'utf-8'))
print(cur_predict_2)
```

Appendix B

B.1 Arduino Sketch of the Project

```
#define MOT1 7

#define MOT2 6

#define MOT3 5

#define MOT4 4



void RIGHT_STEP(){

   int i=0;

  for(i=0;i<20;i++){



  digitalWrite(MOT1,HIGH);

  digitalWrite(MOT2,LOW);

  digitalWrite(MOT3,HIGH);

  digitalWrite(MOT4,LOW);

  delay(10);

  digitalWrite(MOT1,LOW);
```

```
  digitalWrite(MOT2,LOW);

  digitalWrite(MOT3,LOW);

  digitalWrite(MOT4,LOW);

  delay(30);

  }

}

void LEFT_STEP(){

   int i=0;

  for(i=0;i<20;i++){



  digitalWrite(MOT2,HIGH);

  digitalWrite(MOT1,LOW);

  digitalWrite(MOT4,HIGH);

  digitalWrite(MOT3,LOW);

  delay(10);

  digitalWrite(MOT1,LOW);

  digitalWrite(MOT2,LOW);

  digitalWrite(MOT3,LOW);
```

```
  digitalWrite(MOT4,LOW);

  delay(30);

  }

}



void FWD_STEP(){

  int i=0;

  for(i=0;i<40;i++){



    digitalWrite(MOT1,HIGH);

  digitalWrite(MOT2,LOW);

  digitalWrite(MOT4,HIGH);

  digitalWrite(MOT3,LOW);

  delay(10);

  digitalWrite(MOT1,LOW);

  digitalWrite(MOT2,LOW);

  digitalWrite(MOT3,LOW);

  digitalWrite(MOT4,LOW);
```

```
  delay(30);

  }

}


void REV_STEP(){

   int i=0;

  for(i=0;i<40;i++){



  digitalWrite(MOT2,HIGH);

  digitalWrite(MOT1,LOW);

  digitalWrite(MOT3,HIGH);

  digitalWrite(MOT4,LOW);

  delay(10);

  digitalWrite(MOT1,LOW);

  digitalWrite(MOT2,LOW);

  digitalWrite(MOT3,LOW);

  digitalWrite(MOT4,LOW);

  delay(30);
```

```
  }
}
void setup() {
  Serial.begin(9600);
  pinMode(7,OUTPUT);
  pinMode(6,OUTPUT);
  pinMode(5,OUTPUT);
  pinMode(4,OUTPUT);
  Serial.println("Ready...");
}
void loop() {
  char inChar = 0;
  if(Serial.available()>0){
    inChar = Serial.read();
    if(inChar == '1'){
      FWD_STEP();
      Serial.println("condition 1");
    }else if(inChar == '2'){
```

```
    REV_STEP();
     Serial.println("condition 2");
   }else if(inChar == '3'){
     RIGHT_STEP();
     Serial.println("condition 3");
   }else if(inChar == '4'){
    LEFT_STEP();
     Serial.println("condition 4");
   }else if(inChar=='5'){
     digitalWrite(MOT1,LOW);
     digitalWrite(MOT2,LOW);
     digitalWrite(MOT3,LOW);
     digitalWrite(MOT4,LOW);
     Serial.println("condition 5");
   }
  }
  // put your main code here, to run repeatedly:
}
```