Summer Internship Project Report

on

Use of EEG signals to control the movement of a Robot

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Abstract

When people suffer from Neuro motor disability, they are in a condition where they are unable to perform any action due to paralysis in the body. In most cases the eye has control of the person. But some possess the active brain only. The people who are suffering from such disorder may not be able to communicate properly through voice. The only way they can communicate is if someone can read their thoughts. The EEG helps with the same, this technique reads brain activity and now through it we can analyze and understand that person. Their fundamental need is a wheelchair thus this project is meant for controlling a wheelchair.

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Chapter 1

Introduction

1.1 Domain area of the project

EEG analysis is indeed useful for a variety of applications and is a vast topic of interest. It can empower interaction between humans and computers by enabling them to communicate in a more natural way, imagine computers that would be able to perceive and respond to human non-verbal communication such as EEG waves instead of responding conventionally to the events created by the use of a mouse or keyboard. In such a case, after detecting users EEG waves , computers can analyze them and get a clue about the thoughts of the person and can help. The motto of our project is to experiment and nd a way to analyze EEG to give an output of a form to control Forward, Backward, Left, Right, stop movement of the Arduino robot. The project uses NeuroSky MindWave Mobile 2 a single channel non evasive EEG device.

1.2 Motivation

People sufer from a Neuro motor disability, they are in a condition where they are unable to perform any action due to paralysis in the body. The only way they can communicate is if someone can read their thoughts. The EEG helps with the same, this technique reads brain activity and now through it we can analyze and understand that person. Their fundamental need is a wheelchair thus this project is meant for controlling a wheelchair prototype robot.

1.3 Problem Statement

In this project we Study the EEG Signals with a Single Channel Non Evasive device, and analyze and try to classify labels for motion from particular thoughts. The motion label will be used to move the bot.

1.4 Objective

The main aim of this project is to use help the paralyzed control motion through Brainwaves.

1.5 Challenges

1. Creating a reliable connectivity.
2. Collecting data.
3. Built the Bot.
4. Features Extraction.
5. Training and algorithm generation.
6. Real-Time Working.

1.6 Project Development Time Schedule

Week 1: Workshop and Project assignment.
Week 2: Building the Robot and creating a background for work.
Week 3: Data Collection, Analysis, Plotting and Rules Generation.
Week 4: Exploring Machine learning and EMD, making reports.

Chapter 2

Literature Survey

2.1 Previous works

A wide range of methods has been proposed to predict epileptic seizures by classifying EEG signals. Many techniques like Eigen-spectrum of space delay correlation and correlation matrices, Hilbert-Huang transform, Empirical Mode Decomposition(EMD)[1] have been used. An entropy measure was used for the feature extraction and developed an Adaptive Neuro-Fuzzy inference system for the classification of EEG signals into normal and ictal[6]. The aim of their work was to compare the different entropy estimators when applied to EEG data from normal and epileptic subjects. People have generally studied Alpha, Beta Waves to study the functions of the brain and then using a cross-correlation and support vector machine. People have also used Fuzzy logics to define rules for EEG analysis[2], but most of them have set the fixed values for carrying out these tasks.

2.2 Arduino Bot

The bot is a small 2 wheel car with a castor wheel. It's main electronic components are:

Arduino Mega : The Arduino Mega is a micro-computer based on the ATmega1280.It has lots of connectors around the edges which you can use to connect to other electronic stuff. It connects by USB to a PC and there is PC IDE to download and develop programs. It has 54 digital I/O pins, 16 analog inputs, a 16 MHz crystal oscillator, 4 hardware serial ports , a power jack, ICSP Header, and a reset button.It can be a recharge using USB connection or external power supply automatically. It can operate an external supply of 6 -20 volts.

L293D : The L293D is a monolithic integrated motor driver which has 4-channel. It is act as interface between arduino and the motor ,which allow DC motor to drive on either direction. It can control a set of Two DC motor simultaneously in any direction.

Bluetooth HC-05 : This module connects to the arduino through Rx, Tx pin (through which serial communication takes place) so to start with you need a Bluetooth terminal app, which is wireless. Through the Bluetooth terminal you can send/receive data (once your devices have been paired) the same way you would on the serial monitor.

2.3 EEG

The electroencephalography (EEG) is a technique in which signal is a recording of the electrical activity of the brain. The signal is a quite small activity and is in order of microvolts. Brain cells of humans communicate via electrical impulses and all are active at all times. This activity is recorded as EEG Waveforms. [4] The main frequencies for EEG waves for a human :-

1. Delta: It has a frequency of 3.2 Hz or below. It is highest in amplitude and slowest amongst all other waveforms. They are generated in deep meditation and dreamless sleeps.

2. Theta: It has a frequency of 3.5 to 7.5 Hz and is found in locations not related to task at hand

3. Alpha: It has a frequency of 8-13 Hz. It appears when a person closes its eyes and gets relaxed and disappears when a person opens his eyes or gets alert by any mechanism such as thinking and performing some calculation. It is present during most of the life especially after thirteenth year.

4. Beta: It has a frequency of 14- 30Hz. It is seen on both sides of brain in symmetrical distribution. It is mostly observed in patients who are alert or anxious and have their eyes open. Beta brainwaves are most prominent during our normal waking of consciousness and when attention is directed towards some specific tasks of outside world.

5. Gamma: waves are fastest of all other brain waves relate to simultaneous processing of information from different brain areas. Gamma brainwaves pass information rapidly and quietly.

2.4 NeuroSky

MindWave Mobile 2 is an EEG headset which is the culmination of EEG biosensor technology research of many years and is very easy to control. It is available at affordable price and detects different waveforms of EEG signals such as Alpha, Beta, Theta, Gamma, and Delta. It also measures blink strength of a person along with meditation and attention. It is being used to play various games and is helpful in various research projects to detect and analyze EEG signals. MindWave Mobile 2 was released in 2010 in China and 2011 in the US. This device can be used for both entertainment and educational purpose.It works easily on different platforms such as Android and windows. It is single channel headset and has flexible rubber sensor arms and a rounded forehead sensor tip. It has a T-shaped headband, and wider ear clip to make it comfortable for its users.

Chapter 3

Project Design

3.1 Learnings Reflections

3.1.1 Machine Learning

Tom Mitchell provides a modern definition of machine learning. According to him, a computer program learns from an experience E with respect to a task T with performance P, if its performance increases with experience E. Machine learning can be divided into two categories supervised and unsupervised machine learning. In supervised machine learning, we provide a data set to machine knowing how the output will look like and already knows the relationship between input and output. Supervised machine learning can also be categorized into two types Classification and Regression. In Classification problems, we try to predict the results in form of discrete output and in regression problems, we try to predict results in form of continuous output. In unsupervised learning, we provide data to machine without knowing how the output looks like and what is a relationship between input and output. The machine learns by dividing the data into clusters and predicting the cluster for a new input.

3.1.2 Empirical Mode Decomposition

EMD is an adaptive time-space analysis method, it is suitable for processing series that are non-stationary and non-linear. EMD performs operations that partition a series into IMFs (Intrinsic Mode Functions) without leaving the time domain. It can be compared to other time-space analysis methods like FFT and wavelet decomposition. Similar to these methods, EMD is not based on physics. However, the modes may provide insight into various signals contained within the data. In particular, the method is useful for analyzing natural signals, which are most often non-linear and non-stationary.

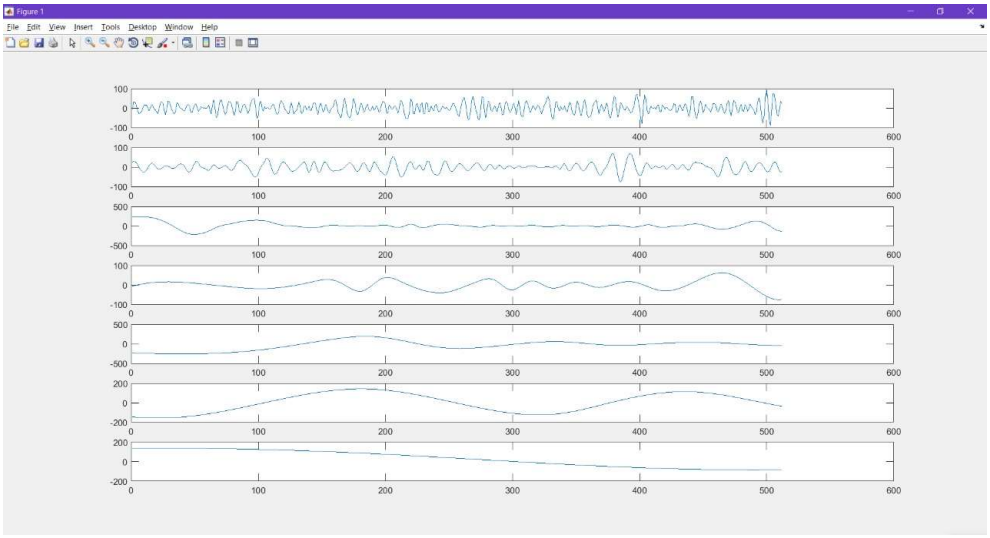

Figure 3.1: IMF of Raw EEG After Empirical mode decomposition

3.2 Work Flow Diagram

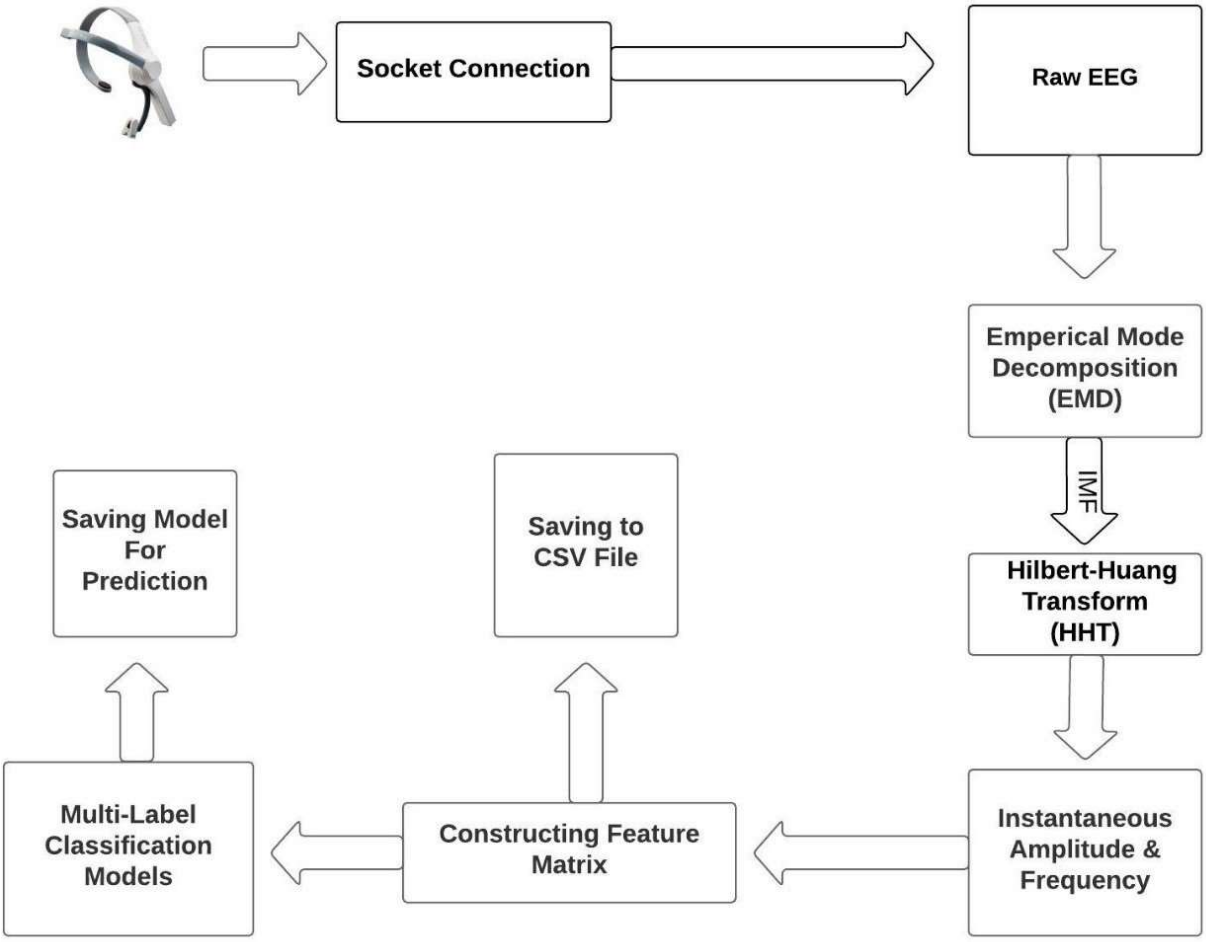

Figure 3.2: Proposed work flow

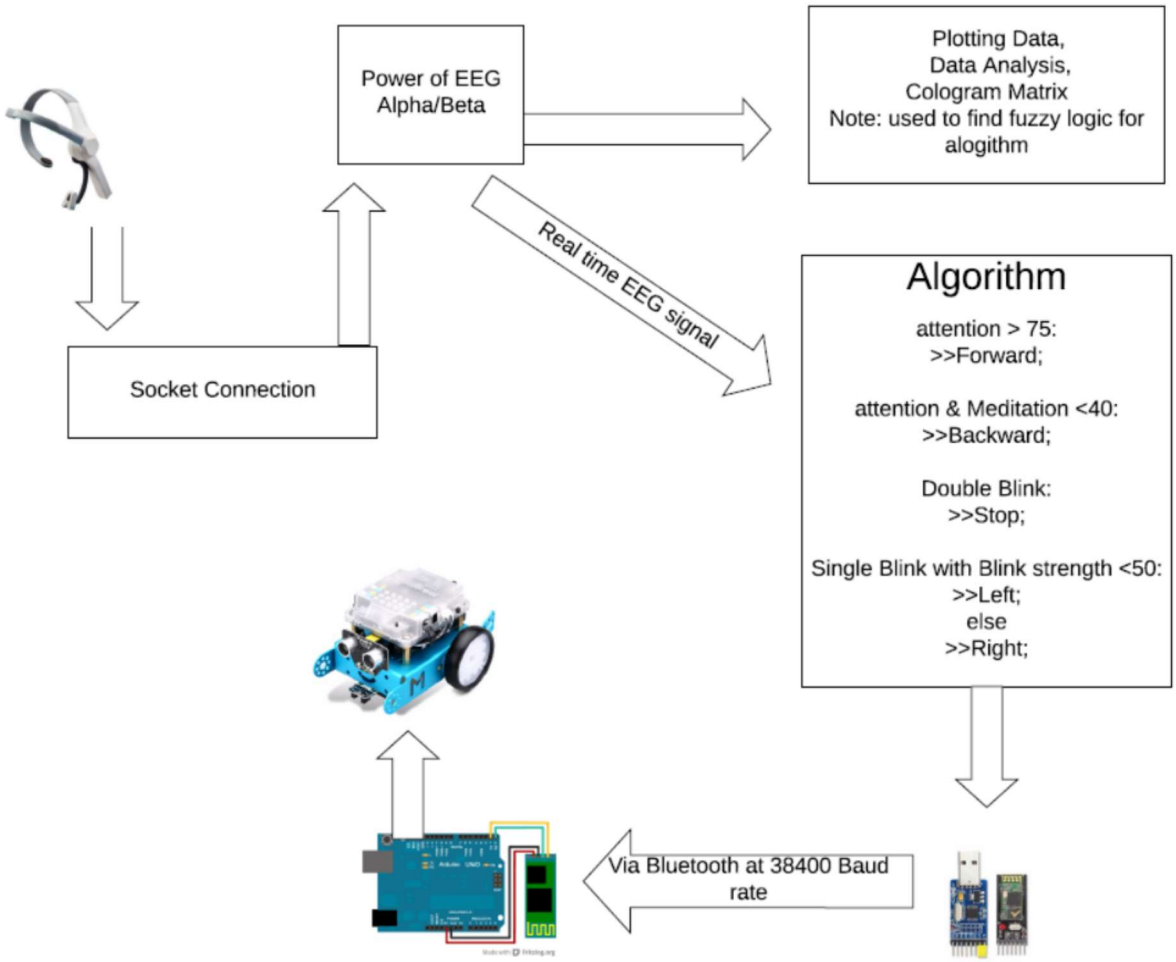

Figure 3.3: Implemented work flow

3.3 Implementation details

Steps given below were followed in order to make our project

1. Installation of Jayrock and Jayrock.Json and were used for connecting with ThinkGear socket connector and to store the collecting data in CSV format. Serial Socket calls were set for controlling the bot.

2. Collecting data for our project: data was collected from 30 different persons with help of Neurosky Mindwave Mobile device and was stored in a file. Different waveforms were recorded from the device like Alpha, Beta, Theta, Delta, Gamma along with the blink strength, meditation and attention. The Raw EEG was also stored.

3. The raw data was processed through EMD and then HHT in Matlab. The data was stored into a CSV file for training. The overlap was so high that classifying it was difficult.

4. That is the reason why we shifted to creating a fixed algorithm. Here we plotted the Power EEG data and using Fuzzy logic we decided upon the rules for the motion.

3.4 Snapshots of the Project

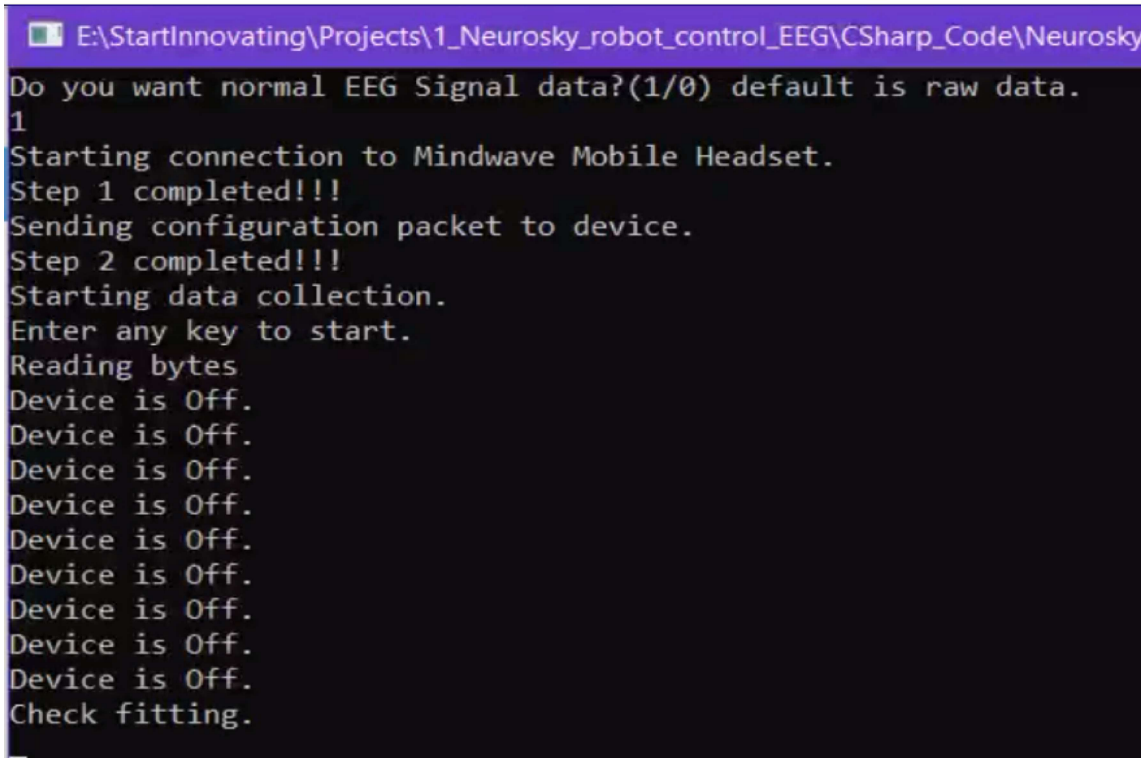

Figure 3.4: Configuring device for data collection

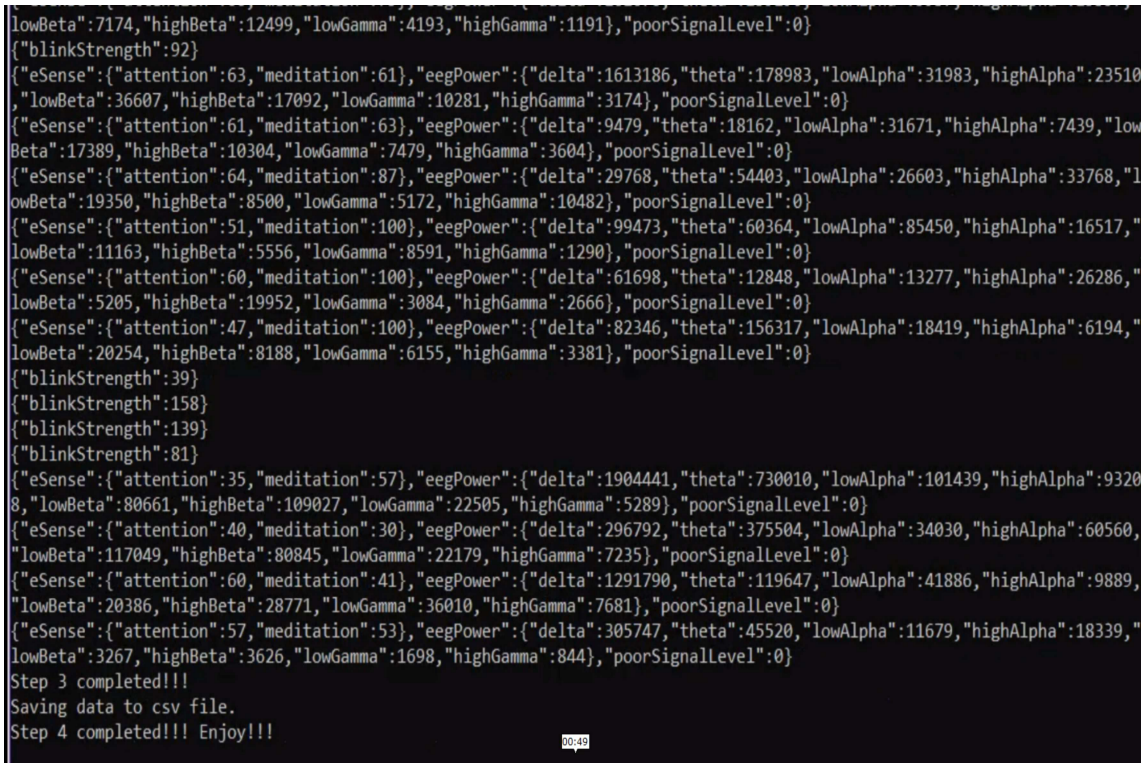

Figure 3.5: Collecting Data

	A	B	C	D	E	F	G	H	I	J
1	attention	meditation	delta	theta	lowAplha	highAlpha	lowBeta	highBeta	lowGamma	highGamma
2	27	48	375013	119765	3154	4055	15558	17955	5728	3941
3	8	63	40758	71406	47082	22769	14122	19653	4047	4497
4	41	69	202399	38285	6041	15477	29932	13612	6816	2410
5	41	56	555692	61855	13630	11552	3988	2016	676	575
6	43	90	2070950	193571	95195	40254	32848	32674	4423	4613
7	56	91	16715	20391	5843	26878	12608	11044	3864	2888
8	48	88	28307	49538	4358	12267	30771	7745	3876	10133
9	66	75	161676	139190	5937	15357	7174	12499	4193	1191
10	63	61	1613186	178983	31983	23510	36607	17092	10281	3174
11	61	63	9479	18162	31671	7439	17389	10304	7479	3604
12	64	87	29768	54403	26603	33768	19350	8500	5172	10482
13	51	100	99473	60364	85450	16517	11163	5556	8591	1290
14	60	100	61698	12848	13277	26286	5205	19952	3084	2666
15	47	100	82346	156317	18419	6194	20254	8188	6155	3381
16	35	57	1904441	730010	101439	93208	80661	109027	22505	5289
17	40	30	296792	375504	34030	60560	117049	80845	22179	7235
18	60	41	1291790	119647	41886	9889	20386	28771	36010	7681
19	57	53	305747	45520	11679	18339	3267	3626	1698	844

Figure 3.6: Data in CSV

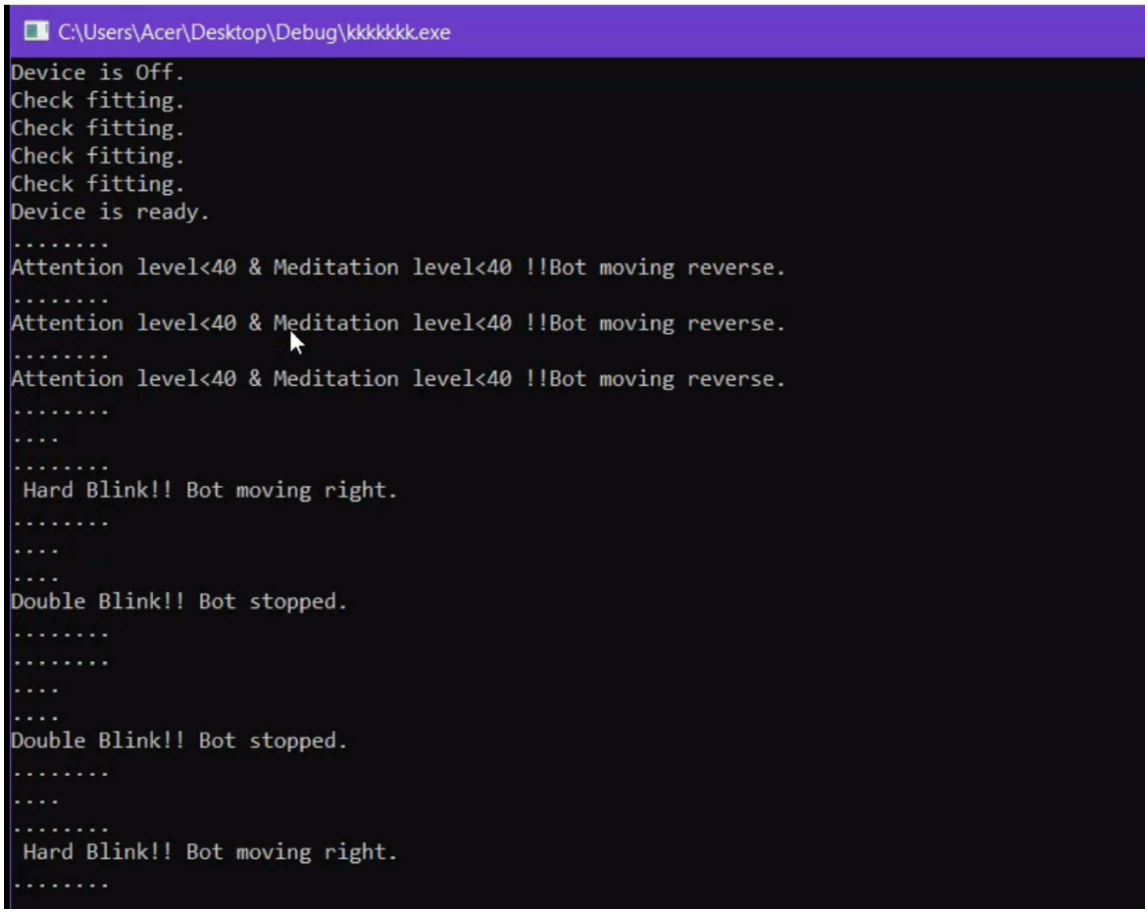

Figure 3.7: Run time output

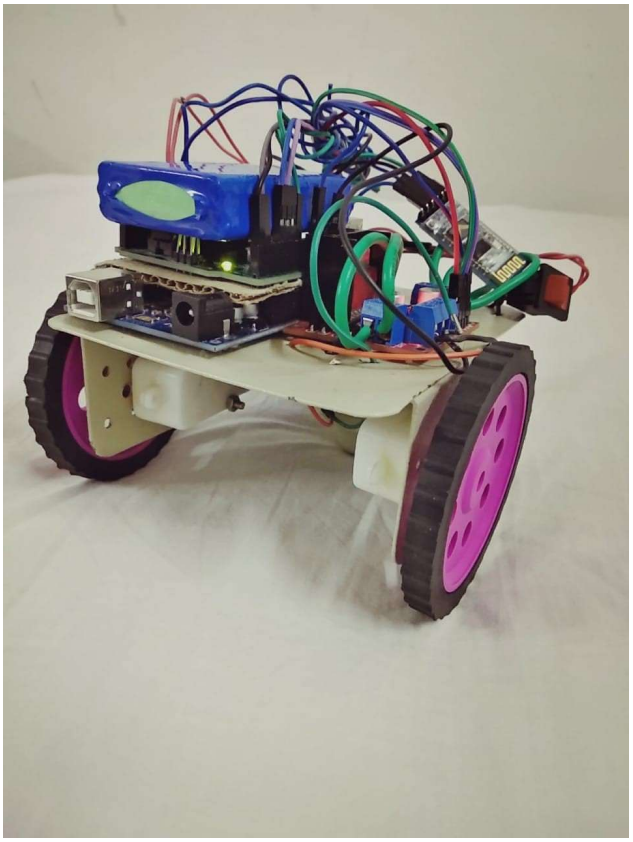

Figure 3.8: Arduino Robot

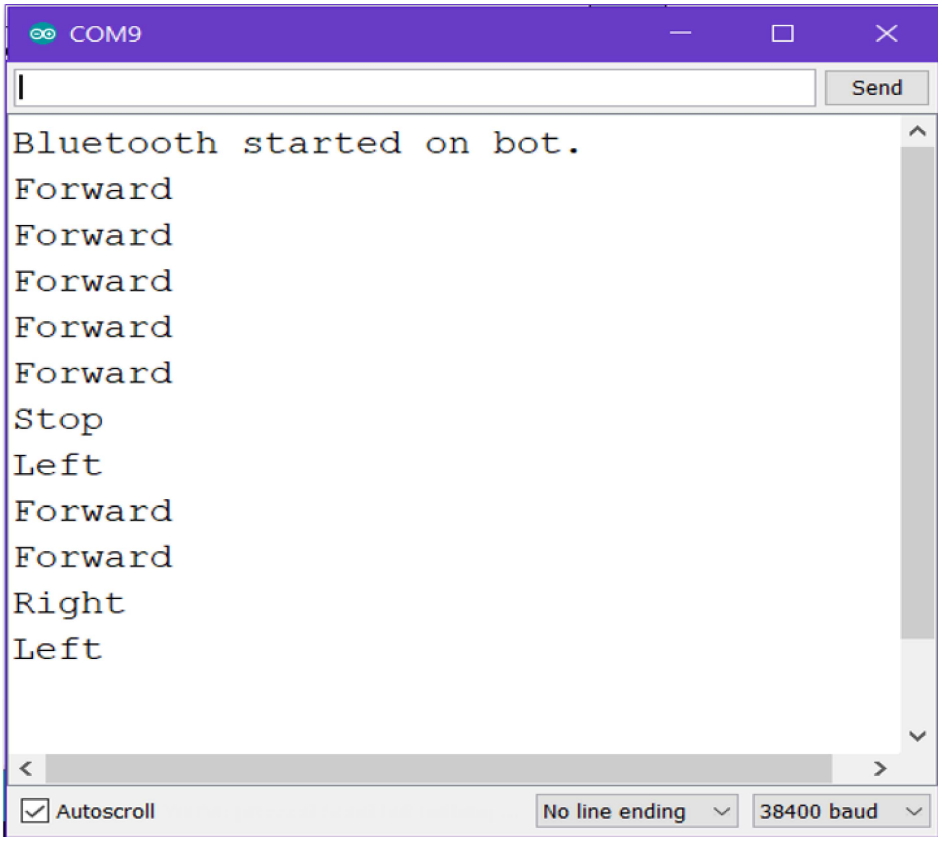

Figure 3.9: Arduino serial output

Chapter 4

Discussion

4.1 Limitations

1. More data needed to be collected .
2. Multi-channel device will be able to localize the source signal.
3. Frequency of computed EEG is low.

4.2 Future Scope

1. Train the data using Multi-Label Classifier.
2. Through Signal localization more functionality can be induced in the project.

4.3 Conclusion

The purpose of this project was to figure out a way such that it could achieve the goal of control the motion of the robot using EEG signals. The Algorithm set to control the robot has been created using Fuzzy Logic. The device used for this purpose was neurosky mindwave mobile 2, a single channel non evasive device. The device gave the feature in the form of EEG waves like delta, theta, gamma, blink strength, attention value etc. along with the raw EEG which was recorded by the C script converting the data to a data.csv format. The stored data was further visualised and then using Fuzzy Logic, rules were made. The project thus paves the way for further improvements and added functionalities to the projects helping out people on a larger scale.

Github link:
http://bit.ly/EEG_Controlled_Robot

YouTube video link:
http://bit.ly/DIY_EEG_Robot

Bibliography

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[4] *https://www.medicine.mcgill.ca/physio/vlab/biomed*$_s$*ignals/eeg*$_n$*.htm*

[5] https://www.ncl.ucar.edu/Applications/eemd.shtml

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