BRAIN-CONTROLLED WHEELCHAIR; TAPPING INTO THE POTENTIAL OF BCI SYSTEMS FOR A BETTER TOMORROW

Katharine Christine Sheen[1], Irfan Jaleel[2] , Lazima Parveen[3] ,Luckman.V[4] and Bushara A.R[5]

[1-2-3-4]B.Tech student, ECE Department,KMEA Engineering College, Kerala, India

[5]Assistant Professor, ECE Department,KMEA Engineering College, Kerala, India

***Abstract*— According to WHO, 10% of the world's population lives with some form of disability, among which the physically disabled covers the most. This includes paralysis, cerebral palsy, Parkinson's disease etc., which effects the motor abilities of the person, leaving him/her in the mercy of their care takers as they have to depend on them for their motor necessities. Although electric wheelchairs are available, it is impossible for people who have lost or are in no control of their limbs, to navigate them. Not to mention the expense of these kind of wheelchairs are fairly high. It is in these circumstances that scientists and researchers coined the two entities; the brain and computer, to come up with a popular and demanding technology, called the BCI or Brain Computer Interface. BCI provides a channel or a pathway that allows the human brain to communicate with external devices. Popular applications of BCI in the present day includes medical applications like prosthetics, which helps replace the patient's 'lost limbs', robotics, education and self-regulation, games and entertainment, smart environment and the list goes on. Our aim is to coin this technology with a normal wheelchair to build a Brain-Controlled Wheelchair the user can navigate by merely using his thoughts.**

***Keywords*— BCI, Parkinson's disease, cerebral palsy, electric wheelchairs, prosthetics, robotics.**

1. INTRODUCTION

Brain is a relevant part of the human body. It consists of millions of neurons, which are responsible for controlling the behavior of the human body related with specific signal frequencies. These frequencies can be acquired using several techniques like Computer Tomography (CT), Positron emission Tomography(PET), Magnetic Resonance Imaging(MRI) and Functional Resonance Imaging(FRI), each having their own merits and demerits. Most of these techniques are expensive. EEG is another modality which helps to analyze brain and its behaviors based on the frequency signals. EEG and related methods can function in almost all environments and requires simple, inexpensive and non-invasive methods to acquire the signals and hence is a practical solution for an inexpensive and accurate BCI.

BCI or Brain Computer Interface is an excellent and powerful communication tool that provides a pathway between the brain and the external devices. This is specifically for the people who have lost all voluntary muscle control, including eye movement and completely locked into themselves.

The training process plays an important role in determining the accuracy of the wheelchair. since it is the EEG signals that are recorded and processed for movement control, it is important to know that mental strength or command of a person varies with age. The older the person is, the weaker his mental command capability will be.

The paper, "Brainwave Controlled Wheelchair Using Eyeblink"[1], proposed a system which uses dry electrodes to capture the EEG and eye blinking signals. The same method is seen in the paper "Robotic Wheelchair Using Eyeblink Sensors and Accelerometers Provided with Home Appliance control" [2], attempts to make use of the eye and head movement to control the wheelchair as well as connect to the home appliances through a RF module. In the paper, "Development of A Smart Wheelchair Control " [3], brought forth a new proposal of using a motor imagery model which allows the user to control the four movements (forward, reverse, left and right movements). In the paper "Mind Controlled Wheelchair using EEG

Journal of Engineering Sciences

Vol 11, Issue 6,June/2020

ISSN NO:0377-9254

Probes Using Microcontroller" [4], discussed the design of a smart wheelchair having real time control and automated guided functions. This design uses GPS to locate and set the path to the desired destination. The user can also set the direction using their imagination/thought. In the paper "iPhone Based Portable Brain Controlled Wheelchair" [5], developed a system that uses an iPhone to process the brain signals, and direct the commands to the wheelchair, which makes it more cost-effective, portable and easy to use.

2. OVERVIEW

The design of this wheelchair can be broken down into three steps; 1. signal acquision 2. signal processing 3. motion control.

Fig.1.Simple Block Diagram

2.1 Signal Acquisition

The signal acquision takes place with the help of the EEG sensors. Many EEG sensors require surgical implantation where the sensors are placed on the cortex or other brain areas to read the brain signals. This is the invasive method. Since the method is expensive and, in most cases, considered impractical, we depend on the non-invasive method. Using non-invasive practices not only reduces the expense, but also provides comfort and portability, hence making it user friendly. In our project, we use the PanTech BrainSense Headset which can be connected to our smart phones and laptop using its Bluetooth module. Although there are many headsets available, we chose the PanTech BCI because of its low cost and ease of operation. This headset reads the delta(0.5 – 4 Hz), theta(4 – 8 Hz), alpha(8 – 13 Hz), beta(13 – 32 Hz) and gamma(32 – 100 Hz). It also records the attention, meditation level and the frequency of eye blink of the user. For this project, we mainly process the alpha and beta waves, which represents state of physical and mental relaxation as well as the state of consciousness and active thinking respectively. By processing these brain frequencies, we can control the direction and speed of the wheelchair. we can also set the threshold frequency of the patient by training process, for appropriate motion control and user experience.

2.2 Processing Unit

The processing unit processes the acquired signals in three different steps;
1 The pre-processing unit 2 Feature extraction 3 Classification.

2.1.1 The Pre-Processing Unit

The acquired EEG signals are of low amplitude and may contain artifacts that can tamper with the significant brain signals and hence disturb their proper processing in the further stages. In order to avoid this, the raw EEG signals undergo pre-processing, so that the unwanted components can be taken off ,
leading to better results.

2.1.2 Feature extraction

The obtained pre-processed signals are not yet useful for the control of the wheelchair as these signals are complicated and hard to distinguish. For proper feature extraction, these signals, which are in time domain, are converted to frequency domain using the FFT transformation. By doing so, we obtain waveforms that are easy to record, distinguish and train. The signals that are analyzed during the training sessions are recorded.

2.1.3 Classification

Once the signals are differentiated and trained, they are given over to the classification unit. The classifier discreets the signals into forward, reverse, left and right commands and is loaded into the microcontroller unit, which in turn controls the servo motor to move in the desired direction.

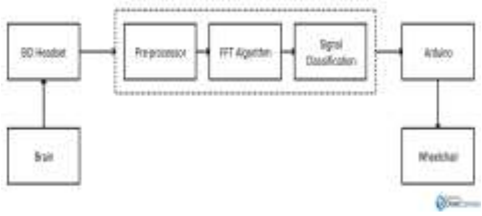

Fig.2. Detailed Block Diagram

2.2 FLOWCHART

Once the patient puts on the headset, his/her EEG signals are obtained, and it goes through a series of processing as discussed before. The algorithm then compares the processed input frequency with that of the preset threshold frequency. If the input signal measures greater than or equal to the threshold, the algorithm then performs a series of comparisons to analyses the mental command and move the wheelchair accordingly.

As mentioned before, the training process plays an important role as the mental strength of an individual varies according to their age.

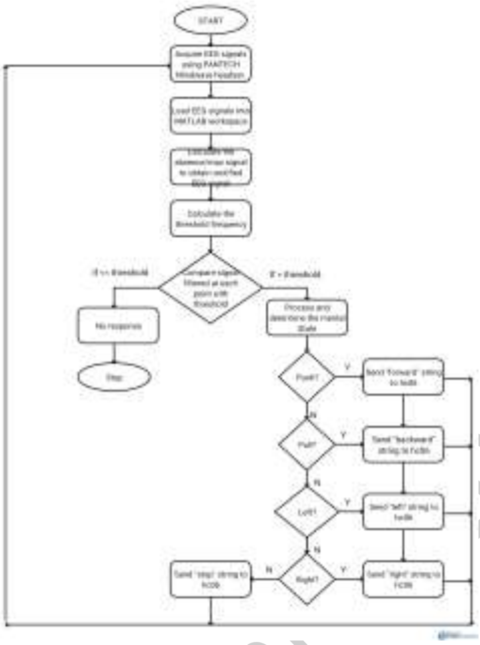

Fig.3. Flowchart

3. TOOLS REQUIRED

The following tools are required to develop our project;

3.1 HARDWARE

3.1.1 PanTech BrainSense Headset

The PanTech Headset measures the raw brainwaves (alpha, beta, gamma and delta), E-sense meters (attention and meditation level) and eye blinks.

Fig.4. PanTech BCI[6]

It consists of a headset, a ear-clip which serves as the reference and ground electrodes, and a sensor arm. The EEG electrode rests on the forehead above the eye (FPI position). It uses a single AAA battery and can operate 8 hours straight. The headset uses a TGAM 1 module as the brain senor and a Bluetooth v2. 1 Class 2 that has 10 meters range.

3.1.2 Arduino Uno

Arduino Uno is a microcontroller board which consists of components like Crystal oscillator, Serial communication, Voltage regulator etc. It has 14 digital input/output pins, 6 analog pins, a USB connect, power barrel jack, ICSP header and reset button. The Arduino Uno can communicate with a computer, another Arduino board or microcontroller.

Fig.5. Arduino Uno[7]

The Arduino board can establish a wireless communication path with the above-mentioned external devices by interfacing a Bluetooth module.

3.1.3 Bluetooth module

Fig.6.HC-05 Bluetooth module[8]

The Bluetooth module facilitates the wireless communication between the Arduino and external devices. The most commonly used one is the HC-05 module because of its ease in connectivity. HC-05 is a Bluetooth SPP (Serial Port Protocol) module, which means that it communicates serially with the Arduino. Once it is interfaced and properly programmed, it can be added to with, by entering the code 0000 or 1234.
whichever device we want to connect it
The HC-05 bluetooth module can operate in Master, Slave or Master/Slave mode, but it works as a slave in default mode. It has a data mode Baud rate of 9600,8,N,1 and a command mode Baud rate of 38400,8,N,1. The maximum range we can attain with this module is less than 100.

3.1.4 Motor Driver

Fig.7. Motor Driver[9]

Motors require high amount of current to run, but the Arduino board works on low current, hence will not be able to provide the sufficient current requirement. So, we use a motor driver to provide the high current signal. The motor driver acts as an interface between the Arduino and the motors.

Since we are doing an experimental set up, we use 12V DC motors and a L9110S H-bridge motor Driver. While implementing it as a product, the selection of motors and motor driver depends on the weight of the person.

3.2 SOFTWARE

3.2.1 MATLAB

MATLAB lets us read and write data into the Arduino as well as connect with devices such as motors, LEDs and 12C devices. MATLAB is a high-level interpreted language and hence makes projects with Arduino much easier. It has many built-in math, engineering and plotting formats that can be used for Arduino programming. We can use EEGLAB, an open source signal processing environment to process EEG signals on MATLAB.

3.2.2 Arduino IDE

The Arduino IDE(Integrated Development Environment) is the software used to program the Arduino board. Once it is installed on the computer, we can use the USB cable to connect it to the board.

4. CONCLUSION

The objective of our project is to help the people suffering from Muscular and Skeletal diseases, making them unable to carry out any body movements. We believe that these people suffering from paralysis, muscular dystrophy, spinal injury, cerebral palsy etc. deserve a better life. It should be considered that, though they have lost all power of muscle control, they still possess the power over their thoughts. This Brain-Controlled wheelchair will give them a sense of a new beginning, as the patient can control the wheelchair by their mental command. It also helps them reduce their dependence on others upto a certain level.

REFERENCES

[1]Harshavardhana N R, Anil G, Girish R, Dharshan T, Manjula R Bharamagoudra, “Brainwave Controlled Wheelchair Using Eye Blinks”, April 2018, International Journal of Advanced Research in School in Science and Engineering (IJARSE)
[2]Colleen Nelson, Nikitha S Badas, Saritha I G, Thejaswini S, “Robotic Wheelchair Using Eye Blink Sensors and Accelerometer Provided with Home Appliance Control”, May 2014, journal of Engineering Research and Applications (IJERA).
[3]Naveen.R.S, Anitha Julian, “Brain Computing Interface for Wheelchair Control”, July 203, IEEE.
[4]Chung-Kang Huang, Zuo-Wen Wang and Guan-Wei Chen, chia-Yen Yang, “Development of a Smart Wheelchair with Dual Functions: Real-time Control and Automated Guide ”, 2017, 2nd International Conference on Control and Robotics Engineering.

Vol 11, Issue 6,June/2020
ISSN NO:0377-9254

[5]Lijun JIANG, "iPhone-based Portable Brain Control Wheelchair",2012, 7th IEEE Conference on Industrial Electronics and Appliances, IEEE.
[6]https://Pantech-solutions-Brainsense-Brain-computer-interface/dp/B00U1BX1OU#
[7]https://cdn.sparkfun.com/asset9/1/e/4/8/515b46J6ce395f8a38000000.png
[8]https://howtomechatronics.com/tutorials/arduino/arduino-and-hc-05-bluetooth-module-tutorial/
[9]https://www.amazon.com/L9110S-H-bridge-Stepper-Controller-Arduino/dp/B01N2MVZ12