Brain Controlled Miniature Wheelchair using BCI and Matlab

Vikas Kumar Shrama[1] Prof. Rajesh Namdeo Patil[2]
[1]PG Student [2]Associate Professor
[1,2]Department of Electronics and Telecommunication Engineering
[1,2]GS Mandal Marathwada Institute of Technology, Aurangabad, India

Abstract— BCI- A brain–computer interface (BCI), sometimes called a brain–machine interface (BMI), is a direct communication pathway between the brain's electrical activity and an external device, most commonly a computer or robotic limb. BCIs are often directed at researching, mapping, assisting, augmenting, or repairing human cognitive or sensory-motor functions. Implementations of BCIs range from non-invasive (EEG, MEG, EOG, MRI) and partially invasive (ECoG and endovascular) to invasive (microelectrode array), based on how close electrodes get to brain tissue. Research on BCIs began in the 1970s by Jacques Vidal at the University of California, Los Angeles (UCLA) under a grant from the National Science Foundation, followed by a contract from DARPA. The Vidal's 1973 paper marks the first appearance of the expression brain–computer interface in scientific literature. Due to the cortical plasticity of the brain, signals from implanted prostheses can, after adaptation, be handled by the brain like natural sensor or effectors channels. Following years of animal experimentation, the first neuroprosthetic devices implanted in humans appeared in the mid-1990s. Recently, studies in human-computer interaction via the application of machine learning to statistical temporal features extracted from the frontal lobe (EEG brainwave) data has had high levels of success in classifying mental states (Relaxed, Neutral, Concentrating),mental emotional states (Negative, Neutral, Positive) and thalamocortical dysrhythmia.

Keywords: Brain computer interface (BCI), Electroencephalography (EEG), Spinal Cord Injury (SCI), Brain-controlled wheelchair (BCW)

I. INTRODUCTION

World Health survey estimates that 110 million people (2.2%) have very significant difficulties in functioning. These people are not capable of to use their hand to operate the wheelchair due to paralysis of body up to neck and limb.

They depend on the help and support of family member for their movement and face the sense of discrimination among the family. The day to day life of such person depends on other people and they become physical and mentally burden on other people of the family.

Even the electrical wheel chair requires human finger or hand for operation.

To overcome this challenges wheel chair based on Brain Controlled Interface (BCI) is required which work on Brain signal produced by eye blink from human brain without any physical intervention and control.

The work carried out in this project will be beneficial for people with a severe Spinal Cord Injury (SCI) are only able to control a muscle movement from a neck and above.

In BCI wheelchair the EEG is a method that captures electrical waveform from the brain. This method employs the EEG device that equipped with sensing electrodes. This head band is placed these electrodes on the forehead of the patient. According to the human thoughts and eye blinking, different electrical waves are produced. Even for a muscle contraction, it will also generate a unique electrical signal.

using the EEG device, these signals are captured and will be transmitted to the computer for further processing by Bluetooth module equipped in brain wave sensor module.

Therefore, during the EEG signal processing, the raw EEG signals are processed in a manner to differentiate the mental commands that are thinking by the user. Further, establishing communication using EEG we make use of interface BCI (Brain-computer Interfaces), this computer based system will obtain signals, process them by analyzing and translating signals to commands to machine as output to operate.

II. OBJECTIVE

The objective of this work is to develop a Brain controlled wheel chair for the person suffering from Quadriplegia a type of paralysis which affects all four limbs and, sometimes, parts of the chest, abdomen, and back.

This work demonstrate a brain controlled wheelchair model using Aurdino based Controller controlling the movement of wheel chair wirelessly in response to brain signal generated by eye blink. This will eliminating the need of physical gear like joystick, switches and voice controlled system. The model is developed by using non –invasive dry EEG sensor placed on patient forehead. This sensor receives and transmits the raw EEG signal to the signal processing unit. This will reduce the dependency of disabled person on other for the movement and live a quality life in term of physical movement

III. BLOCK DIAGRAM

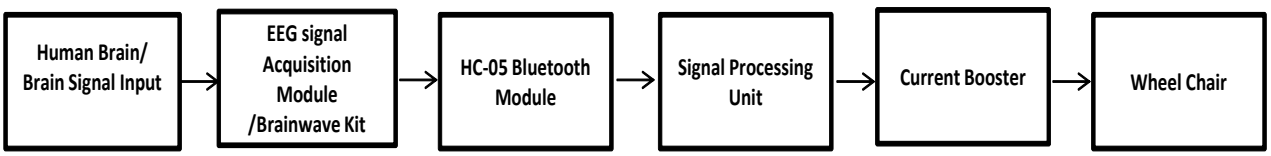


Fig. 3.1: Block Diagram

A. Brain Signal Input

The brain signals used here are Spontaneous EEG signals. These signals are associated with various aspects of brain function related to mental tasks carried out by the subject at his/her own will. The mental tasks include attention, eye blinks and eye movement for forward, reverse and stop actions respectively.

B. EEG Signal Acquisition Unit:

In this application a headgear is used for signal acquisition instead of the electrode cap. The headgear or the brainwave starter kit makes use of dry sensors which does not require application of a conductive gel between the sensors and the scalp. Also this device is much lighter and convenient for usage when compared to the conventional EEG sensors as it requires only one electrode for sensing. Another advantage of using this kit is that the data or brain signals are transmitted to the signal processing unit via Bluetooth connection which was not possible with the conventional signal acquisition methods.

C. Signal Processing Unit

The signal processing unit used in this application is a laptop/PC. The brain signals are transmitted from the headgear via Bluetooth to MATLAB platform in the laptop. The digitized value is then passed on to suitable microcontroller through USB port for further mapping of brain signal values to control signals of the motors.

D. Current Booster

An H bridge is an electronic circuit that enables a voltage to be applied across a load in either direction. These circuits are often used in robotics and other applications to allow DC motors to run forward or backwards. H bridges are available as integrated circuits. They can be built using discrete components.

E. Wheelchair prototype

Two motors of 60rpm each are used to form a wheelchair prototype. The frame is constructed using aluminum sheets. The control signals from the H-bridge circuit are sent to the motors.

Depending on the action performed, the control signals will cause the motor to run in either in clockwise, anticlockwise direction or stop.

IV. HARDWARE DESCRIPTION

A. Arduino:

The Aurdino Uno is an source microcontroller based on the MicrochipATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 Digital pins, 6 Analog pins, and programmable with the Aurdino IDE (Integrated Development Environment) via a type B USB cable. It can be powered by the USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts.

B. HC-05 Bluetooth Modules

HC-05 is a Bluetooth module which is designed for wireless communication.HC-05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. It uses serial communication to communicate with devices. It communicates with microcontroller using serial port (USART).

C. Brain Computer Interface BCI:

In this application a headgear is used for signal acquisition instead of the electrode cap. The headgear or the brainwave starter kit makes use of dry sensors which does not require application of a conductive gel between the sensors and the scalp. Using this kit is that the data or brain signals are transmitted to the signal processing unit via Bluetooth connection which was not possible with the conventional signal acquisition methods.

D. DC Motor

3-12VDC Gear motor with a right-angle drive gearbox offering 180:1 reduction, making it perfect for drive-train use in small to mid-sized robotics and R/C projects.

E. An H bridge

It is an electronic circuit that enables a voltage to be applied across a load in either direction. These circuits are often used in robotics and other applications to allow DC motors to run forward or backwards. H bridges are available as integrated circuits. They can be built using discrete components.

F. Wheelchair prototype

Two motors of 180rpm each are used to form a wheelchair prototype. The frame is constructed using aluminium sheets. The control signals from the H-bridge circuit are sent to the motors. Depending on the action performed, the control signals will cause the motor to run in either in clockwise, anticlockwise direction or stop.

Fig. 4.6: Wheel Chair Prototype

V. SOFTWARE DESCRIPTION

A. Arduino Software (IDE)

The Aurdino Integrated Development Environment - or Aurdino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Aurdino and Genuino hardware to upload programs and communicate with them.

B. MATLAB

MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation.

VI. METHODOLOGY

In this application a headgear is used for signal acquisition of electrode cap. The brain signals used here are Spontaneous EEG signals. These signals are associated with various aspects of brain function related to mental tasks carried out by the subject at his/her own will based on eye blink. The mental tasks include attention, eye blinks and eye movement for forward, reverse and stop actions respectively.

Initially Bluetooth connection is established between the headset and the signal processing unit (PC/Laptop). Once the headset is turned on, depending on the requirements of the motor movements, actions are performed

These received data are then processed in MATLAB. The Patient has to blink his/her eye as per direction highlighted on PC screen. After the eye blink is detected the detection arrow on Screen will turn Green and Motor will be operated to move in desired direction. If patient don't want to move in any direction, then eye blink is not required and the wheelchair will remain at last position.

It has channels to record and analyze different types of brain signals, for example, brain waves like alpha, beta, gamma, and raw EEG.

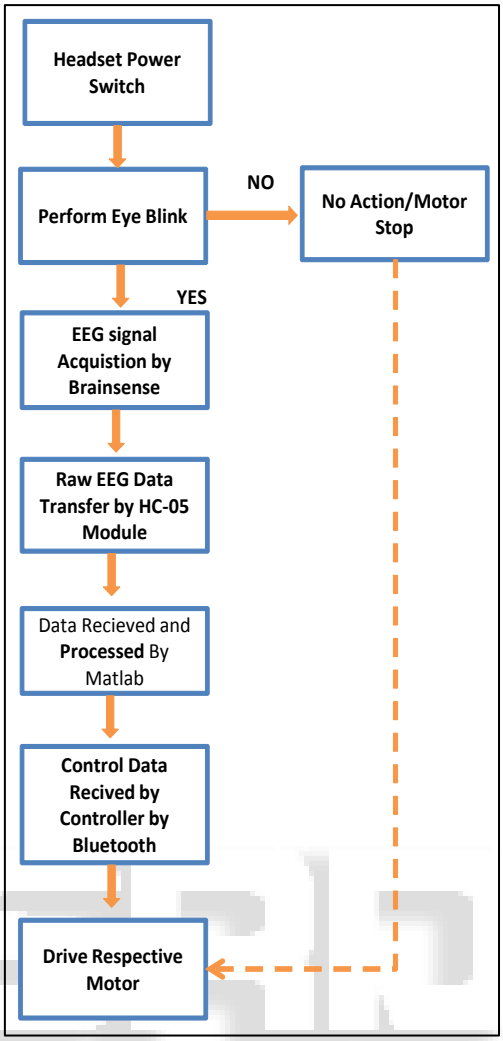


Fig. 6.1: Project Flow Chart

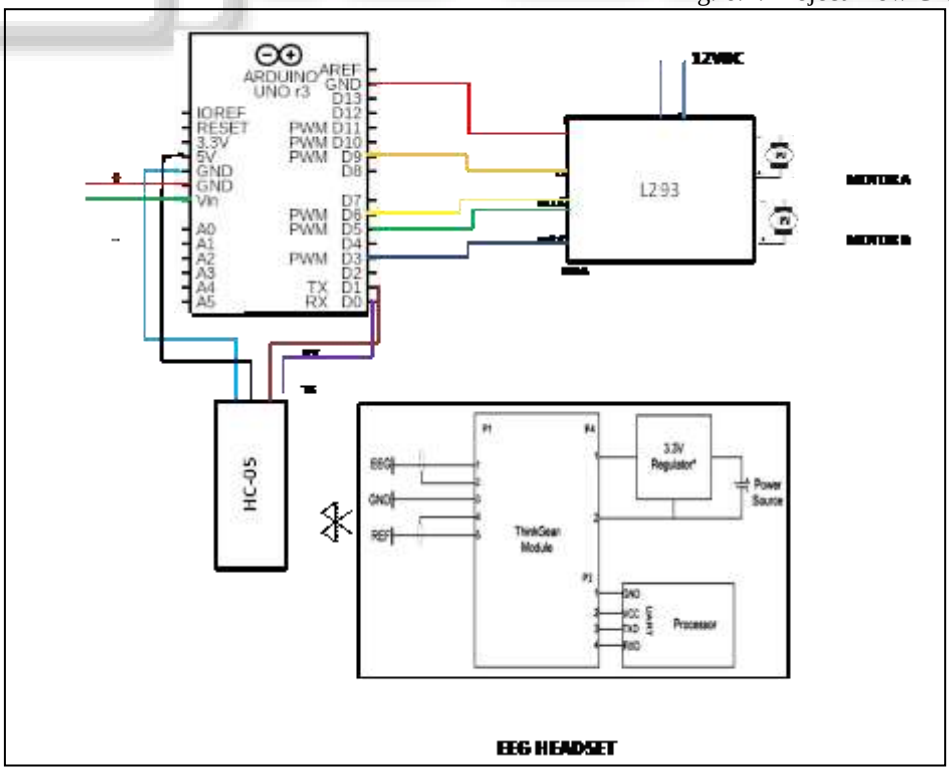
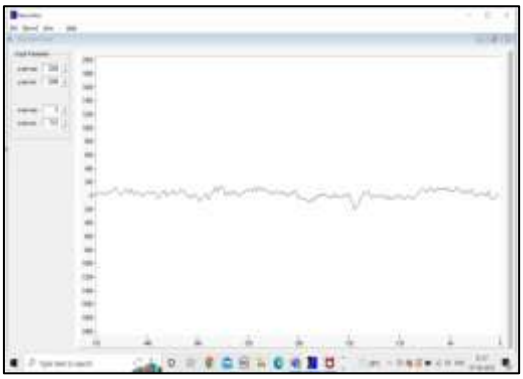


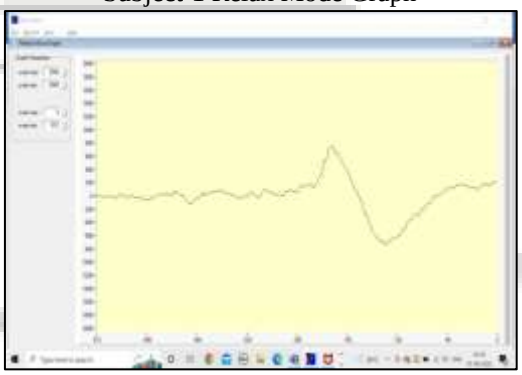
Fig. 6.2: Circuit Diagram of Wheelchair System

VII. RESULT

The prototype working tested by placing Brainwave sensor on two different people. The results obtained are satisfactory. When the device is ready, the screen appears on Laptop/PC as shown in Fig.8.3.The patient has to blink his eyes as per direction indicated by arrow sign for the movement of wheel chair in desired direction. The training was given before the trial and wheel chair started operated as per the eye blink of person. The brain curve of different people corresponding to eye blink and attention was recorded as in Fig.8.1 and Fig.8.2.The

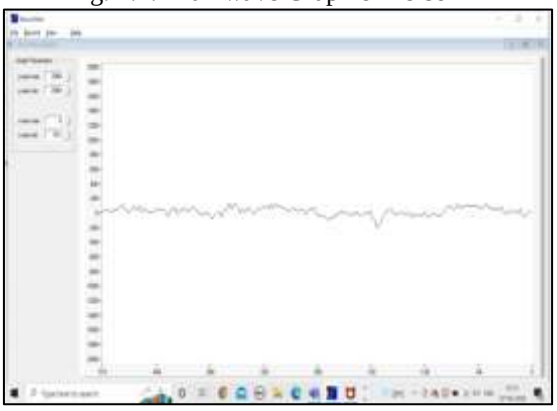


Subject-1 Relax Mode Graph

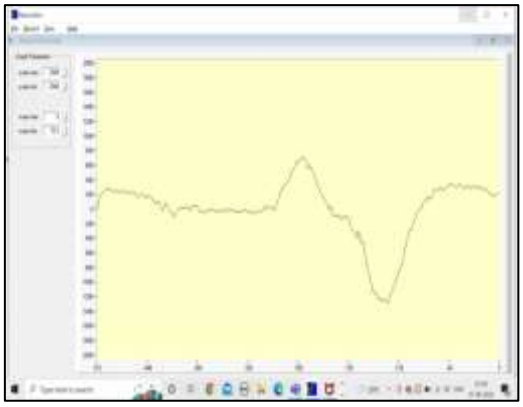


Subject-1 Raw Curve at Eye Blink

Fig. 7.1: Brainwave Graph of Person-A



Subject-2 Raw Curve at Attention



Subject-2 Raw Curve at Eye Blink

Fig. 7.2: Brainwave Graph of Person-B

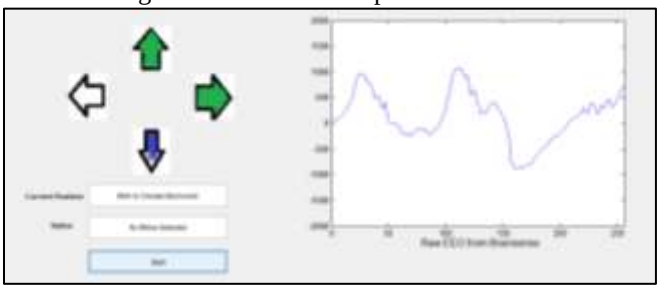


Fig. 7.3: MATLAB Graphic for Direction control.

VIII. CONCLUSION

In the present work, a BCI based wheelchair control system utilizing eye blinks was developed and tested for its operation. The system consist of several components i.e. BCI headgerar, MATLAB, Laptop, Audino microcontroller. The present work require less time for training to operate the wheel chair based on eye blink. This prototype will be beneficial for disabled person for their movement and reduce their dependency on other for their movement and improve their quality life in terms of movement.

IX. FUTURE SCOPE.

Since the BCI is in initiation development phase for Medical application like Wheelchair. The wheel chair can be developed with auto battery charging system with the help of room light to reduce the dependency for regular power charging.

Health monitoring system such as pulse rate, blood oxygen level and fall protection alarm can be developed with alert system over GSM to family member.

REFERENCES

[1] Rahib H. Abiyev,Nurullah Akkaya,Ersin Aytac,Irfan Günsel,and Ahmet CaLman, Brain-Computer Interface for Control of Wheelchair Using Fuzzy Neural Networks, BioMed Research International Volume 2016

[2] V.Purushothaman, R.Androse, M.J.Lokesh, S.Nawin Chander, R.Rajkama, Head Motion Controlled Wheelchair, International Journal of Recent Technology and Engineering (IJRTE), Volume-7 Issue-6S3 April, 2019

[3] Pranob Kumar Charles, Murali Krishna, Praneeth Kumar GV and Lakshmi Prasad D, EEG - Controlled

Wheelchair Movement: Using Wireless Network, Journal of Biosensors & Bioelectronics, 2018
[4] Tara Preeth M, Lokesh Arijilli and Siddhartha Reddy, and Shanmugasundaram M, Control Of Wheelchair By Eye Movement Using Image Processing, International Journal of Electrical Engineering and Technology, Volume 11, Issue 3, May 2020
[5] Nobuaki Kobayashi, Masahiro Nakagawa, Faculty of Engineering Nagaoka University of Technology,Kamitomioka, Nagaoka, Niigata, Japan, BCI-based Control of Electric Wheelchair, 2015 IEEE 4th Global Conference on Consumer Electronics (GCCE)
[6] Ramy Mounir, Redwan Alqasemi, and Rajiv Dubey, Member, IEEE, BCI-Controlled Hands-Free Wheelchair Navigation with Obstacle Avoidance
[7] https://www.pantechsolutions.net/brain-controlled-wheelchair

