DESIGN OF MIND CONTROLLED WHEELCHAIR

An Open Ended Lab Project Submitted
in Fulfillment of the Requirements
for the Degree of Bachelor of Technology

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1) Introduction

The advent of assistive technologies has opened new horizons for individuals with disabilities, enhancing their ability to perform daily activities and improving their quality of life. This project focuses on designing a mind-controlled wheelchair utilizing Brain-Computer Interface (BCI) technology, specifically employing an Electroencephalography (EEG)-based brainwave sensor. EEG is a diagnostic tool that measures and records electrical activity in the brain, often used to detect abnormalities in brainwave patterns. By harnessing the power of EEG, this project aims to interpret brain signals to control the movements of a wheelchair.

This innovation is particularly significant for individuals who are paralyzed and unable to manipulate the joystick of an electric wheelchair. By providing an alternative control method, the mind-controlled wheelchair offers these individuals a means to regain a degree of independence. It allows users to navigate their environments without the constant need for an attendant, granting them the freedom to move independently and enjoy outdoor activities. Ultimately, this technology could greatly enhance the autonomy and quality of life for people with severe mobility impairments.

1.1 Problem Statement

- Paralysis is a condition characterized by the loss of muscle function in part or most of the body, often resulting in a long-term or permanent inability to control motor functions. Despite their physical limitations, patients who are paralyzed continue to exhibit brain activity patterns detectable through Electroencephalography (EEG).
- Globally, about 15% of the population lives with some form of disability. In India alone, approximately 26.8 million individuals suffer from physical disabilities, significantly impairing their ability to perform daily activities independently.
- Currently, there are very few successful Brain-Computer Interface (BCI)-based products available for navigation by individuals with motor disabilities, and those that exist are often prohibitively expensive. This highlights a significant gap in accessible and affordable assistive technology solutions for the physically disabled population, emphasizing the urgent need for innovative, cost-effective solutions to enhance their independence and quality of life. Due to Limitation of current solutions , Lack of standardized , Time consuming training , Accuracy is limited

1.2 Organization of The Report

This section serves as an introduction to the key aspects covered in this report, aligning with the problem statement mentioned earlier. We present a brief overview of our project's functionality, highlighting the main features incorporated, the methodology employed, and the project's current status and future prospects. Introduction dvelves into the problem statement, outlining the necessity for undertaking this project. Moving to **Stage 1,** Understanding BCI and EEG: The Foundations of Mind-Controlled Wheelchair Technology. **Stage 2**, Implementation and Integration: Building the Mind-Controlled Wheelchair with Arduino and Custom Code (Methodology). **Stage 3**, Prototype Development and Testing: Validating the EEG-Driven Control System. **Stage 4**, make exact wheelchair and use and benifitis of our product .

2) Stage 1

Understanding BCI and EEG: The Foundations of Mind-Controlled Wheelchair Technology

2.1 BCI(Brain-computer interface)

Brain-computer interfaces (BCI) are devices that create a direct communication pathway between a brain's electrical activity and an external output. Their sensors capture electrophysiological signals transmitted between the brain's neurons and relay that information to an external source, like a computer or a robotic limb, which essentially lets a person turn their thoughts into actions.

BCI is a computer-based system that obtain brain signal that can be controlled by EEG "electroencephalography" which is an electrophysiological process to archive the electrical activity of the brain. A BCI system recognize users to grant their determination by study their brain signals. this technology is very helpful for paralyzed and disabled person they can easily moves wheel chair in any direction. The main objective of using this sensor because this sensor is portable and easy to use, old type EEG sensors are not portable and take more time to start for obtaining the data but Neurosky sensor more beneficial rather than old type EEG sensor. This prototype project deals the interfacing between brain and wheelchair with the help of Neurosky sensor or EEG technology.

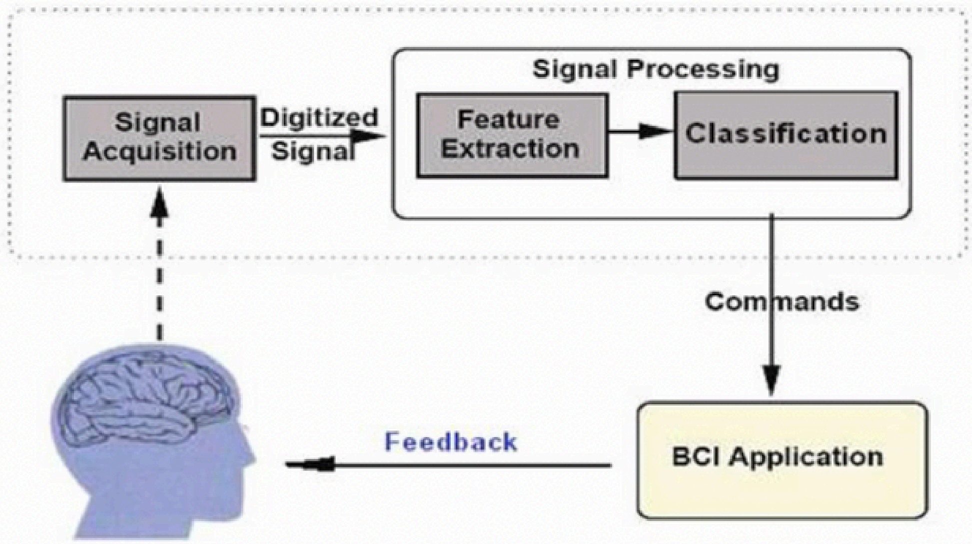


Figure 1. Brain Computer Interface System.

Signal acquisition involves capturing and processing ionic electrical signals produced by neurons in the brain. There are two primary methods for acquiring these signals:

- Invasive Acquisition: This method involves implanting electrodes directly into the brain tissue through surgery. While providing high-quality signals with minimal delay, this approach has drawbacks such as the potential unreliability of electrodes within the brain and ethical concerns associated with invasive procedures. Eg. Neuralink

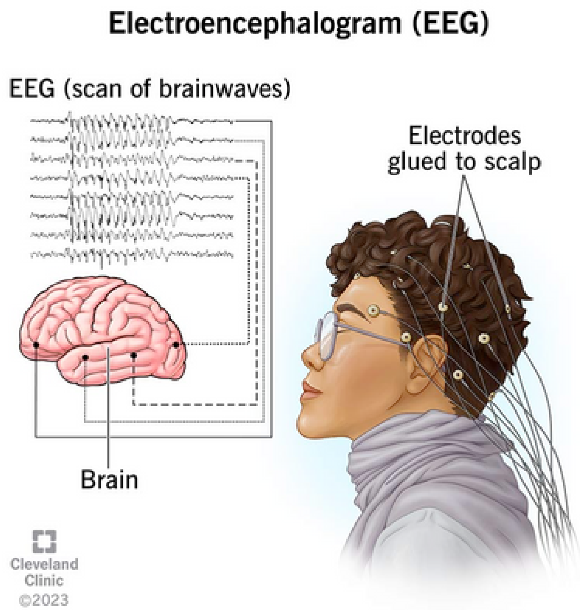
- Non-Invasive Acquisition: Unlike invasive methods, non-invasive techniques gather electrophysiological signals from the scalp. The electroencephalogram (EEG) is a popular choice due to its simplicity and compatibility with Brain-Computer Interface (BCI) systems.

The classification of brain waves can be somewhat challenging due to the continuous capture of signals from multiple scalp electrodes. However, these waves are typically categorized as follows:

i) Alpha Waves: 8Hz to 13Hz, voltage: 5μV to 30μV. Generated during idle brain states.
ii) Beta Waves: 13Hz to 30Hz, voltage: ~30μV. Associated with active thinking and problem-solving.
iii) Theta Waves: 4Hz to 7Hz, voltage: ~20μV. Produced during stress, emotional tension, or meditation.
iv) Gamma Waves: Frequency exceeds 35Hz, associated with conscious brain states.
v) Mu Waves: 8Hz to 12Hz. Typically observed during motor activities.

2.2 EEG(Electroencephalogram)

An EEG (electroencephalogram) is a test that measures your brain activity. Healthcare providers order EEGs to diagnose conditions that affect your brain. An EEG test measures the naturally occurring electrical activity arising from your brain. During an EEG test, a technician places small metal disks (electrodes) on your scalp. The electrodes attach to a machine that monitors the electrical signals that your brain cells (neurons) make to communicate with each other. Monitoring that communication shows how well the different areas of your brain are working.



How does an EEG work?

An EEG works by measuring the electrical signals or impulses that travel between your brain cells. EEGs track those signals by using electrodes that attach to wires that sense electrical impulses.

The electrodes:

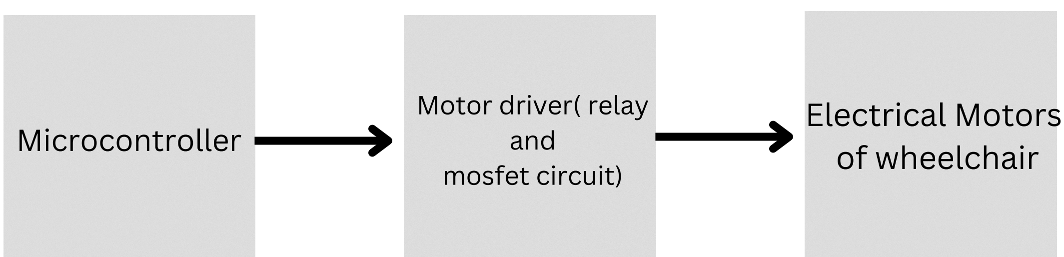
1. Send information about the signals to an EEG machine.
2. The EEG machine records brain waves and generates a visual output in the form of waveforms (traces) on a computer screen that recreate the pattern of brain activity recorded.
3. Your brain wave patterns change when you're awake, asleep or if something affects your brain cells.
4. The image on a computer screen is your EEG.
5. Your healthcare provider will review your EEG for abnormal patterns.

Stage 2

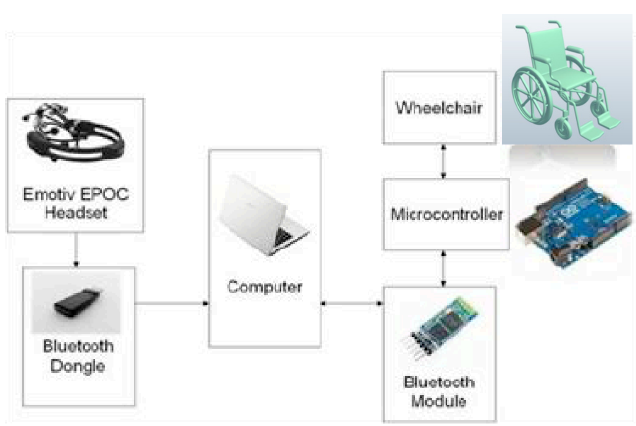
Implementation and Integration: Building the Mind-Controlled Wheelchair with Arduino and Custom Code (Methodology).

3.1 METHODOLOGY

This project necessitates an electric wheelchair, which is constructed entirely from the ground up. The design involves creating custom electronic circuits to manage the wheelchair's motor. These circuits incorporate both a microcontroller and a motor driver.



Electrical Board Connection in Electrical Wheelchair System



Here we are using **Emotiv EPOC** for collecting signals from brain .

The Emotiv EPOC headset is equipped with 14 sensors distributed across the head, while the Mindset device features a single sensor positioned on the forehead. The multi-sensor array of the Emotiv EPOC allows it to measure signal strength from various regions of the brain, providing a comprehensive view of brain activity. In contrast, the Mindset's solitary sensor can only capture EEG signals from a specific area, limiting its monitoring capability.

As a result, the Emotiv EPOC delivers more precise and detailed data compared to the Neurosky Mindset. Additionally, its ability to track overall brain activity patterns is particularly advantageous for this project, as it facilitates the identification of distinct mental commands generated by the user. Consequently, the Emotiv EPOC is the preferred EEG device for our mind-controlled wheelchair project.

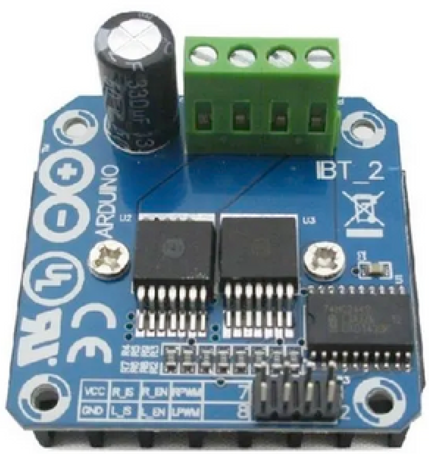
3.2 HARDWARE

1) Wheelchair: here is a prototype design of a wheelchair

2) Motors:

To effectively power the wheelchair with a person on board, high torque motors are essential. Consequently, scooter motors are selected to propel the rear wheels of the wheelchair. These motors operate at a maximum voltage of 24V DC and have a power rating of 250W. They can achieve speeds up to 3000 rpm and have a rated torque of 0.80 Nm, drawing a maximum current of up to 13.4A.

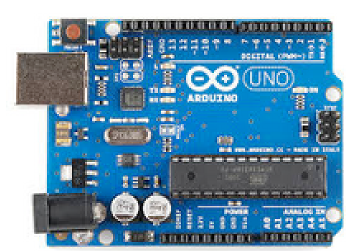
3) High Current Motor Driver:



Given the high current demands of the scooter motor, a motor driver capable of handling substantial current is necessary. Since the scooter motor can draw up to 13.4A, the motor driver must have a current rating that exceeds this maximum. The selected motor driver meets these requirements, supporting voltages from 12V to 30V DC, with a peak current capacity of 160A and a continuous current capacity of 60A. This makes the motor driver highly suitable for operating the scooter motor used in the wheelchair. Figure 5 illustrates the high current motor driver.

4) Arduino Uno:

The Arduino Uno microcontroller board utilizes the ATmega328P microcontroller IC, which features 14 digital I/O pins and 6 analog inputs. Out of these 14 digital I/O pins, 6 can be configured as PWM outputs. The board operates with a 16 MHz quartz crystal and includes a voltage regulator IC, supporting an input voltage range from 6 to 20V. The board measures 68.6 mm x 53.4 mm.



This microcontroller board is chosen for its adequate number of I/O pins needed to control the electric wheelchair. The wheelchair design incorporates 4 switches as inputs, and the motor driver requires 4 digital output pins and 2 PWM pins for control signals. Thus, 4 analog pins are allocated for input switches, while 4 digital output pins and 2 PWM pins manage the motor driver. Additionally, the board's compact size makes it easy to mount on the wheelchair. It also features plug-and-play functionality, requiring only a USB type B cable for programming and serial interface purposes. Figure 6 illustrates the Arduino Microcontroller Board used as the primary controller for the electric wheelchair.

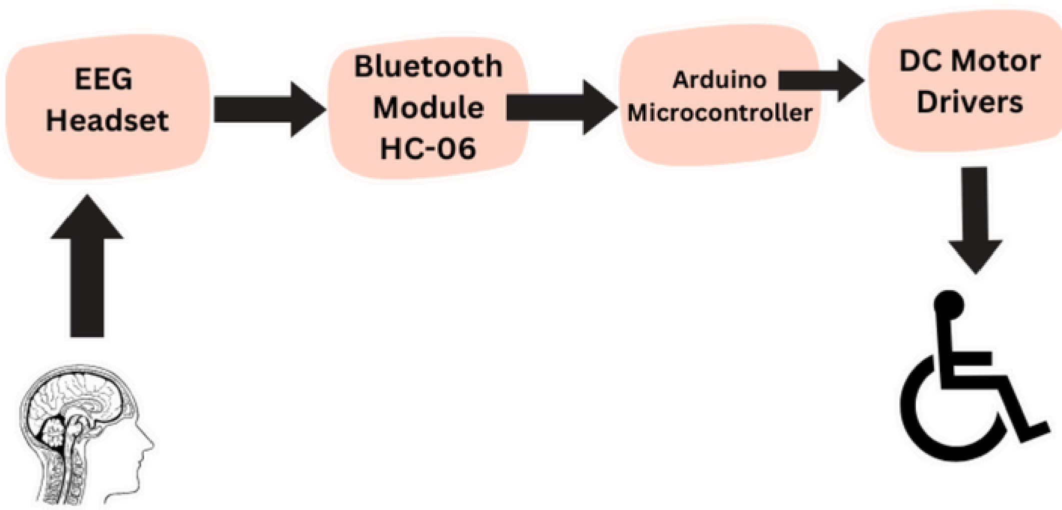
5) HC-06 Bluetooth Module :

For this project, the HC-06 Bluetooth module is employed as the wireless communication component. The HC-06 is a Bluetooth serial module that converts serial port data into Bluetooth signals, utilizing the Serial Port Protocol (SPP). It operates on a 2.4 GHz radio transceiver and baseband, and supports low power operation with an I/O voltage range of 1.8 to 3.6V. One of its notable features is the ability to auto-connect to the last paired device upon powering up.
The HC-06 module is interfaced with the Arduino Uno microcontroller, enabling the wheelchair's control system to receive command signals wirelessly from a PC or smartphone. Figure 7 depicts the HC-06 Bluetooth module.

6) Emotiv EPOC Headset:

The Emotiv EPOC headset, developed by Emotiv, is a high-resolution, multi-channel portable EEG device designed for brain-computer interface (BCI) applications. It features 14 electrodes, the highest number among commercial EEG devices, to capture brain signals. The device uses a single ADC with sequential sampling at a rate of 128 samples per second. It is equipped with digital 5th order Sinc and notch filters at 50Hz and 60Hz.

Powered by a rechargeable LiPoly battery, the headset offers up to 12 hours of use and connects wirelessly via Bluetooth. The Emotiv EPOC translates EEG brainwaves into comprehensible metrics using various detection suites. These suites include facial expression detection, performance metrics, and mental commands. The facial expression detection suite identifies real-time facial movements, while the performance metrics suite monitors the user's emotional states and mental conditions. The mental command detection suite interprets the user's thoughts and intentions into commands such as push, pull, left, and right, making it particularly valuable for controlling the movement of an electric wheelchair.

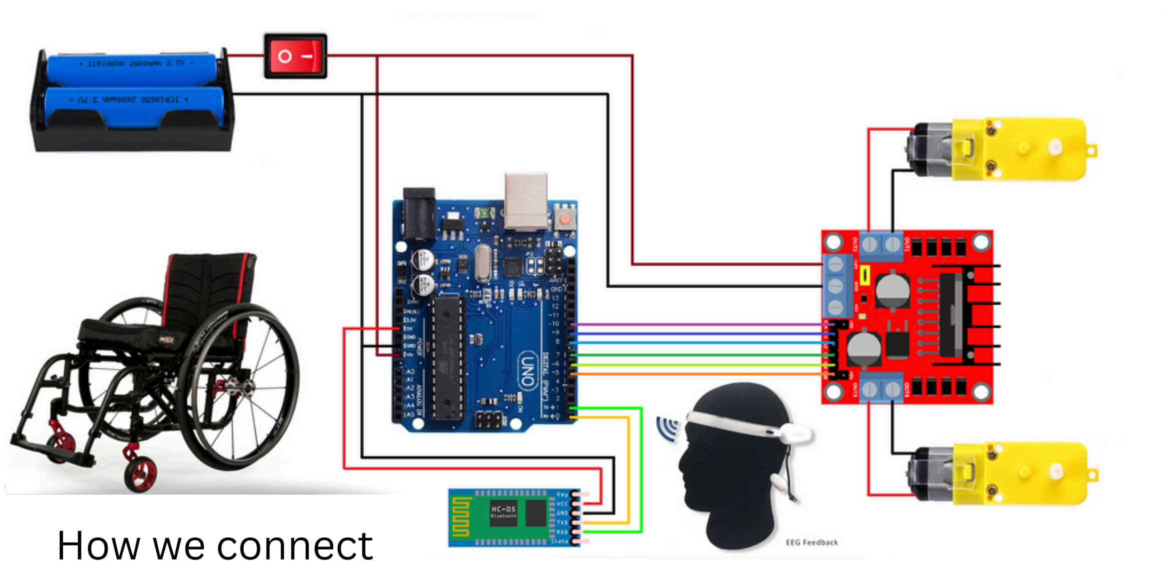


Stage 3

Prototype Development and Testing: Validating the EEG-Driven Control System.

We are here building a prototype instead of an actual mind-controlled wheelchair because building the actual one would take time and budget is also an issue. So, for now, we'll try it out on the prototype and later we'll continue with this project and build the actual one.

below I am showing connection for our prototype :



How we connect our circuit

Link of Code for Arduino Uno: https://bit.ly/44GHYZy

Stage 4

make exact wheelchair and use and benifitis of our product .

- For now, we have created the prototype, but we will continue with this project and build the actual chair as per the methodology we have outlined.

Conclusion and Future Work

Current Status and Result:

We're working on a mind-controlled wheelchair project and we're currently at stage 4, which is the final stage. In stage 3, we've completed the prototype where we've joined and made all the necessary connections and code. However, when we were testing it with the EEG headset, we encountered several problems. The EEG headset provided by our college hasn't been used for four years, so it wasn't functioning properly. Before purchasing a subscription for the EEG headset, we were training it on the BCI website, but it was only giving a 17% contact rate, whereas the EEG quality only giving 8%. Due to the poor quality of the EEG headset, we could not continue the project as it wouldn't function correctly with this EEG headset.

In the future, our project aims to finalize the development of our mind-controlled wheelchair, ensuring that it is fully functional and user-friendly for individuals with paralysis. Our goal is to provide a seamless and efficient mobility solution, allowing paralyzed individuals to navigate their environment with ease and without encountering any difficulties.