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Brain Controlled Wheelchair with Obstacle Detection

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ABSTRACT
Globally, millions of people with mobility limitations need cutting-edge assistive technology. Traditional powered wheelchairs are difficult for wheelchair users to use, which raises safety concerns. In order to solve this, scientists are creating brain-controlled wheelchairs with the use of cutting-edge robotics, sensor, and artificial intelligence technology. Brain-computer interfaces, or BCIs, allow the brain and gadgets to communicate in real time. When compared to standard EEG sensors, portable EEG headsets—like those based on Neurosky —offer a more affordable and user-friendly option that improves accessibility and efficiency with an accuracy of 92%.

KEYWORDS
Brain-Computer-Interface (BCI), Electroencephalography (EEG), wheelchair, brain signal

1. INTRODUCTION

In the modern world, robots are already necessary components in both industrial settings and people's ordinary life. They provide crucial assistance to individuals with disabilities as well; the development of brain-controlled wheelchairs is a significant step toward the general integration of robots into daily life. Wheelchairs can be easily used by able-bodied people with standard controls such as keyboards and joysticks, but people with poor muscular control have major challenges. Although other approaches, including eye tracking, have been proposed, they have drawbacks. The creation of Brain-Computer Interface (BCI) systems has arisen as a response to these difficulties, offering a novel strategy that controls physical equipment and communication devices by directly interacting with the human brain [1-2]. In general, there are two types of BCI techniques: invasive and non-invasive approaches. Brain signals are captured by invasive methods that make use of implanted electrodes that make direct contact with the cortex of the brain. On the other hand, non-invasive methods entail applying electrodes to the scalp. The formation of brain wave is shown in Fi. 1.

This project's main objectives are to use MATLAB software to gather and handle EEG signals from a non-invasive BCI device (Neurosky Mindwave).

· Dividing the EEG signals into four basic movements while considering both visible and invisible user input representations.

· Creating a smart wheelchair that is controlled by brain waves and evaluating EEG signals to calculate the average and peak values of concentration and meditation

Electrodes are sensors used by EEG researchers to capture brain activity electrically. There are two types of electrodes: invasive and non-invasive. The role of electrodes are non-invasive and can be utilized further classified as dry or wet [3]. Some EEG equipment that is widely used to record brain activity has electrode sensors. The commercialized market offers a variety of portable EEG equipment, including wired and wireless [4-5]. Open BCI, Enobio, Open EEG, Mattel Mindflex, Neurosky Mindwave, Muse, and Emotiv EPOC are a few of the well-known gadgets. The purpose of the paper is to describe the development of an intelligent wheelchair that runs on the human brain, assisting people with disabilities in obtaining autonomous `obstacle avoidance system

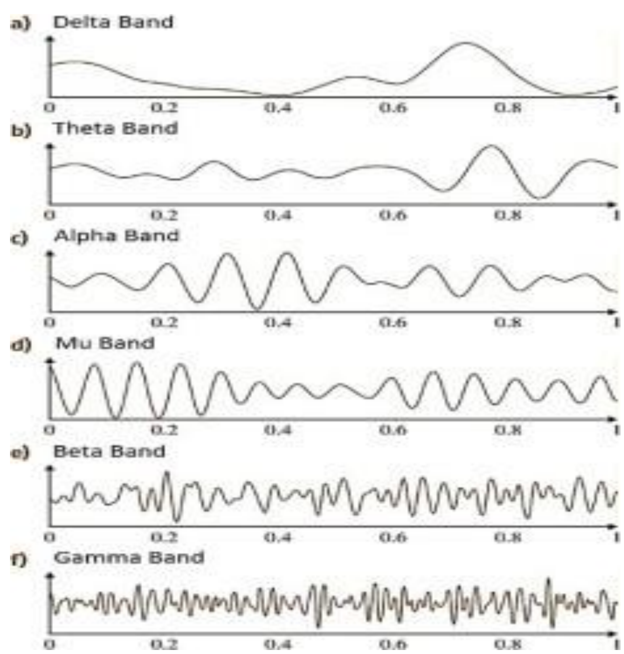


Fig. 1 Brain Waveforms

, the goal is to provide a safe, affordable, and cosy choice that can be widely adopted in society—especially in domestic settings. Furthermore, the proposed system empowers users by enabling smooth transitions between brain-based, joystick, or remote control wheelchair mechanisms via an Android tablet [6-8].

Table 1.EEG frequency bands

Waves	Frequency bands (Hz)	Behaviour Trait	Signal Waveform
Delta	0.3 – 4	Deep sleep	
Theta	4 – 8	Deep Meditation	
Alpha	8 – 13	Eyes closed, awake	
Beta	13 – 30	Eyes opened, thinking	
Gamma	30 and above	Unifying consciousness	

2. METHODOLOGY

The suggested system aims to develop a complex wheelchair featuring three different control modes. While joystick and remote control are used as additional controls, where brain act as the primary means of controlling. The three modes each function separately, giving users the freedom to change wheelchair control whenever it's most convenient for them. Every control mode has an ultrasonic sensor-based safety system to improve safety and guarantee the user's security and dependability of the wheelchair [9-10]. The basic framework of the proposed designed is shown in Figure 2.

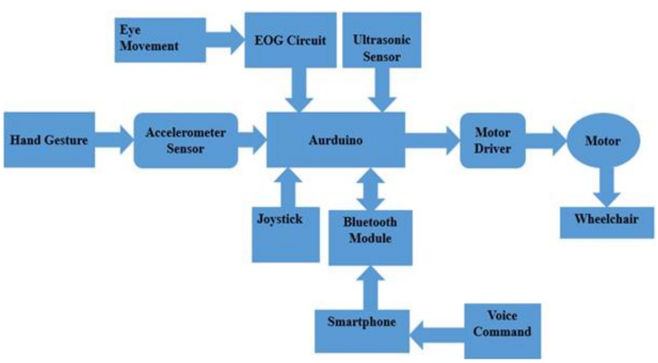


Fig. 2 Proposed System

2.1. Main System of Control

The main method of controlling a wheelchair is thought to be brain control. It includes using a Mindwave mobile headset to acquire EEG data. The platform utilized to gather the EEG facts supplied using wirelss headgear is an Android-based smartphone. The Android Development Toolkit, which Nessky provides, is used to create the application based on android [11]. It is intended to detect the intensity of attention and determine the strength of eye blinks. The application uses the Bluetooth connection the desired protocol to wirelessly gather EEG data signals achieved by headset and then delivered the desired output. With the help of this integration, the application and wireless headset may communicate with ease, allowing for the extraction of useful information like attention spans and eye blinks [12-13].

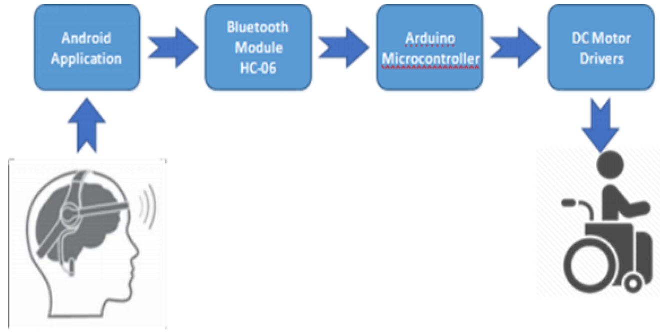


Fig. 3 BCW using mindwave headset

The suggested system's objective is to gather and recognize EEG signals associated with the user's intention to control the wheelchair. The general block diagram of the suggested system is displayed in Figure 3.

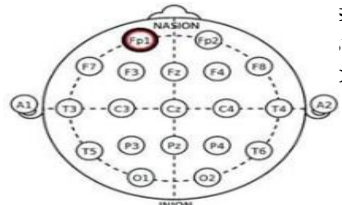
2.2. System for EEG Acquisition

The suggested work utilizes a wireless headset, that minimizes the cost and grant the wheelchair to operate in all the four directions [14-15]. Table 2 contains the EEG headset's technical specifications.

Table 2. Neurosky headset technical specification.

Manufacturer	Neurosky
Channels	1
Type of electrodes	Dry
Rate of sampling	512HZ
Utilization of BW	3-100HZ
Exchange technology	Bluetooth
Battery life	8 hours
Mass	90 grams

The Mindwave headset used for EEG acquisition is depicted in Figure 4(a). One dry electrode on the FP1 frontal lobe of the ; utilized to record EEG activity uch as attention and eye blinks osition is displayed in



in (a) (b)

Fig. 4. Neurosky mind wave Headset (a) and electrode placement at FPl (b).

A proprietary algorithm built inside the android-based smart phone is used to analyse and process brain signals that were obtained from the FP1 position using the Bluetooth-enabled EEG headset.

2.3. The scheme of secondary control

The device has two controls: an Android-based remote control and a joystick. The primary control uses electroencephalography (EEG) to navigate a wheelchair. Through the use of an Arduino microcontroller, both side axis (XY) module joystick that interacts with moits to activate wheelchair users to manoeuvre the device using physical input. Concurrently, a smartphone application for Android has been created to provide wheelchair remote control through the touchscreen interface of the device. Five different commands can be transmitted with the help of this Android-based remote-control application: left, right, forward, backward, and stop. This is accomplished by creating a smooth connection between the Android phone and the microcontroller via Bluetooth communication. Because the joystick and remote-control choices are integrated, users have flexible and accessible ways to use the wheelchair based on their needs and preferences.

2.4. Safety System

The fundamental focus of electric wheelchair design is safety, with a key goal of minimizing collision risks and guaranteeing user safety [18-19]. The wheelchair has four ultrasonic sensors positioned thoughtfully on each side to help with this worry. These sensors work on the basis of ultrasonic beams: an ultrasonic beam is emitted by the sensor in the direction of the target location, and it returns to the sensor after encountering an obstruction. The device evaluates the length by evaluating the cost of time for the beam to reach destination and rerun back. Such estimated distance is an essential component of the safety system, helping to improve the wheelchair's overall safety by detecting and avoiding obstacles.
There is also a buzzer included for safety point of view and get automatically function by sensors. when they detect obstructions, or manually by pressing a button to turn it on like a horn.

3. DESIGN FLOW

The flow of system discussed here associated with brain operated wheelchair with its operations as shown in Figure 5. The wheelchair is operated by means of eye blinks activated by the user and alert span. The directions of cycle in is indicated by LED in every two second of duration using LED and act as a direction panel and within the mobile application. Any person can select a suitable direction by blinking twice in quick succession [20]. Consequently, to increase focus, the user must continue to pay attention. When this level reaches a predetermined threshold—60 in our case, for example—the wheelchair starts moving in the designated direction. This technique guarantees an easy-to-use and intuitive interaction where the wheelchair reacts to the user's focused eye motions and persistent.

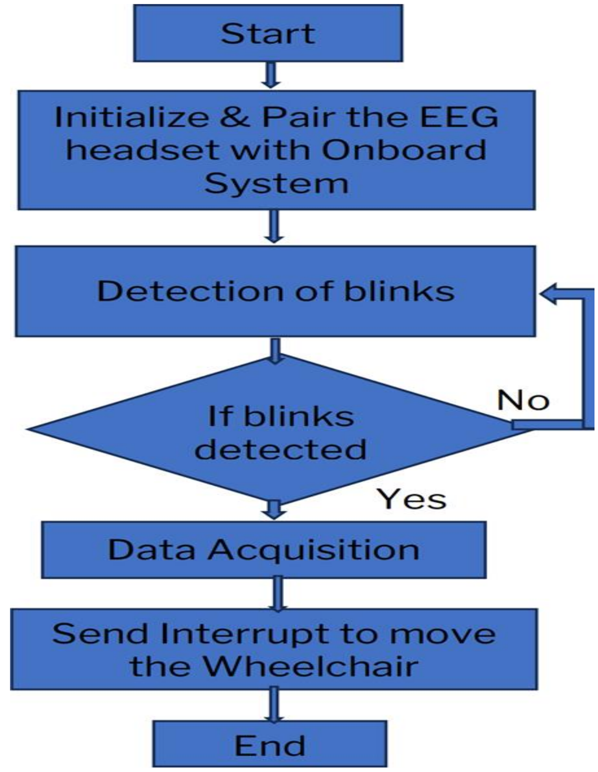


Fig. 5 Complete flow of automated wheelchair

The first step involved for the proper designing of this wheelchair is to use a Neurosky Mindwave sensor to collect brainwave data. A microcontroller or processor processes these signals to extract relevant information like frequency and amplitude. These traits are then translated into useful commands by a command generation module, which governs the direction and motion of the wheelchair. The wheelchair's motors are driven by signals that are received by the Motor Control Unit, which translates them into commands and allows for direct association with the user's brainwave signals [21]. Obstacle-detection sensors could be included for increased safety. Users interact with the wheelchair through real-time feedback systems, which are largely triggered by thoughts recognized by the Mind Wave sensor. Based on user behaviour, adaptive control techniques can further enhance the system. This thorough design process guarantees an easy-to-use.

4. RESULTS

At several stages, the smart wheelchair's features are assessed. Below is a description of the operational outcomes for every feature.
Five trials in all were carried out to assess the wheelchair's functionality. The verification to assure the viability of brain dependent wheelchair involved five healthy individuals. The successful and unsuccessful trials that each of the five subjects completed are displayed in the Fig. 6, Fig. 7, Fig. 8, Fig. 9 and Fig. 10

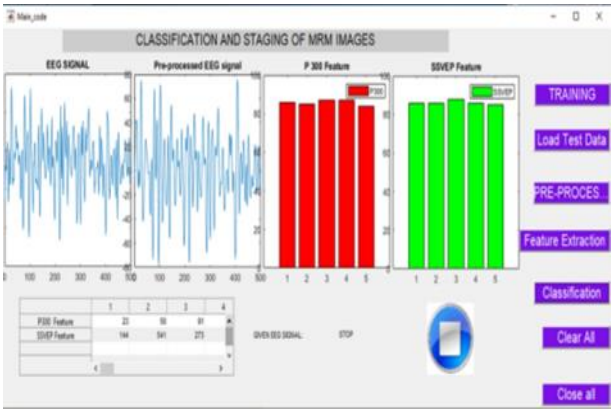


Fig. 6 EEG Signal Classification When Thinking stop

Fig. 7 EEG Signal Classification When Thinking right

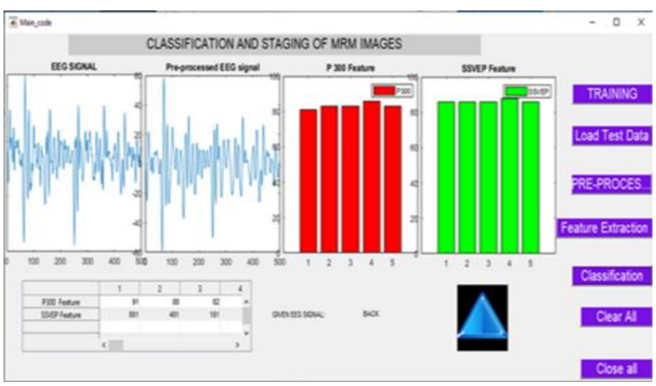


Fig. 8 EEG Signal Classification When Thinking forward

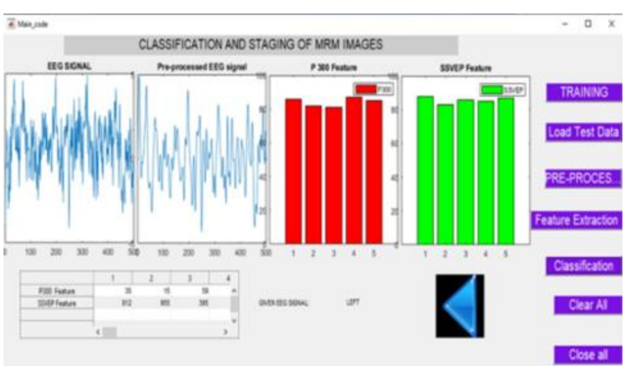


Fig. 9 EEG Signal Classification When Thinking Left

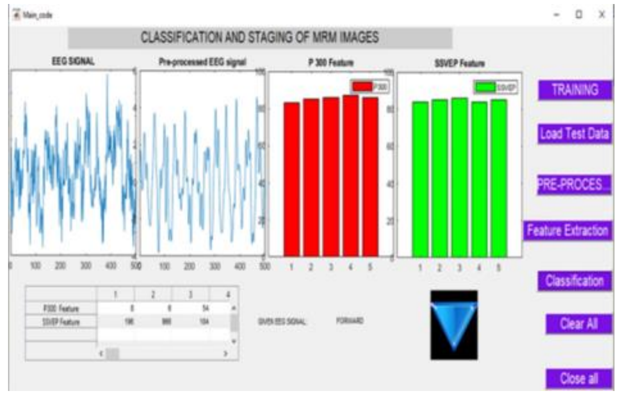


Fig. 10 EEG Signal Classification When Thinking backward

The findings demonstrate that the subjects in the forward group achieve the highest accuracy (i.e., 92%). However, the accuracy in the left, right, and backward directions is 84%, 80%, and 76%, respectively.

5. CONCLUSION

Narosky's Mindwave Mobile headset is utilized to construct a reliable and affordable Brain-Computer Interface (BCI) wheelchair that records EEG signals from FP1. Using Narosky's Android Development Toolkit, the companion Android app extracts feature for Blink Strength and Attention. These characteristics form the basis of wheelchair control, which cycles in four directions every two seconds and requires a double blink to select. When the user's focus reaches sixty after direction lock, the app measures it and uses Bluetooth to transmit a command to a microcontroller that steers the wheelchair motion. The precision of wheelchair, limited by the steadiness of the EEG signal, is 83%. Four ultrasonic sensors are integrated into the wheelchair's safety system, which triggers an immediate stop buzzer upon obstacle detection. The wheelchair has two additional control modes in addition to basic brain control: joystick and smartphone remote control via Bluetooth. To guarantee dependability and user safety, the safety system is interfaced with both primary and secondary controls, with the secondary controls attaining 100% accuracy.

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