IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.021 ⁙ Peer-reviewed & Refereed journal ⁙ Vol. 12, Issue 4, April 2024

DOI: 10.17148/IJIREEICE.2024.12425

# BRAINWAVE CONTROLLED MINIATURE WHEELCHAIR USING BCI TECHNOLOGY

**Theodore Jesudas Dandin [1], Navyashree S [2], Suchithra M [3] , Yashu K [4]**

Professor, Department of Electronics and Communication, APS College of Engineering, Bangalore, India[1]

Department of Electronics and Communication, APS College of Engineering, Bangalore, India [2]

Department of Electronics and Communication, APS College of Engineering, Bangalore, India [3]

Department of Electronics and Communication, APS College of Engineering, Bangalore, India[4]

**Abstract**: Brain-Computer Interface (BCI) serves as the pathway of communication between the brain and any other external entity. It’s an emerging field and has its applications in various industries including bio-medicines. EEG-based Brain-Computer Interfaces (BCIs) can lead individuals with significant health challenges to improve their independence, facilitate participation in activities, thus enhancing overall well-being and preventing impairments. The Electroencephalographs (EEG) or brainwaves are captured and analyzed using Mind-wave mobile headset to yield Attention, Meditation and Eye Blink Strength.

**Keywords**: Brain-Computer Interface (BCI), EEG, Bio-medicine, Health challenges, prevent impairments, Electroencephalographs, Mind wave Headset, Eye blink strength.

## I. INTRODUCTION

The paralysed patient or patients who are suffering from severe physical disabilities have their limited motion in environment. The Human brain consists of billions of neurons which are interconnected. Human brain control of wheelchairs for physically disabled people has attracted great attention due to their convenience and relatively low cost, high mobility, and quick setup. It generates electrical charges during its working. These charges sum up together to generate an electric field having varying potentials of the order of microvolts. The electrical activity of the brain can be recorded from the scalp. The measurement of human brain signals and converting them into control signals require the development of an interface between the brain and the computer. A brain-computer interface (BCI) system provides communication between computer and mind of pupils. These recordings are known as Electroencephalogram (EEG). In EEG techniques electrode caps are placed on the subject's scalp to obtain signals which hold direct or indirect potential difference of scalp and the actions. The classification of EEG signals is done in the following bands: $\alpha$, $\beta$, $\delta$, $\theta$, and $\gamma$. This interface can be based on brain activity during muscular movements or the changes of the rhythms of brain signals. BCI transforms the EEG signals produced by brain activity into control signals which can be later used for controlling the wheelchair without using any physical controls. Since the brain signals are very weak, we need to apply amplifiers and some spatial and spectral filters to the EEG signals in order to extract the features of these signals. The detected EEG signals are based on the change of frequencies and change of amplitudes. For example, during voluntary thoughts, the frequencies of signals change, and during movement, synchronization/desynchronization of brain activity which involves $\mu$ rhythm amplitude change happens. This relevant characteristic makes rhythm based BCI suitable to be used.

In this paper we describe the overall robotic architecture of our brain–actuated wheelchair. We begin by discussing the brain computer interface, since the human is central to our design philosophy. Then, the wheelchair hardware and modifications are described, before we explain how the shared control system fuses the multiple information sources in order to decide how to execute appropriate manoeuvres in cooperation with the human operator. We find that our continuous control approach offers a very good level of performance, with experienced BCI wheelchair operators achieving a comparable performance to that of a manual benchmark condition.

## II. LITERATURE SURVEY

Smart wheelchairs play a significant role in supporting disabled people. Individuals with motor function impairments due to some disorders such as strokes or multiple sclerosis face frequent moving difficulties. Hence, they need constant support from an assistant. This paper presents a brain-controlled wheel-chair model to assist disabled and paralysed patients.

DOI: 10.17148/IJIREEICE.2024.12425

The wheelchair is controlled by interpreting Electroencephalogram (EEG) signals, also known as brain waves.In the EEG technique, an electrode cap is positioned on the user’s scalp to receive EEG signals, which are detected and transformed by the Arduino microcontroller into motion commands, which drive the wheelchair. The proposed wheelchair is implemented using an Arduino-based robot controlled by a human brain wave using a Brain-Computer Interface (BCI). The human brain wave is captured using a low-cost Neuro sky Mind Wave headset. The proposed wheelchair has the potential to have an immense effect on the healthcare industry. The use of this brain-controlled wheelchair can improve the quality of life of a paralysed patient [2].

EEG has been largely used in both clinical and research applications. Brain computer interface (BCI) system is one of the major EEG research applications which can provide a new way of communications for special users who cannot communicate via normal pathways. This paper focuses on the development of the brain controlled wheelchair which incorporates two additional control interfaces including joystick and a remote control through an android phone. All three controls are integrated in such a way that it allows the user to change the mode of control by simply changing the state of the slide switch. This work utilizes the Neurosky Mindwave Mobile headset to capture the EEG signals through a single channel placed at the FP1 position. Eye blinks and attention levels are the key features of the captured EEG that are extracted and identified through an android application. The design also assimilates ultrasonic sensors based safety system which is capable of detecting the obstacles in all four directions to ensure the safety of the user [3].

## III. BCI INTERFACE

### A. BCI Architecture

Brain-computer interface (BCI) systems have a fundamental three-stage architecture:

- **Signal Acquisition:** This stage involves capturing brain activity using various methods, primarily electroencephalography (EEG) in non-invasive systems. Invasive BCIs directly implant electrodes within the brain, offering higher resolution but with increased risks.

- **Signal Processing:** The raw brain signals are often noisy and complex. This stage involves filtering, feature extraction, and classification algorithms to extract relevant information and identify specific patterns related to the user's intent.

- **Command Generation and Application:** The processed signals are then translated into control commands. These commands can be used to interact with external devices, like robotic limbs, virtual environments, or computer software, based on the intended application.

This basic framework allows BCIs to bridge the gap between brain activity and real-world interaction, offering new possibilities for communication, rehabilitation, and control for individuals with disabilities and other potential applications.

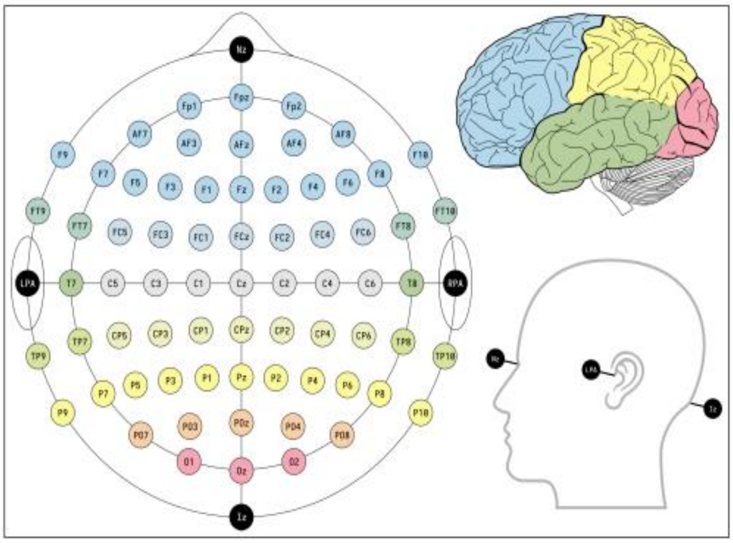

Fig. 1 EEG Electrode System

ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.021 ⁑ Peer-reviewed & Refereed journal ⁑ Vol. 12, Issue 4, April 2024

DOI: 10.17148/IJIREEICE.2024.12425

• **Scalp locations:** The image shows a human head with a schematic representation of the scalp, including the frontal, temporal, parietal, occipital, and central lobes.

• **Electrode labels:** There are 21 electrode sites labeled with letters (Fp1, Fp2, F7, F8, ...) according to the international 10-20 system. These labels indicate the placement of electrodes used in EEG recordings to measure electrical activity in the brain.

• **Reference points:** The image also shows two reference points, A1 and A2, located behind the ears. These points are used as a reference for measuring voltage during EEG recordings.

B. Brainwave Classification

Based on frequency brainwaves are classified into the five bands as:

• **Alpha Waves:** When a person is closing his/her eyes or is in a relaxed condition then alpha waves are produced. The frequency range of these waves is 8*Hz* to 12*Hz*. Alpha waves aid the state of meditation, calmness and learning and were first observed by Hans Berger.

• **Beta Waves:** The beta waves are dominant when a person is in the state of alertness or engaged in some problem solving or is in the process of decision making. The frequency range of beta waves is 12*Hz* to 30*Hz*.

• **Theta Waves:** Theta waves are delivered when a person is in the state of deep meditation or is sleeping. These are low-frequency waves. Their frequency range is 4*Hz* to 7*Hz*. Theta waves are responsible for memory and intuition. Theta waves are active during dreaming also.

• **Delta Waves:** Delta waves are generated when a person is in the deepest meditation or dreamless sleep. This state stimulates healing and regeneration. These waves have frequencies between 0.1*Hz* to 3*Hz*. These waves are slow but the loudest waves.

• **Gamma Waves:** These waves are generated during abnormal conditions or some mental disorder. These are the fastest brainwaves. These waves have frequencies greater than 30*Hz*.

The figure 2 is a classification of brain waves according to their frequency. It shows five main categories: delta, theta, alpha, beta, and gamma. Each category is associated with a different state of mind.

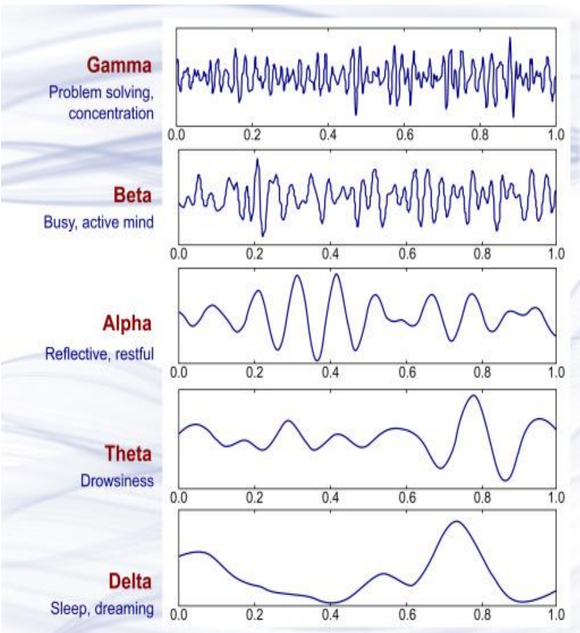


Fig. 2 Classification of Brainwaves

DOI: 10.17148/IJIREEICE.2024.12425

## IV. HARDWARE DESCRIPTION

### I. BRAINWAVE DETECTING HEADSET

This device consists of a headset with an ear-clip and an arm which has a biosensor attached to it (Fig.-1). It offers single-channel EEG electrode (sensor arm rests on the forehead, ground reference are on the ear clip) which safely measures and outputs the EEG power spectrum ($\alpha$, $\beta$, $\delta$, $\theta$, and $\gamma$). These values are analyzed on Think Gear chip to yield the attention/meditation and blink level. Finally, these values are transferred wirelessly to Android/ Mac/ Windows etc. via Bluetooth. The device works on an AAA battery and has around 8 hours of battery life. This device also consists of built-in software/hardware for noise reduction.

### II. WHEELCHAIR

The micro controller process the signals based on the following logic that is Whenever we blink, EEG waves will encounter a peak. This peak value is set as threshold value. If we blink, the output of the ADC goes beyond the threshold value, the Arduino counts it as a blink. The moment we blink; the timer of the microcontroller will start. If we blink a certain number of times in a certain interval of time, the micro controller will enable the relay switches. Depending on which relay switch is provided with the control signal, the respective device turns on. The number of blinks and the interval can be decided by the user.

### III. BATTERY

It is 12V 1.3Ah rechargeable lead acid battery normally used for robots in competition. Seal Lead Acid (SLA) Rechargeable battery is the most common general purpose battery. It uses lead plates and sulphuric acid to generate electricity through a chemical reaction. Relatively low energy density compared to modern batteries, but can provide high surge currents. It is Rechargeable, Recyclable & Is Able to use for most of the 12V controllers, motors or any other appliances.

### IV. H-BRIDGE

H-bridges are commonly used in robotics, but they can also be found in other applications where DC motor control is needed, such as drones, electric vehicles, and conveyor belts. They control the direction of a DC motor by switching the polarity of the voltage applied to it. The circuit consists of four switches that control the flow of current to the motor. By turning on different combinations of switches, the polarity of the voltage applied to the motor can be changed, which determines the direction of rotation. It's crucial to avoid turning on certain switch combinations simultaneously, as this can damage the H-bridge circuit.

### V. ULTRASONIC SENSOR

An electronic device that uses sound waves to measure distance, detect objects, and determine their proximity. The sensor emits high-frequency sound waves (ultrasound) inaudible to the human ear. These sound waves travel and bounce off objects in their path. The reflected sound waves (echoes) are received by the sensor. The sensor measures the time it takes for the sound waves to travel to and from the object. This time is then used to calculate the distance to the object. Doesn't require physical contact with the object being measured. Functions effectively in any lighting environment, including complete darkness. Can detect objects made of various materials, including solids, liquids, and even some gases.

### VI. ARDUINO UNO

The Arduino Uno is a 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 Arduino 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.

### VII. HC-05 BLUETOOTH MODULE

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. Offers a range of around 10 meters (33 ft.).

### VIII. ARDUINO NANO

The Arduino Nano is a compact yet powerful microcontroller board favoured by hobbyists, educators, and professionals alike for its versatility and small form factor. At its heart lies the Atmel ATmega328P microcontroller, running at a clock speed of 16 MHz, with ample memory resources: 32 KB of flash memory for program storage, 2 KB of SRAM, and 1 KB of EEPROM for data retention. Despite its diminutive size, measuring just 18 x 45 mm, the Nano boasts a respectable array of I/O capabilities. It offers 14 digital I/O pins, six of which support PWM output, along with eight analog input pins.

IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526
International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering
Impact Factor 8.021 ⁙ Peer-reviewed & Refereed journal ⁙ Vol. 12, Issue 4, April 2024
DOI: 10.17148/IJIREEICE.2024.12425

### IX. DC MOTOR

A DC motor is any of a class of rotary electrical machines that converts direct current electrical energy into mechanical energy. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current flow in part of the motor. DC motors were the first form of motor widely used, as they could be powered from existing direct current lighting power distribution systems. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings.

### X. GYRO SENSOR

Gyro sensors, also known as gyroscope sensors, are essential components in many electronic devices and systems, providing crucial data about angular motion. Operating on principles of angular momentum, these sensors detect and measure the rate of rotation or angular velocity around one or more axes. They play a vital role in maintaining stability, controlling orientation, and enabling accurate motion tracking in various applications.

### XI. IR SENSOR

Infrared (IR) sensors are electronic devices that detect infrared radiation in the surrounding environment. They work on the principle of detecting changes in the intensity of infrared radiation emitted by objects. IR sensors consist of an IR emitter and an IR detector, typically housed in a single package. The emitter emits infrared radiation, which is then reflected off nearby objects. The detector receives the reflected radiation and converts it into an electrical signal, which can be processed by the sensor's circuitry. IR sensors are commonly used for proximity sensing, object detection, and motion detection applications due to their ability to detect the presence or absence of objects without physical contact.

### XII. LCD DISPLAY

A liquid-crystal display (LCD) is a flat-panel display or other electronically modulated optical device that uses the light-modulating properties of liquid crystals combined with polarizers. To establish a good communication between human world and machine world, display units play an important role. And so, they are an important part of embedded systems. Display units - big or small, work on the same basic principle. Besides complex display units like graphic displays and 3D displays, one must know working with simple displays like 16x1 and 16x2 units. The 16x1 display unit will have 16 characters and are in one line. The 16x2 LCD will have 32 characters in total 16 in 1st line and another 16 in 2nd line.

## V. BCI IMPLEMENTATION

Figure 3 depicts BCI based control of the wheelchair. BCI system consists of a Brainwave detecting headset connected to a computer. Brainwave detecting sensors supply information to the computer. The computer runs the signal processing and classification algorithms and is connected to a microcontroller that controls the movement of the wheelchair. The wheelchair can move in four directions.

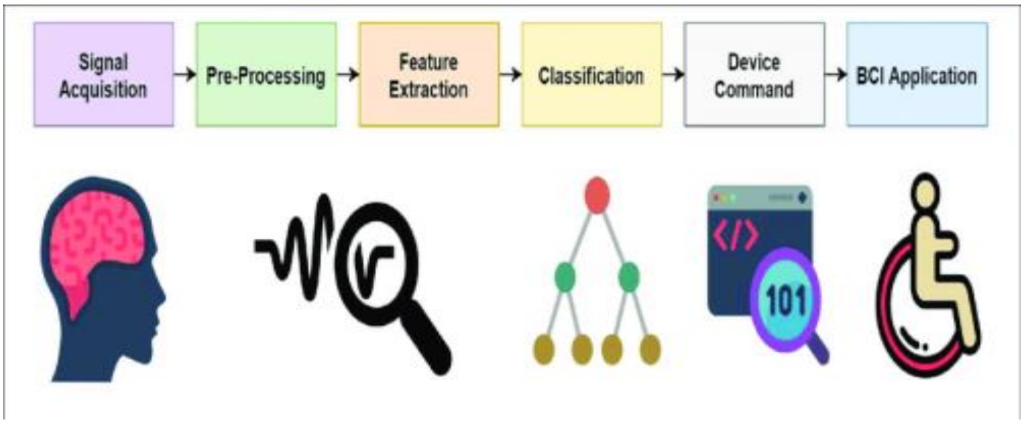


Fig. 3 Block Diagram of BCI Implementation

The speed of the wheelchair is taken as constant and the wheelchair can be switched on and off in the case of necessity. Taking into account the abovementioned functionality, the BCI system uses the following commands: move forward, move backward, turn left, turn right, and turn on and turn off the switch. A BCI based control system is usually composed of five main units: signal acquisition unit, signal preprocessing unit, feature extraction unit, classification unit, and action unit that controls motors of the wheelchair.

IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.021 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 12, Issue 4, April 2024

DOI: 10.17148/IJIREEICE.2024.12425

In signal acquisition block, the EEG signals are captured using the brainwave detecting headset. EPOC is an EEG headset which supplies 14-channel EEG data and 2 gyros for 2- dimensional controls. Our system uses upper face gestures for actuation commands; since most brainwave detecting sensors are located in the frontal cortex; they are the most reliable signals to detect. The EEG input signals are sent to the signal preprocessing unit for filtering and scaling and sent to the feature extraction block. In this block, the basic features are extracted and sent to the classification system. The classification block processes the input signals and outputs the control instructions. Later, these control instructions are sent to the motors of the wheelchair.

## VI. ALGORITHM

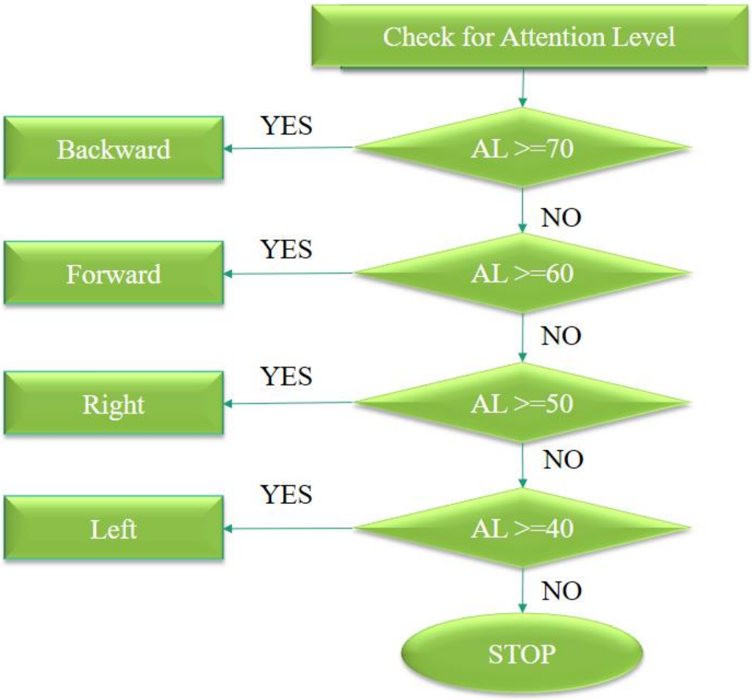


Fig. 4 Working of Proposed System

The figure 4 depicts a system for controlling a wheelchair with attention level. The process starts by checking the user's attention level. If the attention level is high, the wheelchair stops. If the attention level is low, the process moves on to check the direction. The flowchart then checks for specific brainwave patterns associated with moving forward, backward, right, and left. If the user exhibits a pattern associated with moving forward and their attention level is below AL-60, the wheelchair moves forward. If the user exhibits a pattern associated with moving backward and their attention level is high (AL >-70), the wheelchair moves backward. If the user exhibits a pattern associated with moving right and their attention level is below AL-50, the wheelchair moves right. If the user exhibits a pattern associated with moving left and their attention level is equal to or greater than AL-40 (AL >= 40), the wheelchair moves left. If none of the conditions for moving forward, backward, right, or left are met, the wheelchair stops.

## VII. RESULTS AND DISCUSSION

Our project is for the handicap people, paralysed person and all other types of persons that are not able to make any movements or are totally dependent on others.

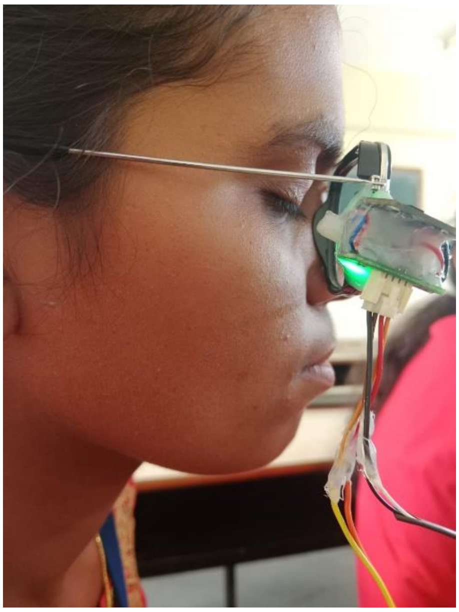

Fig. 5 Sleep Mode

Fig. 6 Hardware setup

## VIII. CONCLUSION

The main objective of our project is to bring mobility back to people who are facing physical disorders and for the paralysed patients who can't move on their own without someone's assistance. The ongoing research and development works in the field of brain controlled robots have received a great attention all over the globe because they can help physically disabled people to move independently. Use of BCI (Brain Computer Interface) technology in human life ensures a comfort zone to a physically challenged people and our project is one among them. We have used Brain sense EEG sensor which is used to capture the EEG signal from the brain. Arduino Uno board is used to control the movement of the wheelchair. Headband used to read and analyse the brain wave data and to generate and send the command to the Arduino board for movement of the wheel chair & ultrasonic sensor is used for obstacle avoidance thereby ensuring the safety of user. Brain-controlled miniature wheelchairs offer promising advancements in mobility and independence for individuals with limited physical control. This technology represents a breakthrough in assistive technology, paving the way for more personalized control interfaces for wheelchairs and other medical devices while acknowledging the exciting possibilities, it's essential to address ethical concerns regarding user privacy, safety protocols, and accessibility of this technology.

## IX. FUTURE SCOPE

In this brain control electronic wheelchair is mainly controlled by thoughts. This wheelchair can be modelled in such a way that it can be easily turn into semi sleeper position to avoid long seating position of the user and to have some relaxation. In this we can use previously invented techniques like stairs climbing, etc. These or more can be proposed in the future scope of the wheel chair. It can be implemented is vehicles which would help a lot in advancing of technology for physically disabled people. This is for a number of reasons, not least that patients tend to take part in fewer sessions per week and generally tire more quickly than healthy participants.

This leads us to another one of the exciting new challenges for the future of such shared control systems. Since each user's needs are not only different, but also change throughout the day (e.g. due to fatigue, frustration etc.), it is not sufficient that a shared control system offers a constant level of assistance. Furthermore, if this assistance is not well–matched to the user, it could lead to degradation or loss of function.

Therefore, we are developing shared control systems that adapt to the user's evolving needs, given not only the environmental context, but also the state of the user. This will allow people to use intelligent assistive devices in their day– to–day lives for extended periods of time.

ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.021 ⋇ Peer-reviewed & Refereed journal ⋇ Vol. 12, Issue 4, April 2024

DOI: 10.17148/IJIREEICE.2024.12425

## REFERENCES

[1]. V.Purushothaman,R.Androse,M.J.Lokesh, S.NawinChander, R.Rajkama, "Head Motion Controlled Wheelchair", International Journal of Recent Technology and Engineering (IJRTE), Volume-7 Issue-6S3 April, 2019.
[2]. Mohammad Monirujjaman Khan et al, "Research and Development of a Brain-Controlled Wheelchair for Paralysed Patients" on 2021.
[3]. Muhammad Ahsan Awais et al, "Brain Controlled Wheelchair: A Smart Prototype"on 2020.
[4]. Pistoia et al, "Navigation of a Brain-Computer Interface Miniaturized Wheelchair in Confined Environments" on 2022.
[5]. Wu et al,"Brain Computer Interface control of a miniature wheelchair using Electroencephalography with a fuzzy logic based Approach" in 2022.
[6]. Liu et al ,"EEG-Based Control of a Miniature Wheelchair: A Pilot Study on Real-Time Feedback and Gaze Interaction" on 2021.