Design of EEG based brain controlled wheelchair for quadriplegic patients

Project/Thesis

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Certification

This is to certify that **Muhammad Faizan Akhtar**, **19MDELE062** and **Muhammad Dawood, 19MDELE063** have successfully completed the final project **EEG based brain controlled wheelchair for quadriplegic patient,** at **University of Engineering and Technology Mardan**, to fulfill the partial requirement of the degree **BSc Electrical Engineering.**

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Abstract

Traditional assistive devices are typically designed for individuals with partial disabilities, such as those who have lost their legs in accidents. These individuals are considered partially special needs as they can operate specially designed machines using joysticks, remote controls, or manual controls. However, these traditional systems may not be suitable for individuals who are paralyzed or who have lost both their hands and legs. To address these challenges, a specially designed system is proposed that uses EEG and EMG (electromyography) signals to control machines without requiring any muscle power or body movement.

To implement and demonstrate this concept, an Arduino-based wheelchair is designed using a Brain-Computer Interface (BCI) and NeuroSky Mind Wave EEG Headset. The wheelchair's movement is controlled by the patient's level of attention, allowing for intuitive control without physical effort. The primary advantage of this smart wheelchair design is its adaptability, as patients can train the machine to respond to their unique brainwave patterns through iterative learning.

The prototype was tested with various patients in different scenarios, achieving over 95% effectiveness in wheelchair movement. This design is highly effective for a wide range of patients, eliminating the need for designing different wheelchairs for different patients' needs. Instead, a single universal design can be commercialized for the benefit of all individuals with mobility impairments

Keywords: Medical Device, EEG, BCI, Neurosky Mind Wave Technology, Quadriplegia, Attention Level, Arduino, Joy stick, Wheelchair

Undertaking

I certify that the project Design of an **EEG-based Brain Controlled Wheelchair for Quadriplegic Patients** is our own work. The work has not, in whole or in part, been presented elsewhere for assessment. Where material has been used from other sources it has been properly acknowledged/ referred.

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We are also thankful to our friends and families whose silent support led us to complete our project.

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Acronyms

BCI	Brain Computer Interface
SPECT	Single Photon Emission Computer Tomography
PET	Positron Emissions Tomography
FMRI	Functional Magnetic Resonance Imaging
MEG	Magneto encephalography
EEG	Electro-Encephalon-Graphy (EEG)
SWMC	Smart Wireless Mind-based Controlled
LCD	Liquid Crystal Display
WSHGWC	Wireless Smart Hand Gesture Wheelchair Control

List of Equations

Equations

For a project involving the design of an EEG-based Brain Controlled Wheelchair for Quadriplegic Patients, the following list of equations may be relevant:

1. EEG Signal Acquisition:
   - $X(t)$ - Raw EEG signal at time t.
   - f_s - Sampling frequency.
   - N - Number of samples.
   - $X[k]$ - Discrete Fourier Transform (DFT) of the EEG signal.
   - $P_X(f)$ - Power spectral density of the EEG signal.

2. Signal Processing:
   - $Y(t)$ - Processed EEG signal at time t.
   - $F_Y(f)$ - Processed EEG signal in the frequency domain.
   - $H(f)$ - Frequency response of the signal processing filter.

3. Classification Algorithms:
   - C - Set of EEG signal classes (e.g., left, right, forward, backward).
   - $P(C_i|X)$ - Probability of class C_i given EEG signal X.
   - $f(X)$ - Feature vector extracted from EEG signal X.
   - w - Weight vector for linear classification.

4. Wheelchair Control:
   - V - Velocity of the wheelchair.
   - D - Direction of the wheelchair.
   - T - Time interval for control signal update.
   - R - Radius of the wheelchair wheels.

5. User Interface:
   - $A(t)$ - User's intent (e.g., turn left, turn right) at time t.
   - $B(t)$ - Brain signal corresponding to user's intent at time t.
   - $G(t)$ - User's gaze direction at time t.

6. System Evaluation:
   - \(E\) - Evaluation metric (e.g., accuracy, sensitivity, specificity).
   - \(N_{TP}\) - Number of true positives in classification.
   - \(N_{FP}\) - Number of false positives in classification.
   - \(N_{TN}\) - Number of true negatives in classification.
   - \(N_{FN}\) - Number of false negatives in classification.

Chapter 1

1.1 Introduction

The human brain is a complex organ made up of approximately 100 billion neurons. These neurons communicate with each other through electrochemical signals, which are responsible for our thoughts, emotions, and actions. When neurons interact, they generate electrical activity. This activity can be measured as brainwaves, which have different amplitudes and frequencies. For example, alpha waves are associated with relaxation, beta waves with alertness, theta waves with deep relaxation or light sleep, and delta waves with deep sleep.

Electroencephalography (EEG) is a technique used to record these electrical signals produced by the brain. EEG devices detect and measure the electrical activity of the brain, providing a window into the brain's functioning. EEG-based Brain-Computer Interfaces (BCIs) utilize these electrical signals to allow individuals to control external devices, such as computers or wheelchairs, using only their thoughts. This technology has the potential to greatly benefit paralyzed patients by enabling them to communicate and interact with the world around them using their brain activity.

Quadriplegia, also known as tetraplegia, is a condition characterized by paralysis or significant impairment in the use of all four limbs and the torso. It is typically caused by an injury to the spinal cord in the cervical (neck) region, resulting in the loss of sensation and motor function below the level of injury. Quadriplegic individuals often require assistive devices such as wheelchairs for mobility. The extent of their mobility impairment can vary depending on the level and severity of their spinal cord injury. This can impact daily activities such as self-care, mobility, and communication.Coping with the challenges of quadriplegia can have a significant emotional and psychological impact on individuals. Support from healthcare professionals, caregivers, and support groups is important for overall well-being. Quadriplegia often requires lifelong care and support. A comprehensive care plan that addresses medical, physical, emotional, and social needs is essential for optimal management of the condition.

A BCI is a communication system that allows individuals to interact with external devices using their brain activity, bypassing the need for traditional neuromuscular pathways. BCIs are particularly valuable for individuals with severe physical disabilities, such as quadriplegia, as they provide a means of communication and control based on brain signals alone. BCIs can be invasive, involving implantation of electrodes directly into the brain, or non-invasive, using external electrodes placed on the scalp to record brain activity. The development of BCIs has the potential to revolutionize assistive technology, enabling individuals to control prosthetic limbs, wheelchairs, or computer interfaces through direct brain signals.

EEG is a non-invasive technique used to record electrical activity in the brain. It involves placing electrodes on the scalp to detect the electrical signals generated by neurons. EEG is particularly useful in BCI applications because it provides real-time monitoring of brain activity with high temporal resolution. EEG signals can be classified into different frequency bands, such as alpha, beta, theta, and delta waves, each associated with different states of brain activity. By analyzing these EEG signals, researchers can decode the user's intentions and translate them into commands for controlling external devices in BCI systems.The integration of BCI and EEG technologies is a key focus area in research and development. This integration involves developing algorithms and signal processing techniques to extract meaningful information from EEG signals for use in BCI applications. Machine learning algorithms, such as deep learning, are often used to classify EEG signals and decode the user's intentions accurately. Improvements in signal processing and machine learning have led to significant advancements in BCI technology, making it more accurate, reliable, and user-friendly.

BCI and EEG technologies have a wide range of applications beyond assistive technology. They are used in neurofeedback, cognitive neuroscience, and brain-computer interface gaming. In clinical settings, EEG is used to diagnose and monitor various neurological disorders, such as epilepsy, sleep disorders, and brain injuries. The development of BCI and EEG technologies continues to advance our understanding of the brain and its functions, paving the way for new and innovative applications in healthcare, communication, and human-computer interaction.

1.2 Statement of the problem

The wheelchair is a pivotal invention that has greatly improved the lives of people with mobility impairments. However, traditional wheelchairs require physical effort to propel, which can be challenging for older individuals or those with limited arm function. This limitation led engineers to develop innovative solutions, such as the hand rotary system similar to a bicycle pedal, to enhance the wheelchair's usability and accessibility for a wider range of users.

These advancements have significantly benefited individuals with various disabilities, including those with locked-in syndrome and Polio. Locked-in syndrome is a condition where a person is conscious but unable to move or communicate verbally due to complete paralysis of voluntary muscles, often caused by conditions like brainstem stroke.

In addition to mobility, advancements in artificial respiration have improved the quality of life for individuals with locked-in syndrome. These developments have led to a growing population of locked-in individuals who can now be more easily integrated into society and lead more fulfilling lives.

Overall, the evolution of the wheelchair and related technologies reflects a broader trend in engineering and healthcare to enhance the quality of life for individuals with disabilities. These innovations not only improve mobility but also contribute to creating a more inclusive and accessible environment for everyone.

1.3 Goals

Certainly! Here are some possible objectives for your Final Year Project (FYP) on the design of an EEG-based Brain Controlled Wheelchair for Quadriplegic Patients:

1.Design and Development of EEG Signal Acquisition System: Develop a system to accurately acquire EEG signals from quadriplegic patients using a non-invasive EEG headset.

2.Signal Processing and Classification:Implement signal processing algorithms to extract meaningful features from EEG signals and classify them into control commands for the wheelchair.

3.Integration of EEG System with Wheelchair Control: Integrate the EEG signal processing system with the wheelchair control system to enable real-time control of the wheelchair based on the user's brain activity.

4.User Interface Design: Design a user-friendly interface for the wheelchair control system, allowing users to easily initiate and control movements using their brain signals.

5.Testing and Validation: Conduct extensive testing and validation of the EEG-based brain-controlled wheelchair system to ensure its safety, reliability, and effectiveness in real-world scenarios.

6.Performance Evaluation: Evaluate the performance of the system in terms of accuracy, speed, and usability, comparing it with existing wheelchair control methods for quadriplegic patients.

7.User Experience and Feedback: Gather feedback from quadriplegic patients and healthcare professionals to assess the user experience and identify areas for improvement in the system.

8.Documentation and Reporting:Document the design process, implementation details, testing results, and findings in a comprehensive report suitable for academic and professional audiences.

9.Future Enhancement and Sustainability: Explore opportunities for further enhancement of the system and its sustainability in terms of cost, maintenance, and scalability for wider adoption.

10.Ethical Considerations: Consider ethical implications related to patient safety, privacy, and informed consent throughout the project development and implementation phases.

1.4 Motivation

The motivation behind the project "Design of an EEG-based Brain Controlled Wheelchair for Quadriplegic Patients" stems from a deep-seated desire to improve the quality of life and independence of individuals with severe mobility impairments. Quadriplegic patients face immense challenges in performing basic daily activities and interacting with their environment due to the loss of control over their limbs

Traditional wheelchairs, while beneficial, often require manual effort to operate, posing difficulties for those with limited arm function or advanced age. By integrating EEG technology into wheelchair control, we aim to provide quadriplegic patients with a more intuitive and effortless means of mobility. This innovative approach allows users to control the wheelchair using their brain signals, offering a level of freedom and autonomy that was previously unattainable.

Furthermore, this project aligns with the broader goals of advancing assistive technology and promoting inclusivity for individuals with disabilities. By developing a reliable and user-friendly EEG-based brain-controlled wheelchair, we hope to not only enhance the mobility and independence of quadriplegic patients but also inspire future innovations in the field of assistive technology. Through this project, we aspire to make a meaningful impact on the lives of individuals with severe mobility impairments, fostering a more inclusive and supportive society for all.

1.4 Assumption and Dependencies

Assumptions and dependencies play a crucial role in project planning and execution. Here are some assumptions and dependencies for the project "Design of an EEG-based Brain Controlled Wheelchair for Quadriplegic Patients":

Assumptions:

1. Availability of Quadriplegic Patients for Testing: It is assumed that there will be a sufficient number of quadriplegic patients available and willing to participate in the testing and evaluation of the EEG-based brain-controlled wheelchair prototype.

2. Functionality of EEG Headset: It is assumed that the EEG headset used for acquiring brain signals will function properly and provide accurate and reliable data for analysis and control of the wheelchair.

3.Compatibility with Wheelchair Components: The project assumes that the EEG-based control system can be effectively integrated with the existing components of a standard wheelchair without significant modifications.

4. **Reliability of Signal Processing Algorithms:** It is assumed that the signal processing algorithms used to extract control signals from EEG data will be reliable and capable of accurately interpreting the user's intentions.

5. **Availability of Resources:** The project assumes access to necessary resources such as funding, equipment, and expertise to design, develop, and test the EEG-based brain-controlled wheelchair system.

Dependencies:

1. **Hardware and Software Development:** The project is dependent on the successful development of both hardware (EEG headset, wheelchair control interface) and software (signal processing algorithms, control system) components.

2. **Ethical Approval:** The project is dependent on obtaining ethical approval for conducting human subjects research involving quadriplegic patients.

3. **Collaboration with Healthcare Professionals:** Collaboration with healthcare professionals, such as neurologists and physiotherapists, is essential for the successful design and implementation of the EEG-based brain-controlled wheelchair.

4. **User Feedback and Iterative Design:** The project depends on receiving feedback from users (quadriplegic patients) to iteratively improve the design and functionality of the wheelchair system.

5. **Regulatory Approval:** Depending on the jurisdiction, regulatory approval may be required for the deployment of medical devices like the EEG-based brain-controlled wheelchair, which could impact project timelines and implementation.

1.6 Methods

The method for the project "Design of an EEG-based Brain Controlled Wheelchair for Quadriplegic Patients" can be outlined as follows

1. **Literature Review:**

- Conduct a comprehensive review of existing literature on EEG-based brain-computer interfaces (BCIs), wheelchair control systems for quadriplegic patients, signal processing algorithms for EEG data, and relevant technologies.

2. **Requirements Analysis:**

- Define the functional and non-functional requirements of the EEG-based brain-controlled wheelchair system based on the literature review and consultation with healthcare professionals and potential users

3. **Hardware and Software Development:**

- Develop or acquire the necessary hardware components, including an EEG headset for signal acquisition and a wheelchair control interface.

- Develop the software components, including signal processing algorithms for extracting control signals from EEG data and a control system for translating these signals into wheelchair movements.

4. **Integration and Testing:**

- Integrate the hardware and software components to create a functional EEG-based brain-controlled wheelchair prototype.

- Conduct rigorous testing of the prototype to ensure its safety, reliability, and effectiveness in controlling the wheelchair based on user's brain activity.

5. **User Evaluation:**

- Recruit quadriplegic patients to participate in user evaluation sessions.

- Gather feedback from users on the usability, comfort, and effectiveness of the EEG-based brain-controlled wheelchair system.

6. **Iterative Design and Improvement:**

- Use the feedback from user evaluations to iteratively improve the design and functionality of the EEG-based brain-controlled wheelchair system.

- Incorporate any necessary modifications or enhancements to address user feedback and improve overall performance.

7. **Ethical Considerations:**

- Ensure that the project complies with ethical guidelines for human subjects research, including obtaining informed consent from participants and protecting their privacy and confidentiality.

8. **Documentation and Reporting:**

- Document the design process, implementation details, testing results, and user feedback.

- Prepare a comprehensive report outlining the methodology, findings, and recommendations for future work.

1.7 Report Overview

Title: Review of EEG-Based Brain Controlled Wheelchair for Quadriplegic Patients

****Introduction:****

The aim of this review is to examine the current state of research and development in EEG-based brain-controlled wheelchairs for quadriplegic patients. This technology holds promise for enhancing the mobility and independence of individuals with severe mobility impairments by allowing them to control wheelchairs using their brain activity.

****Literature Review:****

Research in this field has primarily focused on developing reliable and efficient methods for acquiring and processing EEG signals to control wheelchair movement. Various signal processing algorithms, such as machine learning-based classifiers, have been investigated to interpret EEG signals and translate them into wheelchair commands. Studies have also explored different EEG electrode configurations and signal processing techniques to improve the accuracy and robustness of EEG-based control systems.

Challenges and Limitations:

Despite the advancements, several challenges and limitations exist in the development and implementation of EEG-based brain-controlled wheelchairs. These include the need for robust signal processing algorithms, concerns about user comfort and usability, and the requirement for extensive training for users to operate the system effectively.

Future Directions:

Future research in this area should focus on addressing the challenges and limitations to improve the practicality and effectiveness of EEG-based brain-controlled wheelchairs. This includes developing more user-friendly interfaces, optimizing signal processing algorithms for real-time operation, and conducting long-term usability studies with quadriplegic patients to evaluate the system's performance in real-world scenarios.

Conclusion:

EEG-based brain-controlled wheelchairs have the potential to significantly improve the quality of life for quadriplegic patients by providing them with a means of independent mobility. While challenges exist, continued research and development in this field hold promise for advancing assistive technology and enhancing the autonomy of individuals with severe mobility impairments.

Chapter 2

2.1 Literature Review

"We cannot challenge nature or change someone's faith. Being physically fit is a blessing for which we should be thankful to Allah. However, some individuals face challenges due to conditions like polio, Amyotrophic lateral sclerosis, brain stem stroke, brain or spinal cord injury, cerebral palsy, muscular dystrophy, multiple sclerosis, and other diseases that affect nerve pathways controlling muscles. These conditions make survival difficult and often lead to dependence on others.

To simplify life for such individuals, engineers have developed various technologies. One of the most effective solutions for mobility is the wheelchair, which has evolved over the years. Initially, wheels were added to chairs to provide mobility, but energy for movement had to be provided by the individual or a caregiver. This dependence on others burdened the elderly and paralyzed individuals and limited their independence.

Subsequently, chain-based wheelchairs were introduced, which helped many disabled individuals. However, these wheelchairs had limitations and required manual operation by hands, which was challenging for some patients with complete paralysis.

The introduction of motorized wheelchairs was a significant achievement, providing relief for patients and caregivers. These wheelchairs are controlled by a joystick using a wired system. However, manual operation is still not suitable for some patients with complete paralysis.

Various research studies have proposed different control mechanisms such as joystick-based, gestures-based, and chain-based mechanisms to help disabled individuals become more independent. However, these approaches have their drawbacks, including the complexity of wired communication systems and limited mobility.

Recent advancements include integrating brainwaves with speech recognition systems to control wheelchairs. Although these systems offer more freedom, they are costly and less reliable.

Innovations such as using brainwave sensors to control wheelchairs or integrating GPS and GSM modules for location tracking have been proposed, but they have limitations in accuracy and usability.

Overall, while advancements in wheelchair technology have improved the quality of life for many disabled individuals, there are still challenges to overcome in terms of cost, complexity, and usability.

2.1.1 Signal Processing Algorithms:

Signal processing algorithms play a crucial role in translating EEG signals into control commands for wheelchairs. Many studies have employed machine learning techniques, such as support vector machines (SVMs) and convolutional neural networks (CNNs), to classify EEG patterns associated with different motor intentions. These algorithms have shown promising results in offline analyses, but real-time implementation remains a challenge due to the need for high computational efficiency.

2.1.2 Usability and User Experience:

In addition to technical challenges, usability and user experience are critical factors in the design of EEG-based brain-controlled wheelchairs. Studies have highlighted the importance of user training and adaptation to the system, as well as the need for intuitive user interfaces. User feedback has indicated that comfort, ease of use, and reliability are paramount for the acceptance and adoption of these technologies in real-world settings. EEG-based brain-controlled wheelchairs hold immense potential for improving the mobility and independence of quadriplegic patients. While significant progress has been made in this field, further research is needed to overcome technical challenges and ensure the practicality and effectiveness of these systems in real-world applications.

Chapter 3

3.1 Physical Modeling & Hardware Implementation

3.1.1 SYSTEM DESIGN

In this project we make a wheelchair for quadriplegic patient, which is a brainwave control wheelchair. A wheelchair which is control by a brain with the help of sensor which is called EEG based brainwave sensor. EEG is a test that detect abnormalities in brainwaves, or in the electrical activity of brain. During the procedure, electrodes consisting of small metal discs with thin wires are pasted onto scalp. The electrodes detect thiny electrical charges that result from the activity of brain cells. We are starting from detecting the brain waves and digitize or amplify these signals so that the brain sensor can read. Then these signals will be transmitted through Bluetooth device in the headset and collected or received the data on the Bluetooth module on the ardunio. The ardunio display the condition whether the chair is moving or not. The personal computer can also be used to communicate with the ardunio and can monitor the status of the chair with ardunio serial monitor. Motor drives are used for driving the motors and battery is used for all these process. So, at the end wheelchair is controlled by brain with the help of brainwave control.

3.1.2 Hardware Implementation

EEG Head Set.

BrainLink is a type of EEG (Electroencephalography) headset developed by Macrotellect Ltd. It is designed to monitor and measure brain activity non-invasively by detecting electrical signals produced by the brain. The BrainLink headset is typically used for applications such as brain-computer interfaces (BCIs), neurofeedback training, and cognitive enhancement. The BrainLink headset is worn on the head and uses sensors to detect EEG signals from the scalp. These signals are then transmitted to a computer or mobile device via Bluetooth, where they can be analyzed and interpreted using specialized software. The headset is lightweight and comfortable to wear, making it suitable for long-term use in various settings. BrainLink headsets are often used in research, healthcare, and personal development applications. They can provide valuable insights into brain activity and help users improve their cognitive abilities, enhance focus and attention, and even control external devices using their brainwaves.

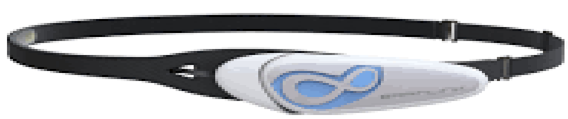


Figure.1 EEG Head Set

Wheelchair.

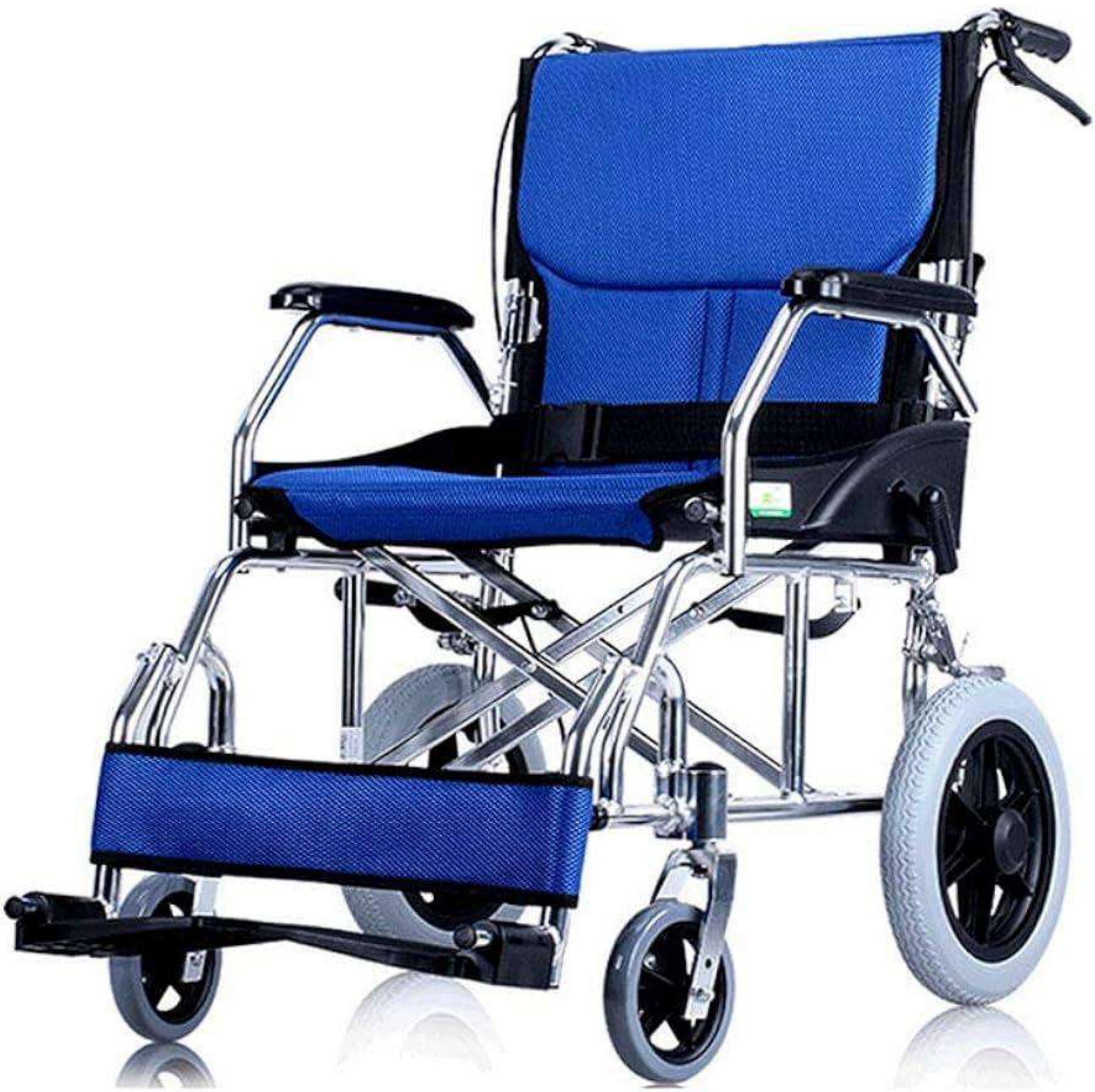


Figure.2 Wheelchair

Brain Waves

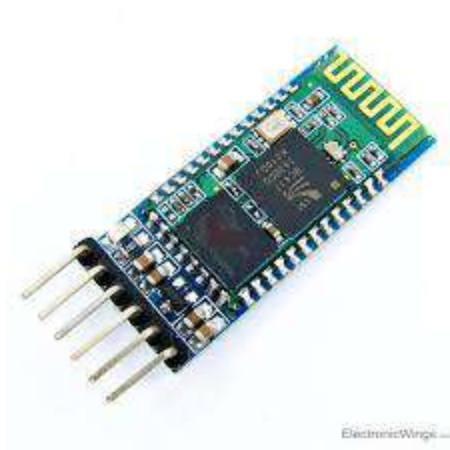
Brain waves are oscillating electrical voltages in the brain measuring just a few millionths of a volt. There are five widely recognized brain waves, and the main frequencies of human EEG waves are listed in Table 2.1 along with their characteristics.

Frequency band	Frequency	Brain states
Gamma (γ)	35 Hz	Concentration
Beta (β)	12–35 Hz	Anxiety dominant, active, external attention, relaxed
Alpha (α)	8–12 Hz	Very relaxed, passive attention
Theta (θ)	4–8 Hz	Deeply relaxed, inward focused
Delta (δ)	0.5–4 Hz	Sleep

Characteristics of the Five Basic Brain Waves

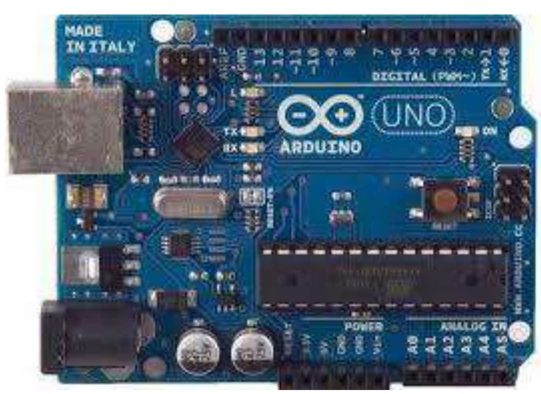
HC-05 - Bluetooth Module

The HC-05 is a class 2 Bluetooth module designed for transparent wireless serial communication. It is pre-configured as a slave Bluetooth device. Once it is paired to a master Bluetooth device such as PC, smart phones and tablet, its operation becomes transparent to the user.



ardunio uno

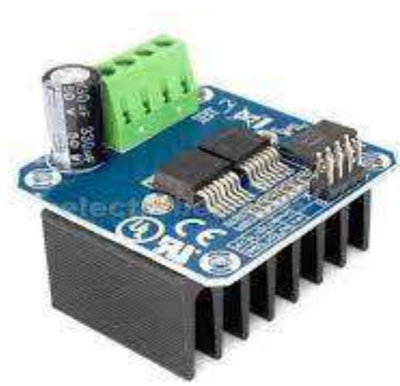
Arduino Uno is a microcontroller board based on the ATmega328P (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), a USB connection, a power jack, an ICSP header and a reset button.



Motor drive circuit

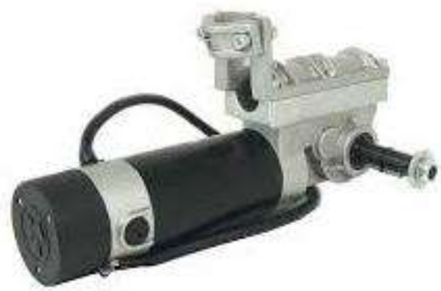
The fundamental purpose of the motor control gear is to lower the speed of a gear series, resulting in an increase in torque.

The motor rotor and main shaft are linked to the gearbox (or integrated gear series) via a second reduction shaft in order to achieve this goal. This is known as a reduction gear series, or a reduction gear train. It is theoretically possible to prolong this reduction gears train, but the longer it is, the lower the ultimate output



D.C Gear motor

A gear motor combines a motor with a gearbox in a single unit. Additives like an external gear limit the speed of a motor while boosting torque. Speed (rpm), torque (lb.-in), and efficiency are the most critical factors for gear motors (percent). You must first determine the load, speed, and torque requirements of your application in order to pick the best gear motor for your needs. ISL Products has a wide selection of Spur Gear Motors, Planetary Gear Motors, and Worm Gear Motors to fulfil the needs of any application.



Chapter 4

4.1 Proposed Solution

Proposed Solution: EEG-Based Brain Controlled Wheelchair for Quadriplegic Patients

The proposed solution involves the design and development of an EEG-based brain-controlled wheelchair system to enhance the mobility and independence of quadriplegic patients. The system will utilize EEG signals to allow users to control the wheelchair using their brain activity, providing a more intuitive and efficient means of mobility compared to traditional manual wheelchairs.

Components of the Proposed Solution:

1. **EEG Signal Acquisition:** Utilize a non-invasive EEG headset to acquire EEG signals from the user's scalp. The headset should be comfortable to wear and capable of capturing reliable EEG signals.

2. **Signal Processing:** Develop signal processing algorithms to extract meaningful features from the EEG signals related to user intent. This may include frequency analysis, time-frequency analysis, and machine learning-based classification techniques.

3. **Wheelchair Control Interface:** Design a user-friendly interface for wheelchair control based on the extracted EEG features. The interface should allow users to initiate and control movement commands using their brain activity.

4. **Integration with Wheelchair Control System:** Integrate the EEG-based control interface with the wheelchair's existing control system. This may involve developing a custom control module or adapting existing wheelchair control systems to accept commands from the EEG interface.

5. **User Training and Adaptation:** Develop a training program to familiarize users with the EEG-based control system and help them adapt to using their brain activity to control the wheelchair.

6. **Usability Testing and Optimization:** Conduct usability testing with quadriplegic patients to evaluate the effectiveness and user-friendliness of the system. Use feedback from testing to refine and optimize the system for improved performance.

7. **Safety and Reliability:** Ensure that the system meets safety standards and is reliable for daily use by quadriplegic patients. Implement fail-safe mechanisms to prevent unintended movements or accidents.

8. **Documentation and Reporting:** Document the design, development, and testing process of the EEG-based brain-controlled wheelchair system.

Prepare a detailed report outlining the methodology, results, and recommendations for future improvements.

Expected Outcome:
The proposed EEG-based brain-controlled wheelchair system is expected to provide quadriplegic patients with a reliable and efficient means of controlling their wheelchair using their brain activity. By harnessing the power of EEG technology, the system aims to improve the quality of life and independence of quadriplegic patients, enabling them to navigate their environment more easily and efficiently.

Activity	Optimistic (a)	Most Likely (m)	Pessimistic (b)	Expected (Te)
A	14	20	25	23
B	0.7	1.3	2.1	3
B	0.9	2	1.5	2

Table 1:PERT Activity Time estimate table

Chapter 5

5.1 Discussion

Discussion: Design of an EEG-based Brain Controlled Wheelchair for Quadriplegic Patients

The design of an EEG-based brain-controlled wheelchair for quadriplegic patients represents a significant advancement in assistive technology. By harnessing the power of EEG signals, this project aims to provide quadriplegic individuals with a new level of independence and mobility.

One of the key strengths of this project is its potential to improve the quality of life for quadriplegic patients. By enabling them to control their wheelchair using their brain activity, this technology has the potential to greatly enhance their freedom and autonomy. This can lead to improvements in mental health and overall well-being, as individuals gain more control over their environment and are able to participate more fully in daily activities.

Another strength of this project is its interdisciplinary nature. By combining expertise from fields such as neuroscience, engineering, and computer science, this project has the potential to drive innovation and push the boundaries of what is possible in assistive technology. This interdisciplinary approach allows for a more holistic understanding of the challenges faced by quadriplegic individuals and enables more creative and effective solutions to be developed.

However, there are also challenges and limitations associated with this project. One of the main challenges is the reliability and accuracy of the EEG signals. EEG signals can be noisy and prone to artifacts, which can make it difficult to accurately interpret the user's intentions. Additionally, there may be challenges related to user training and adaptation, as quadriplegic patients may need time to learn how to use the brain-controlled wheelchair effectively.

In conclusion, the design of an EEG-based brain-controlled wheelchair for quadriplegic patients represents a promising advancement in assistive technology. While there are challenges and limitations associated with this project, the potential benefits for quadriplegic individuals are significant. With further research and development, this technology has the potential to revolutionize the lives of quadriplegic patients and improve their quality of life.

Chapter 6

6.1 Summary and Future work

The project aims to develop an EEG-based brain-controlled wheelchair system to enhance the mobility and independence of quadriplegic patients. By using EEG signals to control the wheelchair, the system provides a more intuitive and efficient means of mobility compared to traditional manual wheelchairs.

The proposed solution includes acquiring EEG signals using a non-invasive headset, processing these signals to extract meaningful features related to user intent, and integrating the control interface with the wheelchair's existing control system. The system will also incorporate user training and adaptation to ensure effective use by quadriplegic patients.

The optimistic outlook for this project is rooted in the transformative potential of EEG technology and BCI systems to revolutionize the lives of quadriplegic individuals. By providing a means of independent mobility, the system aims to improve the quality of life and autonomy of quadriplegic patients, enabling them to navigate their environment with greater ease and dignity.

While there are challenges and limitations associated with this project, such as the reliability of EEG signals and user training, the potential benefits for quadriplegic individuals are significant. With further research and development, this technology has the potential to make a profound and lasting impact on the field of assistive technology and the lives of those with severe mobility impairments.

Chapter 7

7.1 Conclusion

To read and analyze the brainwaves, Macro Telex EEG headset device integrated with Adriano microcontroller is used. The EEG device translate the user's wishes in form of brainwaves to the digital signal and realize the user intention. The wireless technologies used to control SWMC wheelchair enhance the usability, controllability, willpower of the elder user and physically disabled user to provide self-reliant without dependency on the others. The SWMC wheelchair is implemented and simulated by C programming base Adriano IDE and Proteus software. This project is cost effective, reliable, competitive with other market available wheelchair, accurate and efficient. We have compared the SWMC wheelchair with WSHGWC and the result shows that SWMC is far better than WSHGWC in terms of movement change and accuracy response. The only improvement we need to do is to lower its response time. We will work on response time and response accuracy to provide comfort to all disable categories in future. A novel wireless dry EEG brain-controlled wheelchair with five steering behaviors is devised, based on two-stage control strategies combining sustained and brief motor imagery brain–computer interfaces. The result is that the proposed wheelchair requires less training for the operators and is more adaptive to the outdoors. The experimental results demonstrate that the metrics path opt. ratio is very encouraging and the time opt. ratio is especially remarkable because of the multi-command extraction and fast decision-making. More importantly, we have achieved the fastest and most robust stop for the wheelchair controlling by EEGConclude. Finally, finish off with a sentence or two that wraps up your paper. I find this can often be the hardest part to write. You want the paper to feel finished after they read these. One way to do this, is to try and tie your research to the "real world." Can you somehow relate how your research is important outside of academia? Or, if your results leave you with a big question, finish with that. Put it out there for the reader to think about to.

References

[1] F. Al-Wasabi, F., Laager, M., Al-Yakima, F. and Abadan, A., 2019. A Smart-hand Movement-based System to Control a Wheelchair Wirelessly. *Sensors and Materials*, 31(9), p.2947.

[2] Al-Wasabi, F., Laager, M., Medan, M. and Abadan, A., 2020. Smart Mind-based Approach to Control a Wheelchair Wirelessly. *Sensors and Materials*, 32(4), p.1533.

[3] Wang, Jihadi & Kenning, Wang & Chen, Xiao gang & Wang, Huiquan & Xu, Shengpu & Liu, Ming. (2020). Indoor simulation training system for brain-controlled wheelchair based on steady-state visual evoked potentials. Sheng wu yi xue gong cheng xue za zhi = Journal of biomedical engineering = Shengwu yixue gongchengxue zazhi. 37. 502-511. 10.7507/1001-5515.201906025.

[4] Charles, P., Krishna, M., Kumar G, P. and Prasad D, L., 2018. EEG - Controlled Wheelchair Movement: Using Wireless Network. *Journal of Biosensors & Bioelectronics*, 09(01).

[5] Charles, P., Krishna, M., Kumar G, P. and Prasad D, L., 2018. EEG - Controlled Wheelchair Movement: Using Wireless Network. *Journal of Biosensors & Bioelectronics*, 09(01).

[6] Arndt, Sebastian & Voigt-Antons, Jan-Niklas & Gupta, Rishabh & Laghari, Khalil & Schleicher, Robert & Möller, S. & Falk, Tiago. (2013). The effects of text-to-speech system quality on emotional states and frontal alpha band power. International IEEE/EMBS Conference on Neural Engineering. 489-492. 10.1109/NER.2013.6695978.

[7] Xin, Liqiang & Gao, Shang & Tang, Jingyue & Xu, Xin. (2018). Design of a Brain Controlled Wheelchair. 112-116. 10.1109/CCSSE.2018.8724794.

[8] Mansoor, Muhammad & Naz, Bushra & Jaffari, Rabeea & Ansari, Muhammad. (2019). Brain controlled wheelchair with neurosky mindwave. 51. 709 - 712. 10.26692/sujo/2019.12.112.

[9] Fernández-Rodríguez, Álvaro & Velasco-Álvarez, Francisco & Ron-Angevin, Ricardo. (2016). Review of real brain-controlled wheelchairs. Journal of neural engineering. 13. 061001. 10.1088/1741-2560/13/6/061001.

[10] Zhang, Haoran & Dong, Enzeng & Zhu, Lin. (2020). Brain-controlled wheelchair system based on SSVEP. 2108-2112. 10.1109/CAC51589.2020.9327651.

[11] Siledar, Gagandeep. (2021). A Review- Brain Controlled Wheelchair using EEG headset. International Journal for Research in Applied Science and Engineering Technology. 9. 267-270. 10.22214/ijraset.2021.38741.

[12] Khan, Mohammad & Masud, Mehedi. (2021). Research and Development of a Brain-Controlled Wheelchair for Paralyzed Patients. 10.32604/iasc.2021.016077.

[13] Rebsamen, Brice & Guan, Cuntai & Zhang, Haihong & Wang, Chuanchu & Teo, Cheeleong & Jr, Marcelo & Burdet, Etienne. (2011). A Brain Controlled Wheelchair to Navigate in Familiar Environments. Neural Systems and Rehabilitation Engineering, IEEE Transactions on. 18. 590 - 598. 10.1109/TNSRE.2010.2049862.

[14] Ratib, Sherif. (2019). A Smart Brain Controlled Wheelchair Based Microcontroller System. International Journal of Artificial Intelligence & Applications. 10. 67-85. 10.5121/ijaia.2019.10506.

[15] Liu, Kaixuan & Yu, Yang & Liu, Yadong & Tang, Jingsheng & Xinbin, Liang & Chu, Xingxing & Zhou, Zongtan. (2022). A novel brain-controlled wheelchair combined with

computer vision and augmented reality. BioMedical Engineering OnLine. 21. 10.1186/s12938-022-01020-8.

[16] Gunachandra, & Chrisander, Sylvester & Widyotriatmo, Augie & Suprijanto, dr. (2015). Wall following control for the application of a brain-controlled wheelchair. Proceedings of 2014 International Conference on Intelligent Autonomous Agents, Networks and Systems, INAGENTSYS 2014. 36-41. 10.1109/INAGENTSYS.2014.7005722.

[17] Lakas, Abderrahmane & Kharbash, Fekri & Belkacem, Abdelkader Nasreddine. (2021). A Cloud-based Brain-controlled Wheelchair with Autonomous Indoor Navigation System. 1727-1733. 10.1109/IWCMC51323.2021.9498751.

[18] Dev, Antora & Rahman, Md. Asifur & Mamun, Nursadul. (2018). Design of an EEG-Based Brain Controlled Wheelchair for Quadriplegic Patients. 10.1109/I2CT.2018.8529751.

[19] Velasco-Álvarez, Francisco & Fernández-Rodríguez, Álvaro & Diaz, Antonio & Blanca, María & Ron-Angevin, Ricardo. (2018). Control strategies of a brain-controlled wheelchair using two mental tasks. 10.1016/B978-0-12-812892-3.00014-5.

[20] Turnip, Arjon & Kusumandari, Dwi & Arson, Giovani & Setiadikarunia, Daniel. (2021). Electric Wheelchair Controlled-Based EMG with Backpropagation Neural Network Classifier. 10.1007/978-981-33-4062-6_13.

[21] Wang, Hongtao & Yan, Fan & Xu, Tao & Yin, Haojun & Chen, Peng & Yue, Hongwei & Chen, Chuangquan & Zhang, Hongfei & Xu, Linfeng & He, Yuebang & Bezerianos, Anastasios. (2021). Brain-Controlled Wheelchair Review: From Wet Electrode to Dry Electrode, From Single Modal to Hybrid Modal, From Synchronous to Asynchronous. IEEE Access. 85. 1-19. 10.1109/ACCESS.2021.3071599.

[22] Abo-Zahhad, Mohammed & Ahmed, Sabah & Seha, Sherif Nagib. (2015). A New EEG Acquisition Protocol for Biometric Identification Using Eye Blinking Signals. International Journal of Intelligent Systems and Applications (IJISA). 07. 48-54. 10.5815/ijisa.2015.06.05.

[23] Abdul Rahman, Ahmad & Hussin, Hanim. (2019). Detection of attention and meditation state-based brainwave system to control prosthetic arm. Indonesian Journal of Electrical Engineering and Computer Science. 13. 794. 10.11591/ijeecs.v13.i2.pp794-800.

[24] "Components Shown in EEG Sensor." *Mindflex EEG with Raw Data over Bluetooth : 9 Steps - Instructables*, https://shop76004.mycrazyblog.com/content?c=mindflex%20headset&id=17

[25] "EEG Machines EEG Headband--BrainLink Lite Brainwaves EEG Headband." *Eeg Machines Eeg Headband--Brainlink Lite Brainwaves Eeg Headband - Buy Eeg Machines,Eeg Machines Eeg Headband,Brainwaves Eeg Headband Product on Alibaba.com*, https://www.alibaba.com/product-detail/EEG-machines-EEG-Headband-BrainLink-Lite_62339239420.html

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Each chapter shall be numbered as Chapter 1, Chapter 2, etc.

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