SMART WHEELCHAIR WITH VOICE CONTROL FOR PHYSICALLY CHALLENGED PEOPLE

A PROJECT REPORT

Submitted by

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in partial fulfillment for the award of the degree

of

BACHELOR OF ENGINEERING

IN

MECHATRONICS ENGINEERING

Er. PERUMAL MANIMEKALAI COLLEGE OF ENGINEERING

AN AUTONOMOUS INSTITUTION

HOSUR-635117

MAY 2025

BONAFIDE CERTIFICATE

Certified that this project work report “**SMART WHEELCHAIR WITH VOICE CONTROL FOR PHYSICALLY CHALLENGED PEOPLE**” is the bonafide work of “**BARATH.V(610821115002), SANTHOSH KUMAR M(610821115023), SUDHIR V (610821115026), THANISH E(610821115027)**” who carried out the project work under my supervision.

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Submitted for the project work viva-voce examination held on ………….

INTERNAL EXAMINER **EXTERNAL EXAMINER**

DECLARATION

I affirm that the project work titled **"SMART WHEELCHAIR WITH VOICE CONTROL FOR PHYSICALLY CHALLENGED PEOPLE"** being submitted in partial fulfillment of the requirements for the award of the Degree of Bachelor of Engineering is the original work carried out by me. It has not formed the part of any project work or dissertation on the basic of which a degree or award was conferred on an occasion on this or any candidate.

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(Name & signature of

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ACKNOWLEDGEMENT

We sincerely thanks to a number of people who have provided understanding and assistance in the completion of the Project.

We express our sincere gratitude to our Honourable **Founder** of **PMC TECH** Group of Institutions **“Vazhum Theivam” Er.P.PERUMAL** for providing us with the excellent infrastructure to make our project a successful one.

We would like to express our sincere thanks to our beloved **Chairman & Correspondent Shri. P.KUMAR,** most respected **Secretary Smt.P.MALLAR,** and respected **Trustee Smt. P. SASI REKHA** for providing us all the facilities and amenities for the completion of our project.

We would like to express our sincere gratitude to respected and our beloved **Principal Dr.A.SENTHIL KUMAR** and our beloved **DEAN-Electrical science Dr.V.LAKSHMI NARAYANAN** for their assistance to make our project a successful one.

We would like to express a deep sense of gratitude and heartfelt thanks to our Head of the Department, **Dr.M.SUDHAGAR** and thanks to our Project guide **Mr. M. RAMATHAS** for their continuous encouragement and kind suggestions in every step throughout this project.

We also express my heartly thanks to other teaching and non-teaching staff members of department of **MECHATRONICS ENGINEERING** for their encouragement and support to complete the project work.

INSTITUTE VISION AND MISSION

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- To create knowledge, based professionals to enrich their quality of life by empowering self and family.

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MISSION

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PEO2: Prepare students to design and develop products for monitoring, controlling, and industrial automation through Mechatronics Engineering in order to enhance productivity and quality.

PEO3: Develop students to be valuable engineers with good communication skills, ethical conduct towards their profession, and commitment to serve society.

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- **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
- **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
- **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
- **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitation**.**
- **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural Issues and the consequent responsibilities relevant to the professional engineering practice.

- ❖ **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
- ❖ **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
- ❖ Individual and team work**:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
- ❖ Communication**:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
- ❖ Project management and finance**:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
- ❖ Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1: Design and investigate the problems related to instrumentation, control, automation, and robotics provide solutions.

PSO2: To develop a Mechatronics system to meet the requirements and specifications.

PSO3: To analyse and improve the performance of a Mechatronics system and enhance the intellectual capabilities of the system.

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DEPARTMENT OF MECHATRONICS ENGINEERING

MR3811-PROJECT WORK

COURSE OUTCOME:

CO1: Design and fabrication the machine element or the mechanical product.

CO2: Demonstrate the working model of the machine element or the mechanical product.

Sl.No	NAME OF THE PROJECT	Mapping with Cos	POs and PSOs Mapping
1	**"SMART WHEELCHAIR WITH VOICE CONTROL FOR PHYSICALLY CHALLENGED PEOPLE"**	CO1 and CO2 .	PO1,PO2,PO3,PO4,PO5,PO6, PO7,PO8,PO9,PO10,PO11, PO12 & PSO1, PSO2 and PSO3

PROJECT CO-ORDINATOR **HOD/MCO**

ABSTRACT

Mobility is a crucial aspect of independent living, especially for individuals with physical disabilities who have limited or no limb function. Traditional wheelchairs often fail to provide the necessary autonomy for such users. To address this issue, this project presents the development of a Smart Wheelchair that integrates voice control, obstacle detection, and IoT-based monitoring. The system uses an Arduino Uno microcontroller connected to a Bluetooth module (HC-05) to receive voice commands from a smartphone app or voice recognition system. These commands enable hands-free movement in multiple directions such as forward, backward, left, and right, offering improved accessibility for users unable to operate manual controls.

To ensure user safety, ultrasonic sensors are installed to detect obstacles in real-time, automatically halting movement to prevent collisions. Additionally, the wheelchair features IoT capabilities that allow caregivers or family members to remotely monitor the wheelchair's location and status using a cloud platform or mobile application. This provides timely support during emergencies. Designed to be low-cost, reliable, and scalable, the system also supports future enhancements like GPS tracking, health monitoring, and environmental sensing. This smart wheelchair is a significant step toward inclusive assistive technology, aiming to improve the quality of life and independence of physically challenged individuals.

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S.NO	ABBREVATIONS	
1	**MC**	Micro Controller
2	**MCU**	Micro Controlling Unit
3	**I/O**	Input and Output
4	**PC**	Personal Computer
5	**CPU**	Central Processing Unit
6	**FOV**	Field Of View
7	**HD**	High Definition
8	**VRS**	Voice Recognition System
9	**AI**	Artificial Intelligence
10	**RGB**	Red Green Blue
11	**UI**	User Interface

CHAPTER 1

INTRODUCTION

1.1 Introduction To Smart Wheelchair With Voice Control For Physically Challenged People

In today's world, technology plays a vital role in improving the lives of people with disabilities. Mobility impairment is one of the most challenging disabilities, affecting an individual's independence and ability to perform daily activities. Traditional wheelchairs often require significant physical effort or assistance from others, which limits the autonomy of the user. To overcome these limitations, the integration of electronics and intelligent control systems has led to the development of smart wheelchairs. These wheelchairs aim to enhance mobility, safety, and comfort for physically challenged individuals by incorporating automated and voice-based control systems.

This project presents the development of a **Smart Wheelchair with Voice Control** that leverages **Arduino Uno** as the central microcontroller. The system is designed to receive voice commands via a **Bluetooth module** connected to a smartphone. These commands are interpreted and translated into motion instructions for the wheelchair, allowing the user to move in different directions without physical exertion. The integration of voice control simplifies user interaction, especially for individuals with limited limb movement, making the system highly accessible and user-friendly.

To ensure safety during navigation, **ultrasonic sensors** are installed on the wheelchair to detect obstacles in the surrounding environment. These sensors measure the distance to nearby objects and alert the control system to stop or avoid collisions. The combination of voice command input and obstacle detection creates a more intelligent and responsive mobility aid. It helps in navigating both indoor and outdoor environments with greater confidence and security.

In addition to the voice control and safety features, the project incorporates **IoT (Internet of Things)** technology for remote monitoring and control. With IoT connectivity, real-time location tracking, system diagnostics, or emergency alerts can be shared with caregivers or medical staff. This ensures that assistance can be provided promptly if needed, adding an extra layer of protection and reassurance for both the user and their family.

Overall, the smart wheelchair system developed in this project offers a cost-effective, accessible, and efficient solution for physically challenged individuals. By combining embedded systems, wireless communication, and IoT technologies, this wheelchair enhances independence and quality of life. Its modular architecture also allows future expansions, such as health monitoring sensors or integration with smart home systems, making it a promising platform for next-generation assistive mobility devices.

1.2 Methodology

The methodology for developing the smart wheelchair involves a structured approach starting from system design, component selection, circuit development, programming, integration, and testing. The design process begins with identifying the specific needs of physically challenged users, primarily focusing on hands-free operation, safety, and ease of use. Based on these requirements, voice control was selected as the primary interface, using a Bluetooth-enabled smartphone application to convert spoken commands into signals interpretable by the wheelchair's microcontroller.

The heart of the system is the **Arduino Uno**, which acts as the processing unit. The Arduino receives serial data from a **Bluetooth module (HC-05)** paired with an Android smartphone running a voice control app. Voice commands such as "forward," "backward," "left," "right," and "stop" are processed by the smartphone and transmitted via Bluetooth. Upon receiving these commands, the Arduino decodes them and accordingly controls the **motor driver (L298N)**, which then drives the motors connected to the wheelchair wheels to perform the desired movement.

To enhance the safety of the wheelchair user, **ultrasonic sensors** are installed at the front (and optionally the sides) of the wheelchair. These sensors continuously measure the distance from nearby obstacles. If an obstacle is detected within a defined range, the Arduino interrupts the movement command and stops the wheelchair to avoid collisions. This ensures that the system is not only automated but also reactive to its surroundings, offering real-time safety features.

For IoT integration, modules like **ESP8266** or **NodeMCU** can be used to connect the system to a cloud platform or mobile app. Through IoT, features such as real-time location tracking, system status updates, and emergency alerts can be implemented. This data can be monitored by caregivers or family members remotely, offering additional assurance and rapid response in case of emergencies. After all components are assembled, the entire system is tested rigorously under different environmental conditions and command scenarios to ensure reliability, accuracy, and responsiveness.

1.3 Challanges And Solutions

One of the initial challenges encountered in this project was ensuring accurate voice recognition. Since the system relies on spoken commands to operate, any misinterpretation could result in incorrect movements or even safety hazards. Environmental noise, differences in pronunciation, and inconsistent voice input affected command accuracy during early testing. To address this, a smartphone-based voice recognition app was used instead of basic hardware modules, as mobile apps like Google Voice offer more reliable and adaptable speech processing. Additionally, the command set was deliberately limited to simple, clearly distinguishable terms such as “forward,” “backward,” “left,” “right,” and “stop” to enhance recognition precision and reduce error rates.

Another challenge was the limited range and occasional instability of the Bluetooth communication between the smartphone and the HC-05 module. In crowded environments or with physical obstructions, the Bluetooth signal would sometimes drop or lag, delaying responses. This was mitigated by ensuring a direct line of sight between the device and module and by implementing automatic reconnection features in the software. Obstacle detection using ultrasonic sensors also posed a difficulty, as certain objects—especially those with sharp edges or reflective surfaces—were not always detected reliably. To improve accuracy, the sensors were calibrated in real-world settings, and additional sensors were positioned at different angles to provide wider detection coverage and prevent collisions.

Integrating multiple hardware components—such as the Arduino, motor driver, ultrasonic sensors, Bluetooth module, and IoT hardware—presented further complications. Power distribution became an issue, with voltage drops and overheating occurring during prolonged use, particularly when the motors were under heavy load. To resolve this, a separate power supply system was designed using a high-capacity rechargeable battery and voltage regulators, allowing for stable performance across all components. Moreover, incorporating IoT features like real-time tracking added software complexity and required reliable internet connectivity. This was successfully implemented using a NodeMCU and Blynk platform, which provided a user-friendly interface for remote monitoring without requiring extensive backend development.

1.5 Objectives

Design and Develop a Voice-Controlled Wheelchair:

- Create a smart wheelchair that can be operated using voice commands to enhance mobility for physically challenged individuals.
- Eliminate the need for manual input devices like joysticks or buttons, making the system accessible for users with limited motor skills.

Integrate Arduino and Bluetooth for Voice Command Processing:

- Use an **Arduino Uno** microcontroller to process voice commands received from a smartphone app via **Bluetooth (HC-05 module)**.
- Enable voice-controlled movement: forward, backward, left, right, and stop.

Ensure Safety with Obstacle Detection:

- Integrate **ultrasonic sensors** to detect obstacles in the wheelchair's path.
- Automatically stop the wheelchair or alter its movement when an obstacle is detected, preventing potential accidents or collisions.

Incorporate IoT Features for Remote Monitoring:

- Use **IoT technology** (e.g., **NodeMCU** or **ESP8266**) for real-time monitoring and remote control.
- Allow caregivers and family members to track the wheelchair's location, receive system status updates, and receive emergency alerts.

Provide an Affordable and User-Friendly Solution:

- Ensure that the system is affordable, using commonly available components that can be sourced easily and inexpensively.
- Design the wheelchair to be easy to operate, with simple, clear voice commands and a user-friendly smartphone interface.

CHAPTER 2

LITERATURE REVIEW

Smart wheelchairs have emerged as a critical innovation in assistive technology, aiming to improve mobility, independence, and quality of life for individuals with physical disabilities. A. Gupta et al. [4] developed a voice-controlled smart wheelchair system intended to help physically challenged users navigate their surroundings without manual effort. The wheelchair responded to predefined voice commands through an embedded microcontroller system. Their implementation demonstrated significant improvement in usability and accessibility, particularly in indoor settings with minimal ambient noise interference.

Advancing from voice-only control, A. Joshi et al. [5] presented an Android-based automated wheelchair where a mobile application was used to send control commands via Bluetooth to a microcontroller. This approach emphasized the use of common smartphones as control devices, eliminating the need for separate hardware remotes and reducing the overall system cost. The system showed good user adaptability and highlighted the growing trend of mobile-integration in assistive devices.

For users with speech impairments, gesture-based control systems offer a promising alternative. D. Goyal and S. P. S. Saini [3] introduced an accelerometer-based hand gesture controlled wheelchair. The system allowed users to control the wheelchair's direction using subtle wrist movements. This hands-free approach expanded accessibility and was particularly suited for individuals with intact upper limb motor control but limited speech capabilities. Their work demonstrated real-time responsiveness and accurate gesture interpretation.

H. Xue and S. Qin [15] explored the concept of mobile motion gesture design tailored for deaf individuals, which laid the groundwork for intuitive gesture-based interaction in smart devices. Their research, although not wheelchair-specific, emphasized the importance of ergonomically designed gestures and the impact of user-centric interfaces. Their findings suggested that the efficiency of gesture-based systems heavily depends on gesture design, recognition accuracy, and user comfort.

An integrated approach was taken by J. Leaman et al. [8], who designed a smart wheelchair with multiple control modalities and built-in sensors for safety and obstacle detection. Their system demonstrated that incorporating diverse control options (e.g., joystick, voice, sensors) enhanced usability for a broader user base. Additionally, the study addressed power management and user interface optimization, contributing to the development of intelligent assistive systems that are both functional and user-friendly.

J. Zeng et al. [16] further refined gesture control by employing vision-based systems that utilized computer vision algorithms to interpret hand gestures. Their natural gesture interface system allowed for more intuitive and accurate control, especially for users uncomfortable with physical controllers. Their work emphasized the role of machine learning in adaptive control systems and the potential for these systems in medical and assistive technologies.

Combining voice and gesture control, K. Sudheer et al. [13] designed a hybrid electric-powered wheelchair using an ARM microcontroller. This dual-mode control approach provided backup options in case one mode failed, thus enhancing system reliability. The integration of voice and gesture inputs allowed users with varying levels of disability to operate the system efficiently, making it suitable for complex real-world environments. The system also showed potential for expansion into autonomous or semi-autonomous control in future iterations.

Low-cost and embedded system-based designs were explored by P. Doshi Siddharth and S. Deshpande [2] and P. Sutha et al. [12]. These works demonstrated that real-time interaction and voice-controlled systems could be implemented using platforms like Arduino and simple sensors. Their contributions are particularly important for resource-constrained environments where affordability and ease of implementation are crucial. Their work supports the idea that even basic systems can significantly improve the lives of people with mobility challenges when designed thoughtfully.

CHAPTER 3

NEED OF THE PROJECT

People with physical disabilities, especially those who suffer from severe motor impairments, face significant challenges when it comes to mobility and independence. Traditional manual or joystick-controlled wheelchairs require the user to exert physical effort or possess adequate hand coordination, which is not possible for all individuals. As a result, many disabled individuals remain dependent on caregivers for even basic movement. There is a clear and growing need for an intelligent, hands-free mobility solution that restores a sense of freedom and autonomy to such users.

A voice-controlled smart wheelchair addresses this critical gap by allowing users to control their movement using simple voice commands. This technology opens up new opportunities for people who cannot use their hands or arms effectively but can speak and interact vocally. With voice command integration, users can move forward, backward, turn, or stop the wheelchair simply by speaking, thereby improving their quality of life and reducing reliance on others.

Safety is another major reason that necessitates the development of this project. Physically challenged users may not be able to react quickly in case of sudden obstacles or dangerous situations. By integrating ultrasonic sensors for obstacle detection, the system adds a crucial safety layer that can prevent collisions or falls. This feature is especially important in environments where the user might encounter furniture, walls, or other people.

Furthermore, the use of IoT technology adds immense value to the system by enabling real-time monitoring and remote assistance. Family members or caregivers can track the wheelchair's movement and receive alerts in case of emergencies. This connectivity improves not only safety but also peace of mind for both the user and their loved ones, especially in outdoor or unsupervised settings.

In addition, there is a strong societal and humanitarian need to make such technologies affordable and accessible. Most advanced wheelchairs available in the market are expensive and out of reach for the average person, especially in developing countries. This project uses cost-effective and easily available components like Arduino Uno, Bluetooth modules, and ultrasonic sensors, making the smart wheelchair a practical and economical solution for large-scale adoption.

3.1 Existing System

The current landscape of wheelchair technology includes both manual and motorized options, each with distinct limitations. Manual wheelchairs are the most common and affordable but require physical strength or caregiver assistance to operate. For users with severe motor impairments, this results in a lack of autonomy and increased dependence. Even motorized wheelchairs, which rely on joysticks or button controls, are not suitable for individuals with restricted hand movement or muscle weakness, thereby failing to meet the needs of a specific group of users.

To address this gap, several assistive technologies have emerged over the years. Some existing systems incorporate joystick-based electric wheelchairs, which offer better control and reduced physical effort. While these are widely used, they still rely on hand coordination and do not solve the issue for users with upper limb disabilities. Additionally, some advanced wheelchairs make use of eye-tracking systems, brain–computer interfaces (BCI), or gesture recognition to operate. However, these technologies are often costly, complex, and not easily accessible to most users, especially in low-income or rural settings.

Voice-controlled systems have also been introduced in recent years. Some commercial models use in-built voice recognition hardware to operate the wheelchair. However, these systems tend to be expensive and sometimes unreliable in noisy environments. Moreover, voice recognition modules integrated into hardware have limited language support and lack adaptability. Many of these products also do not incorporate IoT or obstacle detection, which are essential for user safety and remote monitoring.

In terms of obstacle detection, certain motorized wheelchairs are equipped with basic sensors that help avoid collisions. However, these features are typically only available in premium models and often lack real-time responsiveness. Some systems even require external programming or calibration by trained professionals, which can be inconvenient and not user-friendly for the average person. The lack of integration between safety, control, and monitoring features remains a major limitation of current systems.

Therefore, while there are several existing solutions on the market, most of them either lack affordability, comprehensive functionality, or accessibility. They often focus on one feature—like control or mobility—without addressing the complete set of needs faced by physically challenged individuals. This project aims to build on the strengths of these existing systems while overcoming their limitations through a low-cost, voice-controlled, sensor-integrated, and IoT-enabled smart wheelchair that offers an all-in-one solution.

3.4 Proposed System

The proposed system is designed to assist physically challenged individuals by providing a smart wheelchair that operates through voice commands, with integrated safety features and IoT capabilities. The system uses an **Arduino Uno** as the main controller, interfacing with a **Bluetooth module (HC-05)** to receive commands from a **voice recognition app on a smartphone**. This voice-based interface enables users with limited or no hand movement to control the wheelchair's direction—forward, backward, left, right—and stop, using simple voice inputs. This eliminates the need for physical controls like joysticks or switches and significantly improves user autonomy.

To ensure safety during movement, the system includes **ultrasonic sensors** mounted at the front of the wheelchair to detect obstacles in the surrounding environment. These sensors continuously measure the distance to nearby objects, and if an obstacle is detected within a predefined range, the Arduino automatically stops the wheelchair to prevent collisions. This real-time obstacle detection enhances user safety, especially for users who may have slower reaction times or limited spatial awareness.

The project also integrates **IoT (Internet of Things) technology** to provide remote monitoring and emergency support features. Using a **NodeMCU or ESP8266 Wi-Fi module**, the wheelchair can send real-time updates such as GPS location or system status to a connected mobile app or cloud platform. In the event of an emergency or if the user needs assistance, alerts can be sent to a caregiver or family member. This feature ensures peace of mind for both the user and their caregivers, especially in outdoor or unsupervised environments.

The system is designed to be **cost-effective and modular**, using readily available components such as Arduino, Bluetooth modules, ultrasonic sensors, and basic motor drivers (like L298N). By utilizing open-source hardware and software, the solution remains accessible for development, customization, and future expansion. The low cost makes it feasible for use in developing regions where advanced mobility aids are often unaffordable.

Overall, the proposed system aims to bridge the gap between expensive commercial smart wheelchairs and the basic mobility devices currently available. By combining voice control, obstacle avoidance, and IoT integration in a user-friendly and budget-conscious design, the project provides a meaningful and practical solution that enhances independence, safety, and dignity for people with physical disabilities.

CHAPTER 4

SYSTEM FUNCTIONS

The **system function** of the proposed smart wheelchair is centered around providing an accessible, voice-controlled mobility solution with enhanced safety and monitoring features. It consists of several integrated modules that work together to perform specific tasks aimed at improving the user's mobility, independence, and safety.

1. **Voice Command Operation:**
   The primary function of the system is to allow the user to control the wheelchair through voice commands. A smartphone application with built-in speech recognition listens to commands such as “forward,” “backward,” “left,” “right,” and “stop.” These commands are converted into data and sent via Bluetooth to the HC-05 module connected to the Arduino Uno. The Arduino processes these commands and controls the movement of the motors accordingly, enabling hands-free operation.
2. **Motor Control Mechanism:**
   The Arduino Uno receives instructions from the Bluetooth module and sends control signals to the motor driver (L298N) to power the DC motors. Each command from the user triggers a specific motor rotation direction, enabling forward, backward, or turning motions. The motor driver controls the speed and direction of the wheels, ensuring smooth and accurate movement of the wheelchair.
3. **Obstacle Detection System:**
   For safety, ultrasonic sensors are mounted at the front of the wheelchair. These sensors continuously emit ultrasonic waves and measure the reflection time to detect obstacles. If an obstacle is detected within a set distance (e.g., 30 cm), the sensor sends data to the Arduino, which immediately stops the motors to avoid collision. This function adds an essential layer of safety, especially for users navigating unfamiliar or cluttered environments.
4. **IoT-Based Monitoring and Alerts:**
   The system also includes an IoT component using a NodeMCU or ESP8266 module. This module connects the wheelchair to a cloud platform or mobile app via Wi-Fi. The system can send real-time updates such as location tracking or emergency alerts to caregivers or family members. This ensures that users remain connected and monitored remotely, especially useful in outdoor or solo travel scenarios.
5. **Power Supply and Integration:**
   A rechargeable battery powers all the components, including the Arduino, sensors, Bluetooth module, and motors. Voltage regulation ensures stable

operation of each module. All the components are integrated neatly on the wheelchair frame, making the system compact and functional without interfering with the user's comfort.

4.1 Hardware Block Diagram

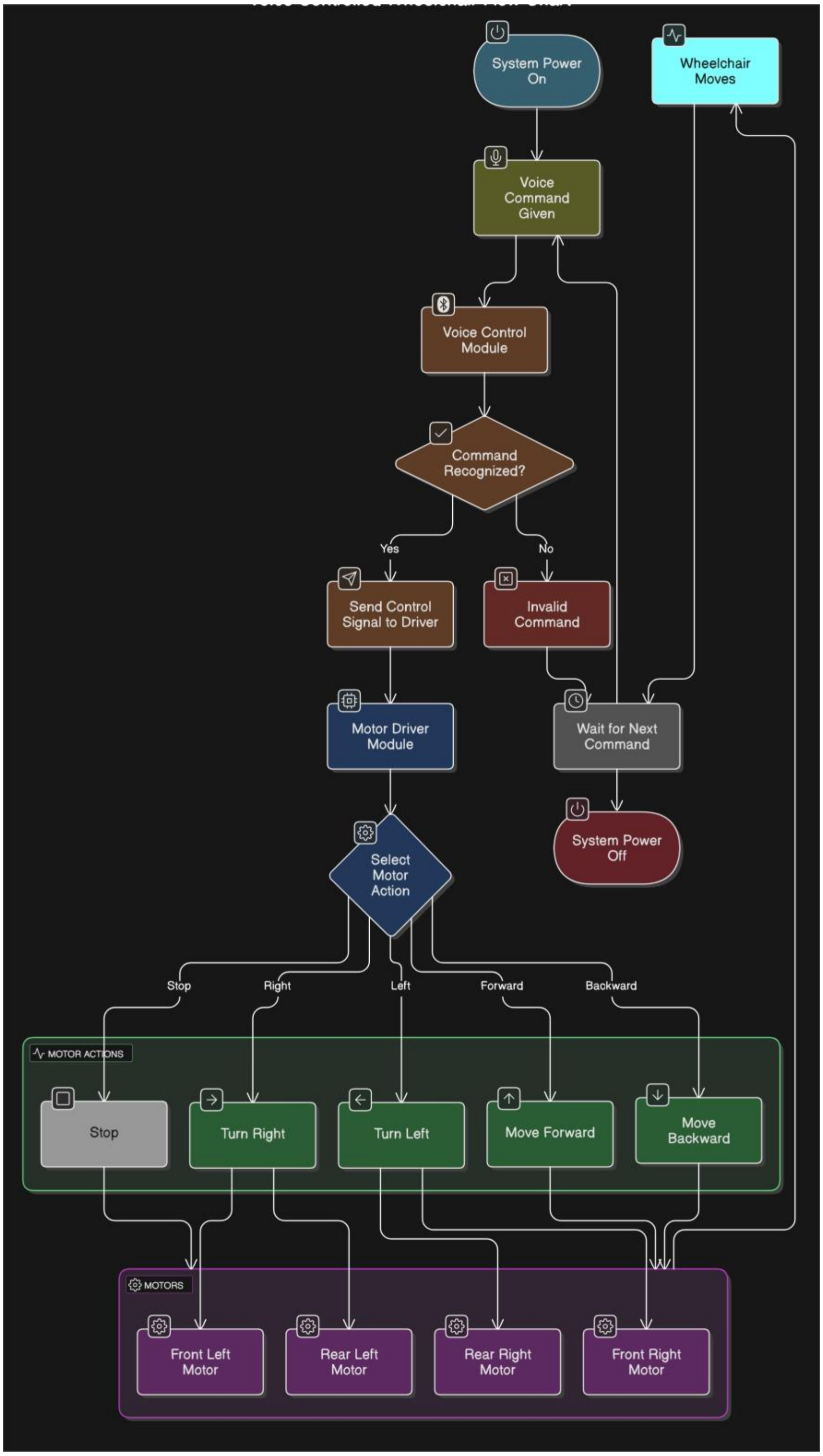

Fig 4.1: block diagram for proposed system

CHAPTER 5

HARDWARE REQUIERMENTS & SPECIFICATION

5.1 Arduino Uno

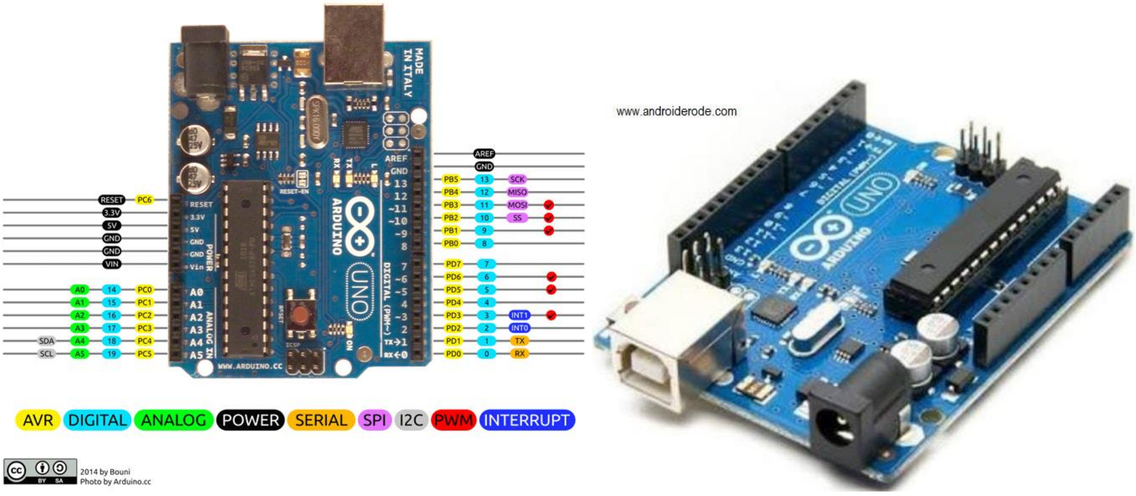

Fig 5.1: Arduino Uno

The **Arduino Uno** plays a vital role as the main controller that manages the overall functionality of the system. It is a microcontroller board based on the ATmega328P, known for its simplicity, reliability, and flexibility in handling various input and output devices. The Arduino Uno is programmed to interpret voice commands received via a voice recognition module or Bluetooth module and convert them into electrical signals to control the direction and speed of the wheelchair. This enables hands-free operation, making it especially beneficial for individuals with limited mobility.

Furthermore, the Arduino Uno interfaces with additional components such as motor drivers, obstacle detection sensors (like ultrasonic sensors), and power supply modules to ensure smooth and safe navigation. It processes sensor data in real time to avoid collisions and respond to the user’s commands promptly. Due to its open-source nature, ease of integration with various modules, and wide community support, the Arduino Uno is an ideal platform for prototyping and developing assistive technologies such as this smart wheelchair, which aims to enhance the independence and quality of life of physically challenged individuals.

5.2 Bluetooth Module

The **Bluetooth module** serves as a key component that enables wireless communication between the user and the wheelchair. Commonly used modules like **HC-05** or **HC-06** are preferred for their compatibility with the **Arduino Uno** and ease of integration. These modules receive voice commands transmitted from a smartphone application and forward them to the Arduino via serial communication. This setup allows users to operate the wheelchair remotely without physical controls, which is especially beneficial for individuals with limited mobility.

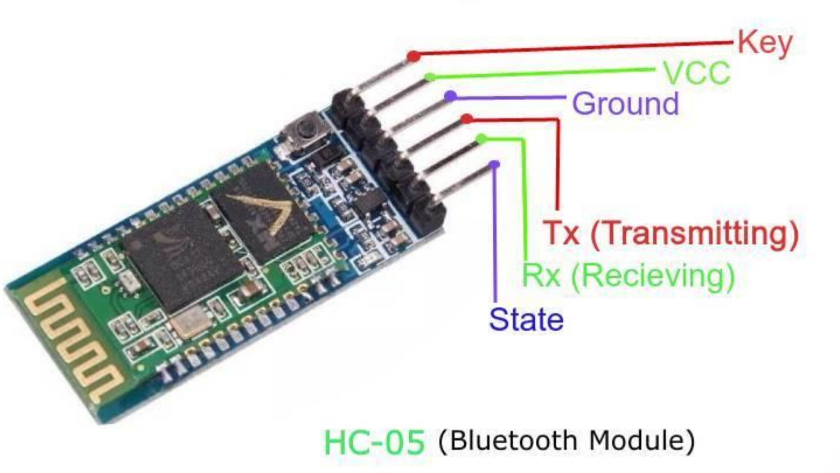

Fig 5.2: Bluetooth Module

The Bluetooth module communicates using the UART (Universal Asynchronous Receiver/Transmitter) protocol, connecting to the Arduino's TX and RX pins. When a user gives a command such as "forward" or "left" through the mobile app, the Bluetooth module receives the signal and instantly sends it to the Arduino for processing. The Arduino then interprets the command and activates the appropriate motors to move the wheelchair in the desired direction. This real-time interaction ensures responsive control, offering a smooth and user-friendly experience.

With a range of up to 10 meters, the Bluetooth module provides reliable wireless connectivity in indoor and controlled environments. Its low power consumption and compact size make it ideal for embedded applications like this smart wheelchair system. By eliminating the need for physical input devices, the Bluetooth module contributes to a cleaner design and greater ease of use. Overall, it plays a crucial role in enhancing the wheelchair's functionality, allowing for efficient, hands-free operation and increased independence for the user.

5.3 Ultrasonic Sensor

Fig 5.3: Ultrasonic Sensor

The **ultrasonic sensor** plays a crucial role in ensuring safe navigation by detecting obstacles in the wheelchair's path. The most commonly used sensor for this purpose is the **HC-SR04**, which operates by emitting ultrasonic sound waves and measuring the time it takes for the echo to bounce back after hitting an object. This time is used to calculate the distance between the wheelchair and the obstacle, allowing the system to sense and avoid potential collisions.

The ultrasonic sensor is typically positioned at the front of the wheelchair and sometimes on the sides, depending on the design, to cover multiple directions. When the wheelchair is in motion, the sensor continuously monitors the surroundings and sends real-time distance data to the **Arduino Uno**. If an obstacle is detected within a predefined safety range, the Arduino is programmed to either stop or redirect the wheelchair to avoid the object. This automatic response adds an extra layer of safety, reducing the risk of accidents and making the wheelchair more reliable in various environments.

By integrating the ultrasonic sensor, the smart wheelchair gains an important autonomous feature that does not rely on user input. This is especially helpful for users who may have limited awareness of their surroundings. The sensor's fast response, accuracy, and ability to function in various lighting conditions make it highly suitable for assistive applications. Overall, the ultrasonic sensor enhances the system's safety, intelligence, and usability, making the wheelchair more effective for physically challenged individuals.

5.4 DC Gear Motor

The **DC gear motor** is a key component responsible for driving the wheels and enabling movement in various directions. These motors are selected for their ability to provide a good balance between speed and torque, making them ideal for applications that require controlled and stable motion. The gear reduction mechanism in these motors allows them to deliver higher torque at lower speeds, which is essential for carrying the weight of the wheelchair and the user while ensuring smooth operation.

Fig 5.4: DC Gear Motor

Each DC gear motor is connected to the motor driver module, which receives control signals from the **Arduino Uno** based on the user’s voice commands. For example, commands such as "forward," "left," or "stop" are processed by the Arduino, which then activates the motors accordingly to achieve the desired movement. The 150 RPM rating ensures that the wheelchair moves at a safe and manageable speed, suitable for both indoor and outdoor environments.

These motors are durable, energy-efficient, and capable of running on 12V DC supply, which aligns well with the power requirements of the overall system. Their compact design and mechanical strength make them suitable for integration into the wheelchair frame without adding excessive bulk. Overall, the 150 RPM DC gear motors play a vital role in enabling reliable and safe mobility for physically challenged users, contributing significantly to the functionality and efficiency of the smart wheelchair system.

5.5 Motor Driver

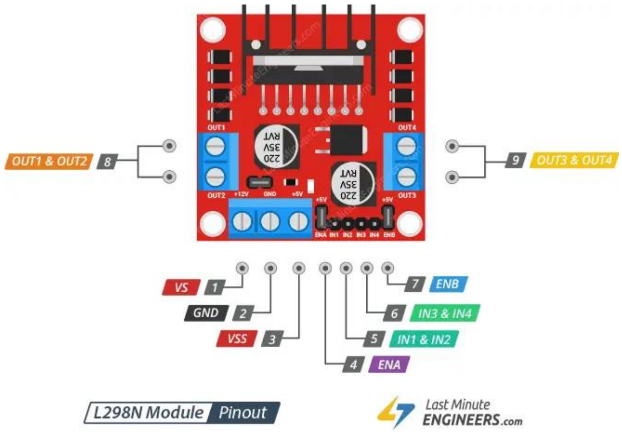

Fig 5.5: Motor Driver

The **L298N Motor Driver Module** plays a crucial role in controlling the movement of the DC gear motors based on commands received from the **Arduino Uno**. The L298N is a dual H-Bridge motor driver module that allows independent control of two DC motors in both forward and reverse directions. It acts as an interface between the low-power control signals from the Arduino and the higher power required by the motors, enabling efficient motor control without overloading the microcontroller.

The L298N receives input signals from the Arduino, which are generated in response to the user's voice commands transmitted via Bluetooth. These signals determine the direction and operation of the motors, such as moving forward, backward, turning left or right, or stopping. The module can handle motor voltages from 5V to 35V and currents up to 2A per channel, making it suitable for driving the 150 RPM DC gear motors used in the wheelchair.

In addition to directional control, the L298N also allows speed regulation through Pulse Width Modulation (PWM) signals from the Arduino. This enables smooth acceleration and deceleration, enhancing user safety and comfort. Its built-in heat sink and compact design make it reliable for long-term use in mobility applications. Overall, the L298N motor driver is an essential component that ensures accurate, stable, and safe control of the wheelchair's motion, making it a critical part of the smart wheelchair system.

5.6 Wheels

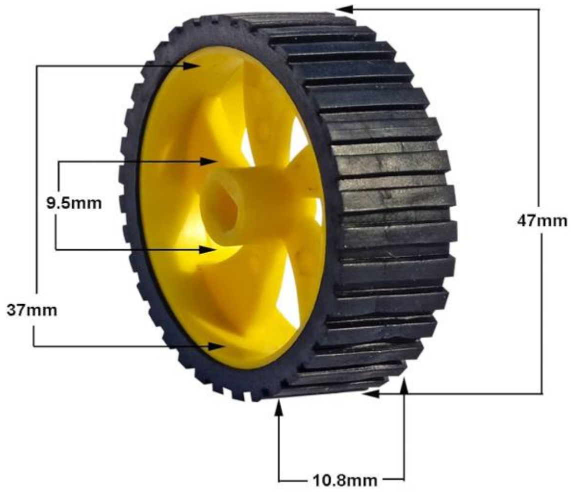

Fig 5.6: Wheels

The **wheels** are a fundamental mechanical component that enable the actual movement and navigation of the wheelchair. Typically, two large rear wheels are directly connected to the 150 RPM DC gear motors, providing the main driving force, while smaller front caster wheels offer balance and allow smooth turning. The size, material, and grip of the wheels are selected to ensure stability, support the user's weight, and provide smooth movement on various surfaces. Proper alignment and installation of the wheels are essential for effective turning, braking, and overall performance of the smart wheelchair system.

5.7 Jumper Wires

Fig 5.7: Jumper wires

Jumper wires are essential for making electrical connections between different components on the breadboard and the Arduino Uno. These flexible wires come with male-to-male, female-to-female, or male-to-female connectors, allowing easy and quick connections without the need for soldering. Jumper wires are used to connect modules such as the Bluetooth module, ultrasonic sensor, motor driver, and power supply to the Arduino, enabling communication and signal transmission. Their reusability and ease of use make them ideal for prototyping and testing, ensuring reliable connectivity throughout the smart wheelchair system.

5.8 Power Supply

The **12V 1.3A power supply** is used to provide stable electrical power to key components such as the DC gear motors and the L298N motor driver. This power rating is sufficient to drive the motors efficiently while ensuring that the system operates smoothly without overheating or voltage drops. The 12V output matches the operating voltage of the motors and driver module, while the 1.3A current provides enough capacity for moderate load conditions. A regulated and reliable power source like this ensures consistent performance, making it a crucial part of the smart wheelchair's electrical system.

Fig 5.8: Power Supply

CHAPTER 6

SYSTEM REQUIREMENTS

6.1 Arduino Ide

Fig 6.1: Arduino Ide

The **Arduino Integrated Development Environment (IDE)** is the primary software platform used for writing, compiling, and uploading code to the Arduino Uno microcontroller in this smart wheelchair project. It provides a user-friendly interface that supports programming in a simplified version of C/C++, making it accessible to both beginners and experienced developers. The IDE allows users to control and coordinate various hardware components such as the DC motors, ultrasonic sensor, Bluetooth module, and motor driver through a central microcontroller.

In the context of this project, the Arduino IDE enables developers to write the logic that processes voice commands received via the Bluetooth module and triggers appropriate actions, such as moving the wheelchair forward, backward, or stopping. It also handles input from the ultrasonic sensor to avoid collisions by stopping the motors if an obstacle is detected. These functions are defined in the form of code blocks, uploaded to the Arduino Uno through a USB connection directly from the IDE.

One of the main advantages of the Arduino IDE is its **extensive library support**. Libraries for handling Bluetooth communication, motor drivers, and ultrasonic sensors are readily available and easy to integrate. This simplifies development by allowing users to focus on higher-level logic rather than writing low-level code for hardware interaction. The serial monitor built into the IDE is another useful feature, which helps in real-time debugging and testing by displaying data sent from the Arduino board.

Additionally, the Arduino IDE supports code modularity and reusability, allowing functions and sensor routines to be written in separate blocks. This not only improves the readability of the code but also makes it easier to troubleshoot and upgrade specific features without affecting the entire system. Its compatibility with multiple operating systems—Windows, macOS, and Linux—adds to its flexibility, making it suitable for use in various development environments.

In summary, the Arduino IDE plays a vital role in the development and functioning of the smart wheelchair project. Its simplicity, powerful tools, and strong community support make it the ideal platform for programming the control logic, handling real-time sensor inputs, and ensuring smooth communication between components, ultimately contributing to the overall success and reliability of the system.

6.2. ARDUINO BLUETOOTH CONTROL:

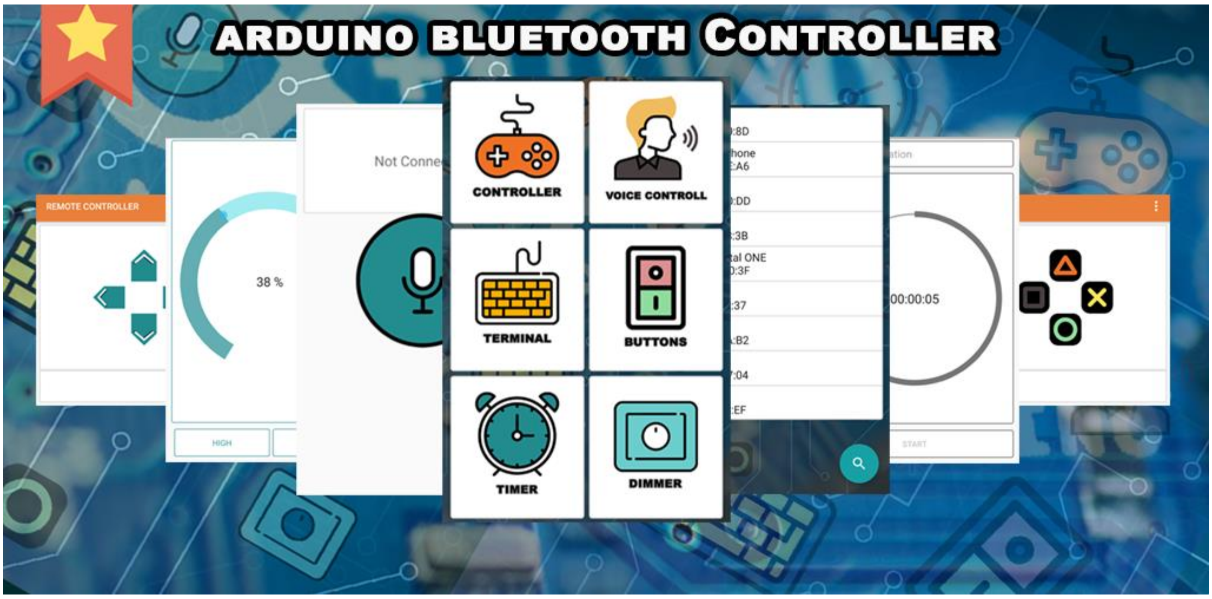

Fig 6.2: Arduino Bluetooth Control

The Arduino Bluetooth Control App is a widely used mobile application designed to facilitate wireless communication between a smartphone and an Arduino-based system using Bluetooth technology. This app plays a crucial role in various automation and robotics projects, particularly in assistive devices like voice-controlled smart wheelchairs. By leveraging Bluetooth modules such as the HC-05 or HC-06, the app allows users to send specific commands from their smartphones to the Arduino board, which then interprets and executes those commands to perform desired functions, such as moving forward, backward, or turning.

One of the major advantages of using this app is its simplicity and user-friendliness. It typically features customizable buttons where predefined commands can be assigned, making it easy even for non-technical users to operate a complex system. For example, pressing the “Forward” button on the app sends a specific character or string like “F” to the Arduino via Bluetooth, which the Arduino code is programmed to interpret and respond to by activating the motors in the forward direction.

The app eliminates the need for physical switches or remotes, making it ideal for users with limited mobility. When integrated into a wheelchair system, the Arduino Bluetooth Control App provides users with enhanced independence and control. Moreover, it supports voice command integration through the phone’s built-in speech recognition feature, which translates spoken commands into text and sends them to the Arduino—this functionality is particularly beneficial for people with severe physical disabilities.

Another useful feature of this app is its compatibility with Android devices and its ability to work without an internet connection. This ensures that the system remains functional even in remote areas or during power outages. The app can also be customized or expanded by developers using platforms like MIT App Inventor or Android Studio to better suit specific project needs, including adding sensors, camera feeds, or gesture control interfaces.

In conclusion, the Arduino Bluetooth Control App is an essential tool for building wireless control systems, especially for assistive technologies like smart wheelchairs. Its ease of use, flexibility, and cost-effectiveness make it a popular choice for students, developers, and innovators working on accessible and inclusive engineering projects.

CHAPTER 7

WORKING PROCESS

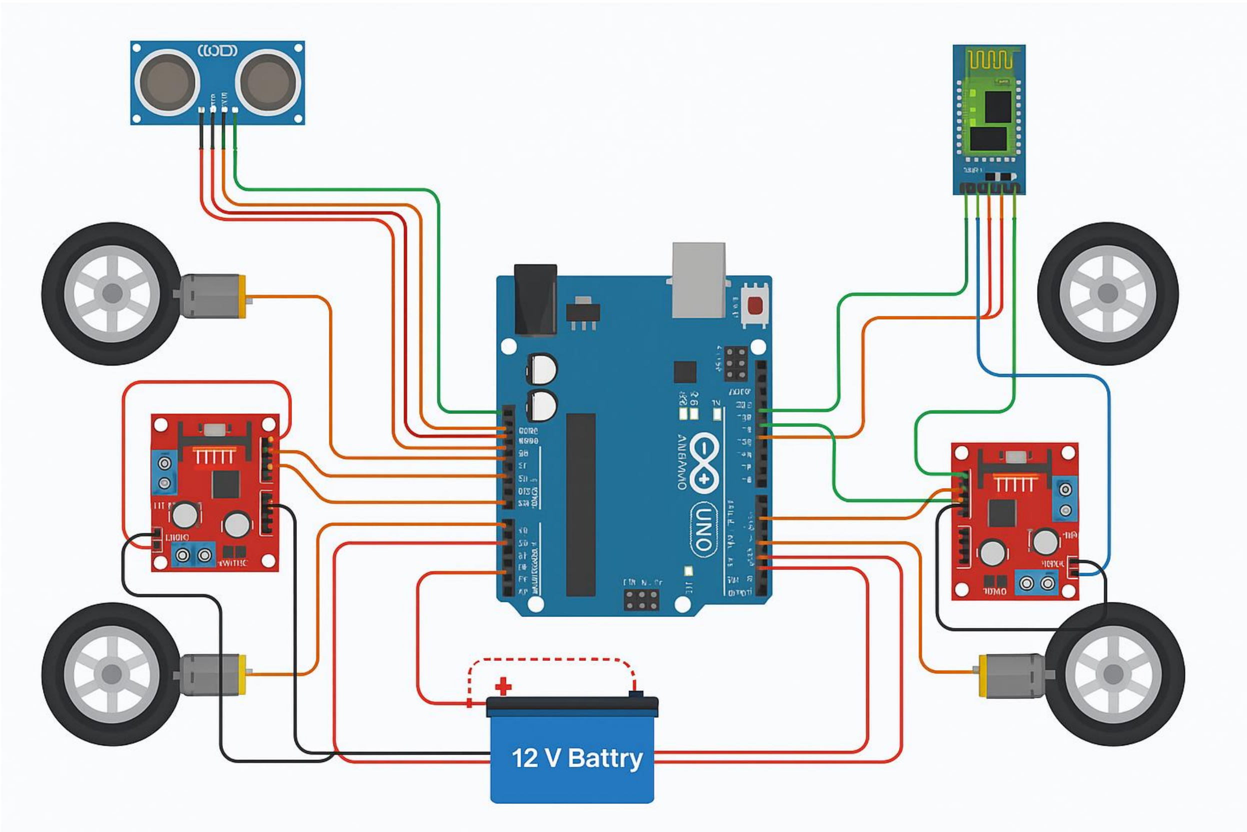

Fig 7.1: WORKING PROCESS

The development of assistive technologies has become increasingly important in the effort to improve the quality of life for individuals with disabilities. Among these innovations, the smart wheelchair stands out as a critical solution to provide enhanced mobility and autonomy. Physically challenged individuals, especially those with limited hand or upper body movement, often struggle with conventional manual or joystick-controlled wheelchairs. The goal of this project is to design and implement a smart wheelchair that can be controlled using voice commands, providing a more accessible and user-friendly experience. This system combines the power of Arduino Uno, Bluetooth communication, ultrasonic sensors for obstacle detection, and IoT technology for remote monitoring and support.

The smart wheelchair operates through a simple yet effective mechanism. The user interacts with the system using their voice through a smartphone application. This app is responsible for converting spoken words into text commands, which are then sent via Bluetooth to an Arduino Uno microcontroller mounted on the wheelchair. Commands such as "forward," "backward," "left," "right," and "stop" are recognized and transmitted wirelessly to the Arduino through the HC-05 Bluetooth module. This communication allows the user to control the movement of the wheelchair without requiring any physical input, making it ideal for individuals with severe physical limitations.

Once the Arduino receives the command, it processes the instruction and triggers the corresponding motion by controlling two DC motors connected via an L298N motor driver module. Each command is mapped to a specific motor configuration. For instance, when the command "forward" is received, both motors are powered in a forward direction, causing the wheelchair to move ahead. If the command is "left," the system may stop the left motor while powering the right one, allowing the wheelchair to turn left. The "stop" command cuts off power to both motors, halting all motion. This basic yet flexible motor control system allows the wheelchair to navigate in all directions based solely on voice inputs.

An essential part of the design is ensuring user safety. This is accomplished using ultrasonic sensors, typically mounted on the front, left, and right sides of the wheelchair. These sensors constantly emit sound waves and calculate the distance to nearby objects based on the echo received. The Arduino uses this data to determine whether there are any obstacles in the immediate path of travel. If an obstacle is detected within a preset threshold—say, 30 centimeters—the system automatically halts the wheelchair's motion, regardless of the voice command. This safety mechanism prevents collisions and accidents, ensuring that users can navigate safely even in cluttered or dynamic environments.

Another innovative feature of the system is the integration of IoT technology. By including a Wi-Fi-enabled module like the ESP8266, the Arduino can connect to the internet and communicate with cloud platforms such as Blynk, ThingSpeak, or Firebase. This connection allows real-time monitoring of the wheelchair’s status, movement history, or battery level. It can also be used to send alerts or emergency notifications to caregivers or family members. For example, if the wheelchair remains stationary for an unusually long time or if the system detects repeated obstacles, an alert can be sent to a mobile device to prompt intervention. This capability is particularly valuable in healthcare facilities or homes where constant human supervision may not be possible.

The entire system is powered using a 12V rechargeable battery that supplies power to the Arduino, motor driver, motors, sensors, and Bluetooth and IoT modules. Power management is crucial in this design, as the components must function reliably for extended periods without frequent charging. Advanced versions of the system can include power-saving techniques such as turning off the Bluetooth or Wi-Fi module when idle or adding solar panels to extend battery life.

The software development for this project is carried out using the Arduino IDE, where the logic for interpreting commands, controlling motors, and reading sensor data is written in C/C++. Libraries such as SoftwareSerial are used to manage Bluetooth communication, while ultrasonic sensor libraries help in accurate distance measurement. The logic flow in the program continuously checks for incoming Bluetooth commands, parses the data, and executes motor control functions. Simultaneously, it checks the ultrasonic sensor readings to ensure obstacle detection is active. If a command is received that would lead the wheelchair into an obstacle, the system overrides the voice command and stops the motors. This makes the wheelchair intelligent enough to prioritize safety over user input when necessary.

In addition to its core functionalities, the smart wheelchair is designed with modularity in mind, allowing for future upgrades and customization based on user needs. Features such as GPS tracking, emergency buttons, or integration with smart home devices can be easily added without significant changes to the existing system. This flexibility not only enhances the usability of the wheelchair but also extends its relevance across different user environments—whether at home, in hospitals, or in public spaces. By prioritizing adaptability, the project ensures that the smart wheelchair remains a practical and scalable solution for improving the independence and safety of physically challenged individuals.

CHAPTER 8

PROGRAMMING

```
#include <SoftwareSerial.h>

SoftwareSerial BT(0,1); // RX, TX

String readvoice;

#define MLa 5   //left motor 1st pin

#define MLb 4    //left motor 2nd pin

#define MRa 3    //right motor 1st pin

#define MRb 2    //right motor 2nd pin

#define enb1 9

#define enb2 10

#define trigPin 7

#define echoPin 6

long duration;

int distance;

void setup()

{

  Serial.begin(9600);

  BT.begin(9600);

pinMode(MLa,OUTPUT);   //left motors forward

pinMode(MLb,OUTPUT);   //left motors reverse

pinMode(MRa,OUTPUT);   //right motors forward

pinMode(MRb,OUTPUT);   //right motors reverse

pinMode(enb1,OUTPUT);

pinMode(enb2,OUTPUT);
```

```
pinMode(trigPin,OUTPUT);
  pinMode(echoPin,INPUT);
}
void loop()
{
 digitalWrite(trigPin,LOW);
  delay(2000);
  digitalWrite(trigPin,HIGH);
  digitalWrite(trigPin,LOW);
  duration =pulseIn(echoPin,HIGH);
  distance= duration * 0.034/2;
  Serial.print("Distance:");
  Serial.print(distance);
  Serial.println("cm");
  if (distance <100)
  {
 digitalWrite(MLa,LOW);
 digitalWrite(MLb,LOW);
 digitalWrite(MRa,LOW);
 digitalWrite(MRb,LOW);
 analogWrite(enb1,0);
 analogWrite(enb2,0);
  }
while (BT.available())
```

```
{
  delay(10);
  char c = BT.read();
  readvoice += c;
}
 if (readvoice.length()>0)
 {
  Serial.println(readvoice);
  if (readvoice == "forward")
  {          //move forward(all motors rotate in forward direction)
        digitalWrite(MLa,LOW);
        digitalWrite(MLb,HIGH);
        digitalWrite(MRa,HIGH);
        digitalWrite(MRb,LOW);
        analogWrite(enb1,500);
        analogWrite(enb2,500);
        delay(100);
      }
  else if (readvoice == "Back")

      {     //move reverse (all motors rotate in reverse direction)
        digitalWrite(MLa,HIGH);
        digitalWrite(MLb,LOW);
```

```
        digitalWrite(MRa,LOW);
        digitalWrite(MRb,HIGH);
        analogWrite(enb1,500);
        analogWrite(enb2,500);
        delay(100);
       }
 else if (readvoice == "Left")
       {          //turn right (left side motors rotate in forward direction, right side motors doesn't rotate)
        digitalWrite(MLa,HIGH);
        digitalWrite(MLb,LOW);
        digitalWrite(MRa,HIGH);
        digitalWrite(MRb,LOW);
        analogWrite(enb1,500);
        analogWrite(enb2,500);
        delay(100);
       }
  else if (readvoice == "Right")

       {      //turn left (right side motors rotate in forward direction, left side motors doesn't rotate)
        digitalWrite(MLa,LOW);
        digitalWrite(MLb,HIGH);
        digitalWrite(MRa,LOW);
        digitalWrite(MRb,HIGH);
```

```
        analogWrite(enb1,500);
        analogWrite(enb2,500);
        delay(100);
       }
  else if (readvoice == "Stop")
       {          //STOP (all motors stop)
        digitalWrite(MLa,LOW);
        digitalWrite(MLb,LOW);
        digitalWrite(MRa,LOW);
        digitalWrite(MRb,LOW);
         analogWrite(enb1,0);
        analogWrite(enb2,0);
        delay(100);
       }
readvoice="";}
}
```

CHAPTER 9

COST ESTIMATION

SL.NO	COMPONENTS	COST Rs/-
1	ARDUINO UNO	765
2	HC-05 BLUETOOTH MODULE	345
3	L298N MOTOR DRIVER	275
4	HC SRO4	246
5	DC GEAR MOTOR(4)	1280
6	WHEELS	152
7	12V RECHARGEABLE BATTERY	1540
8	JUMPER WIRES AND CONNECTORS	256
9	CHASSIS	1560
10	CONNECTOR WIRES	230
11	MISCELLANEOUS	560
	TOTAL	7209

Table.9.1: Cost Estimation

CHAPTER 10

CONCLUSION

The development of a smart wheelchair with voice control marks a significant advancement in assistive technology, greatly enhancing the mobility, autonomy, and overall quality of life for individuals with physical disabilities. By integrating voice recognition technology with motorized movement control, the system allows users to operate the wheelchair through simple voice commands, eliminating the need for manual controls. This makes it an ideal solution for users with limited limb functionality or other mobility challenges, offering a more accessible and dignified mode of transportation.

Furthermore, the project highlights the practicality of using cost-effective hardware components like Arduino Uno, HC-05 Bluetooth modules, and ultrasonic sensors, along with open-source platforms, to create reliable and user-friendly assistive devices. The successful design and implementation open the door to further enhancements such as GPS tracking, real-time health monitoring, and IoT-based remote assistance for caregivers.

APPENDIX

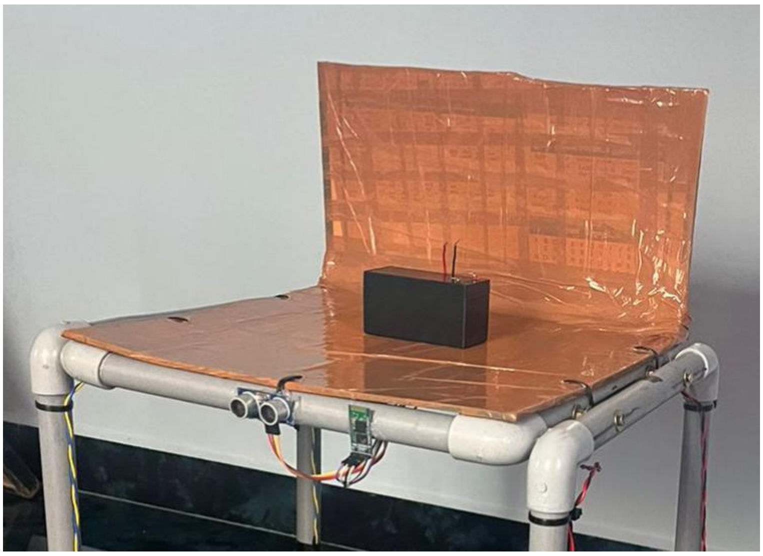

Fig : APPENDIX

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