School of
Electronics and Communication Engineering

Minior Project - 1 Report

on

Gesture Controlled Wheel Chair

By:

1. **Diven Bafna** USN: 01FE21BEC141
2. **Lakshmishree** USN: 01FE21BEC142
3. **Ravindra.R** USN: 01FE21BEC164
4. **Manjula.B** USN: 01FE21BEC074

Semester: VI, 2023-2024

Under the Guidance of

Prof.Vidyashri Hiremath

K.L.E SOCIETY'S
KLE Technological University,
HUBBALLI-580031
2023-2024

SCHOOL OF ELECTRONICS AND COMMUNICATION ENGINEERING

CERTIFICATE

This is to certify that project entitled **Gesture Controlled Wheel Chair** is a bonafide work carried out by the student team of **Lakshmishree (01FE21BEC142), Diven Bafna (01FE21BEC141), Ravindra Radder (01fe21bec164), Manjula Benal (01FE21BEC074)**. The project report has been approved as it satisfies the requirements concerning the mini project work prescribed by the university curriculum for BE (VI Semester) in the School of Electronics and Communication Engineering of KLE Technological University for the academic year 2023-2024.

Prof.Vidyashri Hiremath **Guide**	**Suneeta V Budihal** **Head of School**	**B. S. Anami** **Registrar**

External Viva:

Name of Examiners **Signature with date**

1.

2.

ACKNOWLEDGMENT

The success of every initiative is mostly due to the efforts of many people who have regularly offered their wise advice or a helpful hand. We are grateful to everyone who made this endeavor possible by providing inspiration, guidance, and support. We take this opportunity to thank Dr. Suneeta V. Budihal, Head of the School of Electronics and Communications for giving us a learning environment that supported the growth of our practical skills, which was essential to the success of our project. We would also like to take this opportunity to express our gratitude to Prof. Vidyashri Hiremath. for her ongoing guidance, supervision, and providing of the data we required to finish the research. We are appreciative and happy to have continued assistance, inspiration, and

-PKP Team 14

ABSTRACT

The Controlled Hand Gesture Robot for Various Applications project presents a cutting-edge method of employing hand gestures to control robots, with an emphasis on tilting motions. The technology uses a variety of sensors to identify the user's hand tilt and converts these movements into orders for the robot's control or navigation. Applications for the technology are numerous and include wheelchair navigation in the medical industry, as well as security and surveillance using quadcopters and unmanned ground vehicles (UGVs). This article describes the tilt-controlled hand gesture robot's development, use, and prospects.

Alternatively, We done by The Semi-Automatic Wheel Chair for Various Applications project describes how to create a semi-automatic wheelchair that can be controlled by Bluetooth. It does this by using an L298N motor driver, ordinary wheels, and an ESP32 microcontroller that can all be programmed using the Arduino IDE. A smartphone serves as the control device, pairing via Bluetooth with the ESP32 to carry out navigational commands. Standard wheels are mounted atop DC gear motors, connected to the ESP32 and motor driver, and powered by an appropriate battery pack as part of the hardware arrangement. Software is used to implement command reception systems, motor control operations, and Bluetooth configuration. This initiative promotes creativity in robotics and wireless control by giving hands-on, practical experience in microcontroller programming, motor control, and Bluetooth connectivity. Furthermore, the flexibility of the ESP8266 code.

List of Figures

Chapter 1

Introduction

1.1 Motivation

This strategy is driven by its potential to revolutionize several sectors where exact control and navigation are crucial. For example, in the field of security and surveillance, unmanned ground vehicles (UGVs) and quadcopters with tilt-controlled hand gesture technology can provide better agility and reactivity, which makes them perfect for jobs like perimeter monitoring and reconnaissance. Furthermore, the uses go beyond monitoring and security. The capacity to operate devices using basic hand gestures can greatly improve accessibility and freedom in medical settings, such as wheelchair navigation for those with mobility disabilities. Users with restricted mobility may be empowered by this technology, giving them more autonomy and efficiency when navigating their surroundings.

The urgent need to improve mobility solutions, particularly in the medical field, is what motivates this initiative and will improve the lives of those who are limited in their movement. The purpose of creating a wheelchair that is partially autonomous and can be operated by Bluetooth is to address the challenges encountered by individuals who have limited mobility and provide them with increased freedom and control over their environment. With the use of Bluetooth connectivity and the ESP32 microcontroller's capabilities, the project seeks to develop an approachable mobility solution that can be managed with a smartphone. It also provides an educational opportunity to explore motor control, Bluetooth communication integration, and microcontroller programming, encouraging creativity and skill development in robotics and wireless control. The project's focus on medical applications is intended to further the development of.

1.2 Objectives

The purpose of this wheelchair with hand gestures.
1. Hardware Integration: Attach sensors to the LPC1768 microcontroller platform that can recognize hand tilt motions. To precisely record hand movements, an accelerometer or six gyroscope sensors may be used.
2. Signal Processing: Create signal processing techniques that can decipher sensor data and derive useful information about hand tilt gestures made by the user.
3. Gesture Recognition: Put gesture recognition algorithms into practice to convert tilt gestures that are recognized into particular commands or control signals for the robot. This entails mapping different tilt motions to matching actions or movements of the robot.
4. Real-Time Control: Verify that the system can operate the robot in real time by using hand movements that have been identified. This necessitates prompt control signal generation and

effective sensor data processing.

The purpose of this ESP32 semi-automated wheelchair system.
1. Develop a Semi-Automatic Wheelchair System: - Provide people with mobility disabilities with a semi-automatic wheelchair system that can be operated via Bluetooth.

2. Improve Mobility Solutions: - Provide people with mobility impairments with an accessible and easy-to-use way to navigate their environment, thereby addressing the difficulties they encounter.

3. Make Use of the ESP32 Microcontroller and Bluetooth Communication: - Make use of the ESP32 microcontroller's and Bluetooth communication features to enable smooth wheelchair system control from a smartphone.

4. Ensure User-Friendly Operation: - Make sure the wheelchair system is simple to use and intuitive so that people with mobility issues may use it efficiently on their own without help.

5. Educational Opportunity: - Offer a platform for learning about motor control, Bluetooth integration, and microcontroller programming, encouraging creativity and the growth of robotics and wireless control skills.

6. progress Assistive Technology: - Develop a mobility solution that greatly enhances the quality of life and fosters inclusion for people with mobility issues. This will help progress assistive technologies, especially in the medical industry.

.

1.3 Literature survey

The Gesture Controlled Robot: Various studies focusing on gesture detection systems for improving human-machine interaction and controlling robotic devices are included in the literature review. These systems provide simple interfaces for users to interact with robots by using sensors like gyroscopes and accelerometers to understand hand gestures. Research publications address the development of gesture-based control systems intending to improve accessibility and simplify complex tasks for robotic wheelchairs, underwater remotely operated robots, and general-purpose robots. These systems frequently use Arduino microcontrollers because of their adaptability and simplicity of use. The body of research indicates that gesture recognition technology has the potential to transform robotics by facilitating efficient and natural interactions between people and machines.

Hand Gesture Controlled Robot using Accelerometer : A review of the literature on hand gesture-controlled robots demonstrates the wide variety of methods and tools used in the creation of these systems. Researchers have used a variety of combinations of hardware components, such as RF modules, Bluetooth, Zigbee, and Arduino communication modules; accelerometers (ADXL345 and ADXL355); and microcontrollers (ATmega and Arduino series). With the use of these devices, people may operate robots with hand gestures as an alternative to traditional joysticks or physical controllers, providing a more natural and intuitive means of engagement. Studies have looked into applications in a variety of fields, including medical, assistive technology, industrial robotics, and defense. These studies have shown how gesture-controlled robots can improve human-robot interaction and meet particular user needs, such as those of people with physical disabilities. Thanks to developments in wireless communication, signal processing, and sensor technology

Embedded system design for real-time interaction with Smart Wheelchair : Over the past ten years, there has been a lot of research interest in smart wheelchairs, to improve mobility and independence for the elderly and physically challenged. Numerous strategies have been investigated, such as fall detection mechanisms, semi-automated visual aids, and RFID-based navigation systems; however, many of the current methods are either expensive or do not allow for real-time environmental interaction. Current research highlights the use of MEMS accelerometers for fall detection and ultrasonic sensors for obstacle avoidance in conjunction with RTOS-integrated microcontrollers for precise control. To increase user autonomy and safety, innovations including health monitoring systems, GPS for location tracking, and GSM for emergency communication have been implemented. The problem of creating universally accessible, cost-effective smart wheelchairs persists despite progress made in this area.

An autonomous wheelchair with a health monitoring system based on the Internet of Things : In order to provide patients and the elderly with mobility support and health monitoring, Hou et al.'s (2024) research focuses on the creation of an autonomous wheelchair system integrated with biophysical sensors based on the Internet of Things (IoT). To facilitate proactive healthcare management, the study suggests a powered wheelchair outfitted with three biophysical sensors that would gather and communicate users' vital indicators in real-time. The system also makes use of cloud-based artificial intelligence (AI) algorithms for data analysis and visualization, which enables clinicians to monitor patients remotely. Notably, O-MAS-R, an improved data compression technique, is introduced to improve the efficiency of data transmission. The wheelchair prototype is equipped with functions including autonomous localization, point-to-point route planning within a designated area, and obstruct laser scanning.

Design of Voice-Controlled Smart Wheelchair for Physically Challenged Persons : literature review delve into the advancement of smart wheelchair technology, emphasizing how cutting-edge innovations might improve mobility for those with physical disabilities. The article addresses several strategies to allow for ease of use and autonomous movement, including line following, voice control, obstacle avoidance, and sensor and microcontroller integration. The survey's references cover a wide range of approaches, such as voice recognition, eye tracking, touch screen control, and collision avoidance systems, which reflects the variety of technological solutions that have been investigated in the sector. The study highlights the significance of intuitive interfaces and instantaneous feedback systems in guaranteeing the efficiency and practicality of intelligent wheelchair designs. This thorough analysis offers insightful information about the most recent developments in assistive technology for improving mobility.

1.4 Problem Statement

"To develop a Gestured Controlled Wheel Chair"

1.5 Application in Societal Context

"Hand Gestured Wheel Chair"
1. Assistive technology for people with disabilities:
a controlled hand gesture robot can be used by people with disabilities as an assistive technology impairment, especially for individuals with restricted movement. The robot can improve users' freedom and quality of life by helping them with a variety of tasks, like collecting goods, opening doors, and turning on and off appliances, by understanding hand gestures.
2. Rehabilitation and Therapy:
Controlled hand gesture robots can be used for therapy and rehabilitation in healthcare environments. To facilitate the development of motor skills and aid in the healing process, patients undergoing physical therapy or recuperating from injuries can engage with a robot via hand gestures.
3. Education and STEM Outreach:
Students can be engaged in STEM (Science, Technology, Engineering, and Mathematics) subjects by using technology in educational settings.

1.5.1 Alternate Design

"Semi-Automatic Wheel Chair"
1. Improving Inclusion in Social Circles:
The semi-automatic wheelchair system encourages social inclusion by giving people with mobility limitations more independence and autonomy so they may take part more actively in social events, activities, and gatherings.

2. Enhancing Quality of Life:
Having access to an accessible and user-friendly mobility solution can greatly enhance the quality of life for people who have mobility issues by enabling them to participate in daily activities with more confidence and ease.

3. Promoting Community Engagement:
Thanks to their increased mobility, people utilizing semi-automatic wheelchairs are better able to interact with their surroundings, go to social gatherings, see friends and family, and engage in leisure activities.

4. Lessening Reliance on caretakers:
The wheelchair system's improved freedom gives people less reliance on caretakers, enabling them to make

5. Encouraging Self-determination and Respect:
Giving people with mobility limitations the freedom to move around and negotiate their surroundings on their own fosters a sense of dignity and empowerment that improves their general well-being and self-worth.

6. Overcoming Physical Obstacles:
The wheelchair system promotes a more inclusive atmosphere for all community members by assisting in the removal of physical barriers that can prevent those with mobility issues from fully engaging in society.

7. Promoting Social Engagement:
People who use wheelchair systems are more likely to interact socially and build lasting relationships with others because of their increased mobility and accessibility, which promotes a sense of community cohesion and belonging.

8. Increasing Advocacy and Awareness:
The creation and application of cutting-edge mobility solutions, such as the wheelchair system that operates semi-automatically, increases awareness.

1.6 Organization of the Report

Each chapter's subjects are summarized here, and the report is arranged as follows:

The proposed system design, functional block diagram, design alternatives, and final design are described in Chapter 2.

Implementation details, components and specification, and the flow chart are described in Chapter 3.

Chapter 4 includes the Result Analysis.

Chapter 5 addresses how the project relates to different SDGs.

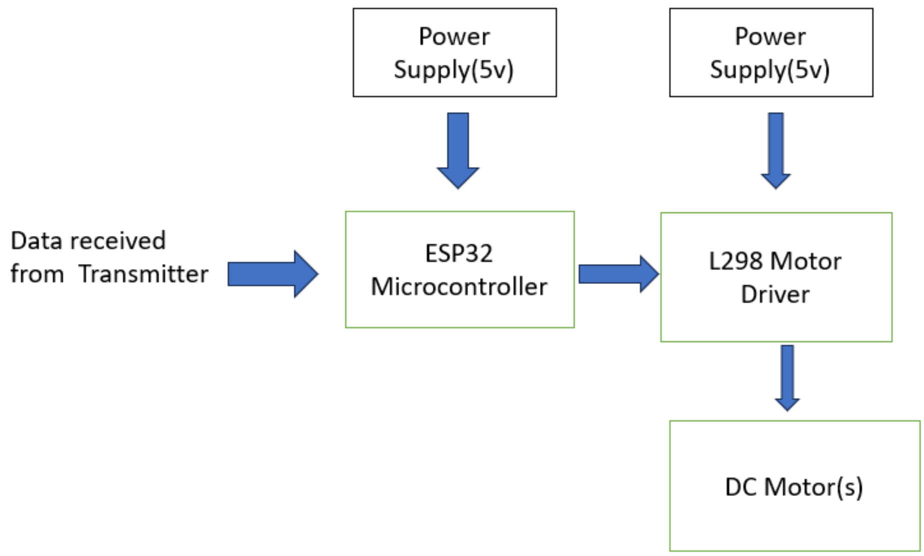
The project conclusion and Future scope are part of Chapter 6

Chapter 2

System Design

Conceptual, logical, and physical design are distinct aspects of the overall process within system design. System design is the methodical process of creating a system's modules, interfaces, parts, and data to satisfy specified requirements. This stage can be thought of as the product development process using systems theory in practice.

2.0.1 Functional Block Diagram



To implement the model, we have also employed two ESP modules: one for the controller and one for the receiver. presuming that the modules that are broadcast and received are ESPs.The control is applied by the

MPU6050, a gyroscope and accelerometer that monitors acceleration, tilt angle, and velocity. Slave ESP was then transmitted via the signals, expanding the wheelchair's range of motion. An alternative design for the semi-automated wheelchair could incorporate a wireless radio frequency control system, which enables remote control and offers a robust signal over extended distances. The built-in joystick or touchpad interface of a wheelchair could also provide an extra control option. Safety features like object detection sensors might be employed to enhance collision avoidance, and modular design elements would facilitate customization.

2.0.2 Design of model

"Hand Gestured Wheel Chair"
The Controlled Hand Gesture Robot uses hand gestures, specifically tilting motions, to operate robots in security surveillance applications utilizing UGVs and quadcopters, as well as wheelchair mobility. The system consists of a hand gesture detection module that sends data to the robot control unit via Bluetooth or Wi-Fi, a microprocessor that processes sensor data, and sensors (accelerometer, gyroscope, and magnetometer) on a wearable device. The robot control unit decodes these orders and manages the robot platform's motors, which may consist of rotors for quadcopters or wheels for UGVs. Tilt angles are mapped by software algorithms to particular movement orders, and the system provides redundant communication and emergency stop mechanisms to guarantee safety. Future developments for this technology could include increased usage and the incorporation of AI for improved gesture detection.

2.0.3 Alternate Design

"Semi-Automatic Wheel Chair"
The semi-automatic wheelchair's design makes extensive use of the ESP32 microcontroller for efficient communication and Bluetooth technologies for remote control. People with mobility impairments might easily and independently use a wheelchair with the aid of an app on their phone, providing them greater flexibility to move around their environment. Safety features including autonomous braking and object detection sensors will be there to

safeguard human safety. The wheelchair's emphasis on comfort and accessibility also extends to ergonomic design elements and adjustable seating. Additionally, the project will include educational components that provide opportunities to learn microcontroller programming, Bluetooth communication integration, and motor control. The creation of a user-friendly and accessible mobility solution is the ultimate goal.

2.0.4 Components Used

2.0.5 ESP32 Module

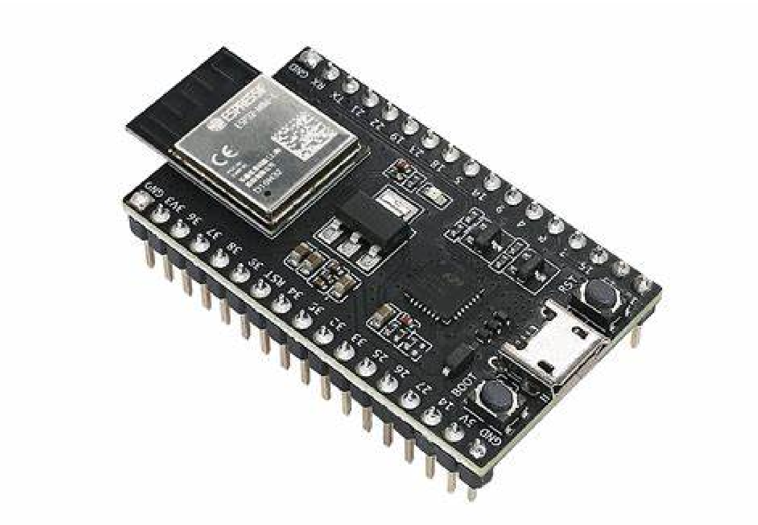


Figure 2.1: ESP32

Specifications

- **RAM Memory Installed Size**: 512 GB
- **CPU Speed**: 2.4 GHz
- **Connectivity Technology**: Bluetooth, WLAN
- **Wireless Communication Standard**: Bluetooth, 802.11bgn Espressif Systems created the incredibly strong and adaptable ESP32 microcontroller, which is well-known for its talents in embedded and Internet of Things (IoT) applications. Strong processing capability is

offered by its dual-core Xtensa® 32-bit LX6 CPU, which has a clock frequency of up to 240 MHz. The ESP32 incorporates 448 KB of ROM and 520 KB of SRAM. External flash and SRAM are supported over SPI. Notably, it has integrated Bluetooth (both traditional and BLE) and Wi-Fi (802.11 b/g/n), which makes it perfect for tasks requiring wireless communication.

Numerous peripheral interfaces are available on the ESP32, such as 34 GPIO pins, capacitive touch sensors, 12-bit ADC channels, DAC channels, and several communication protocols like I2C, SPI, I2S, and UART. Additionally, it offers PWM output, which is necessary for robotics applications' motor control. A low-power coprocessor supports the chip's deep sleep and hibernation modes, among other power management capabilities that improve energy economy.

2.0.6 L298N motor driver module

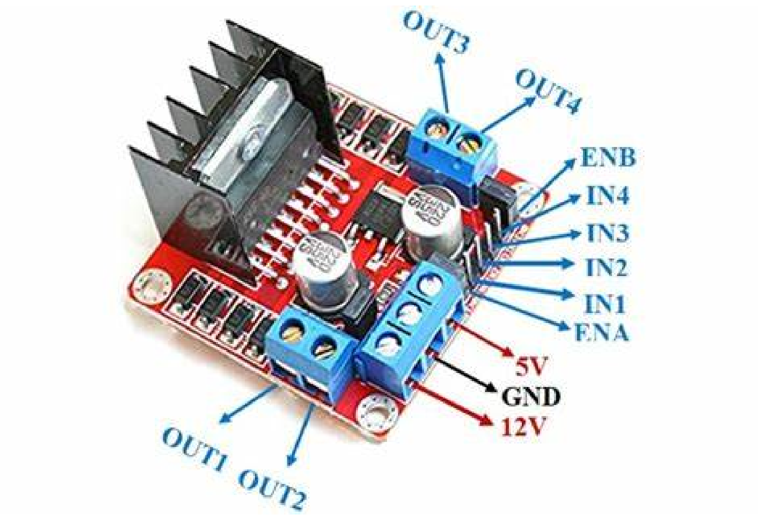


Figure 2.2: L298N motor driver

2.0.7 Pin configuration of ESP32

The signal is shown in the figure. After turning on ENA ENB, the connecting technique is displayed in the figure. Using a DC motor for driving The module can run two motors at once because it is powered by a double H bridge. After entering the driving timing from IN1 to IN4, the DC motor's direction and speed can be adjusted.

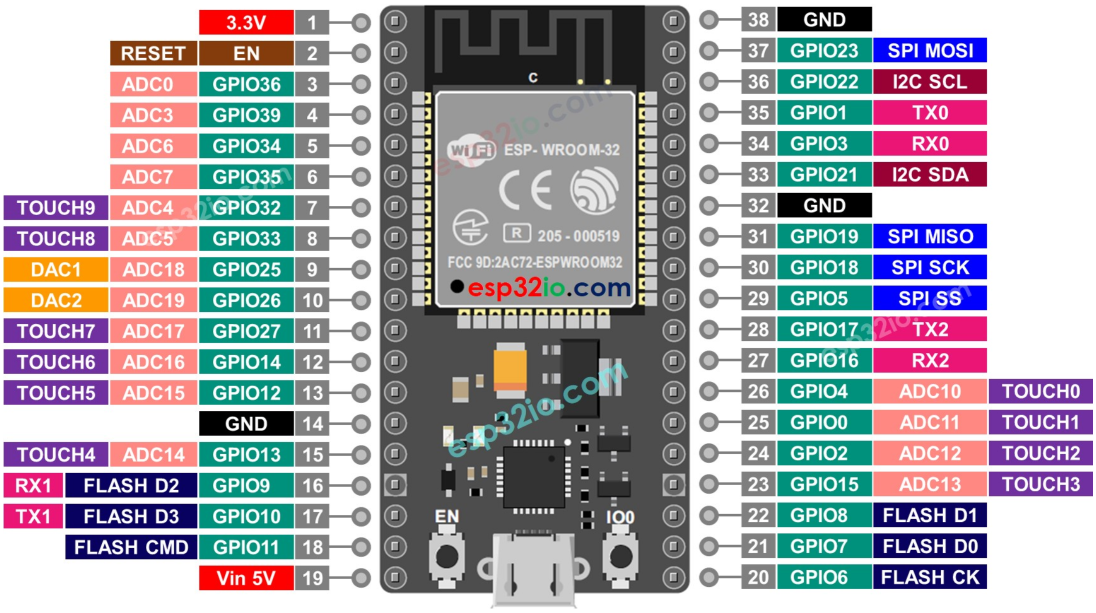


Figure 2.3: Pin configuration of ESp32

2.0.8 DC Motor

Figure 2.4: DC Motor

Voltage Rating: The operating voltage of the motor, such as 12V or 24V.

Current Rating: The amount of current the motor draws under normal operating conditions, measured in amperes (A).

Speed (RPM): The rotational speed of the motor's output shaft, specified in revolutions per minute (RPM).

Torque: The twisting force the motor can produce, measured in Newton meters.

Power Rating: The maximum power the motor can deliver, specified in watts (W) or horsepower (HP).

Efficiency: The ratio of mechanical output power to electrical input power, typically expressed as a percentage.

Voltage Rating: The operating voltage of the motor, such as 12V or 24V.

Chapter 3

2.1 Implementation details

2.1.1 Model Interfacing

Interfacing the components for the semi-automatic wheelchair project involves several steps:

1.Supply:
Ensure a suitable power supply for the ESP32, L298N motor driver, and DC gear motors. This typically involves connecting a battery pack to the ESP32 and motor driver.

2.ESP32 and Bluetooth Module Setup: Program the ESP32 using the Arduino IDE to configure Bluetooth communication. Utilize libraries such as the ESP32 BLE Arduino library to enable Bluetooth functionality.

3. Motor Driver Connections: Connect the output pins of the ESP32 to the input pins of the L298N motor driver to control motor direction and speed. Use PWM pins on the ESP32 for speed control and GPIO pins for direction control.

4. DC Gear Motors: Mount standard wheels onto the DC gear1. Provide:
Make sure that the DC gear motors, ESP32, and L298N motor driver have an appropriate power source. Usually, to do this, a battery pack must be connected to the ESP32 and motor driver.

2.ESP32 and Bluetooth Module Setup: To set up Bluetooth connectivity, program the ESP32 with the Arduino IDE. To enable Bluetooth capabilities, use libraries such as the ESP32 BLE Arduino library.

3. Motor Driver Connections: To control the direction and speed of the motor, connect the ESP32's output pins to the L298N motor driver's input pins. For direction control and speed control, use the ESP32's GPIO pins and PWM pins.

4. DC Gear Motors: Attach standard wheels to the DC gear motors and link them to the L298N motor driver's output terminals. Make sure motors connect them to the output terminals of the L298N motor driver. Ensure proper polarity for correct motor rotation.

5. Implementation of Software: To set up Bluetooth connectivity, manage motor control operations, and take in mobile phone navigation commands, write code in the Arduino IDE. Put in place the proper safety measures and error handling.

6. Calibration and Testing: Send navigational commands from the phone to test the system, making sure the wheelchair responds appropriately. For best results, adjust the motor control parameters and calibration settings as necessary.

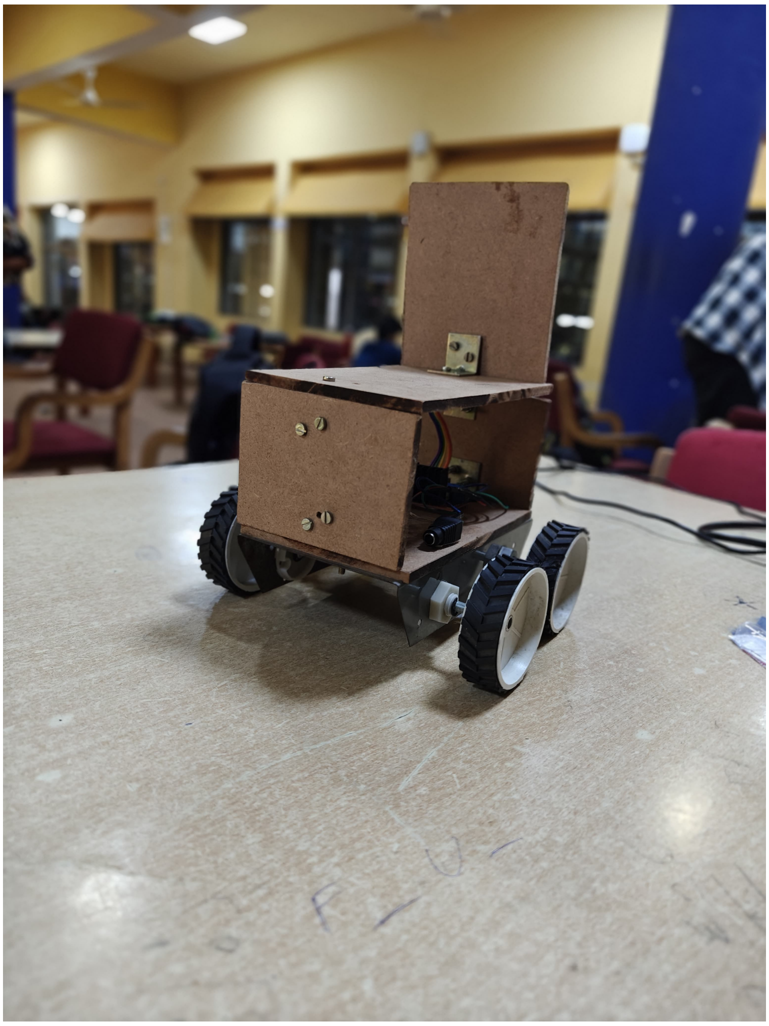


Figure 2.5: Final Module

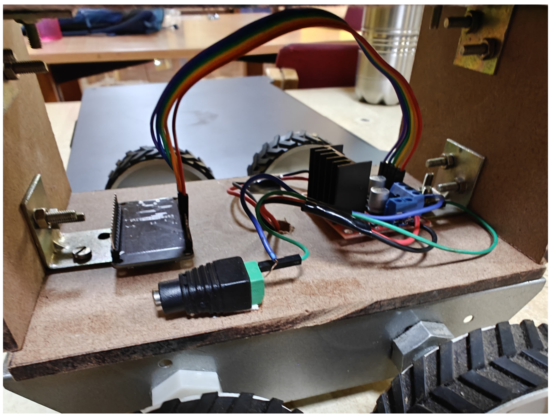


Figure 2.6: Final Module

Chapter 4

2.2 Results and discussions

"Hand Gestured Wheel Chair"
Through the use of hand gestures—more especially, tilting motions—the Controlled Hand Gesture Robot project showcases a notable leap in robot control technology. Promising outcomes have been observed in the precise translation of hand tilts into orders for the robot through the integration of various sensors. The technology has shown promise in a variety of real-world settings, including medical wheelchair navigation, where it has improved users' mobility and independence. Furthermore, its application in security and surveillance through the use of quadcopters and unmanned ground vehicles (UGVs) has demonstrated enhanced responsiveness and maneuverability, which are essential for threat identification and real-time monitoring. The system's capacity to adjust to various jobs and surroundings demonstrates its adaptability and promise for wider applications. Future advancements might improve command responsiveness and sensor accuracy even more.

"Semi-Automatic Wheel Chair"
An ESP32 microprocessor, an L298N motor driver, and DC gear motors were successfully incorporated into the semi-automatic wheelchair project to produce a Bluetooth-controlled mobility solution. The method made smooth and responsive motor operations possible through efficient remote control using a mobile phone. The wheelchair, which was powered by an appropriate battery pack, showed stable navigation on a variety of surfaces. The overall user experience was good, with a user-friendly interface and low command latency, despite some possible Bluetooth interference in crowded areas. Although the fundamental functionality was accomplished, to improve the real-world application and user safety, it is advised that more improvements be made, such as obstacle detection and improved safety features. The project's ability to be modified for the ESP8266 microcontroller highlights its instructive value as well as its practical applications in assistive technology and robotics.

2.2.1 Timing

To estimate the total response time from user input (e.g., pressing a button on a remote) to the wheelchair starting to move, we sum up the individual latencies:

Data transmission: 20-30 ms
ESP32 Processing:
Data reception and parsing: 1-2 ms
Sensor data acquisition: 2-5 ms
Decision making: 5-10 ms
Motor Control:
Signal transmission to the motor driver: 1 ms
Motor driver response: 5-10 ms
Physical Motor Response:
Motor activation: 20-50 ms
Summing these values gives an approximate total latency:
Minimum Total Latency: $20 + 1 + 2 + 5 + 1 + 5 + 20 = 54$ ms
Maximum Total Latency: $30 + 2 + 5 + 10 + 1 + 10 + 50 = 108$ ms
Approximate Total Latency Range: 54 to 108 milliseconds

Chapter 5

2.3 Alignment with SDG

The United Nations Sustainable Development Goal (SDG) 9: Industry, Innovation, and Infrastructure is in line with the semi-automatic wheelchair project. This objective highlights how crucial it is to provide resilient infrastructure, support equitable and sustainable industry, and encourage innovation. Through the incorporation of contemporary technology like Bluetooth connectivity and the ESP32 microcontroller into assistive equipment, the project promotes creative approaches to enhancing the mobility of people with impairments. By advancing the creation of cutting-edge, easily navigable, and accessible infrastructure, it demonstrates a dedication to promoting inclusive innovation and assisting in the sustainable growth of assistive technology.

SDG 9

2.3.1 Targets and Indicators

By promoting innovation in assistive technology, the semi-automatic wheelchair initiative seeks to enhance scientific research and technological capacities, particularly in developing countries. Its main goal is to increase the independence and mobility of people with impairments by providing them with high-tech but approachable solutions. Important success indicators include users' adoption of the wheelchair, the addition of new technology features, and the wheelchair's accessibility and price. Furthermore, user happiness, educational outcomes in robotics and skill development, and sustainability considerations are important variables to keep an eye on. In the end, by supporting the development of robust, widely accessible infrastructure and pushing for inclusive and sustainable industrial practices, this effort is in line with SDG 9.

Chapter 6

2.4 Conclusion and Future Scope

2.4.1 Conclusion

"Hand Gestured Wheel Chair"
To sum up, the Controlled Hand Gesture Robot project offers a novel method of controlling robots by using hand tilt motions to deliver accurate and understandable command inputs. This technology's effective use in the surveillance, security, and medical domains highlights its adaptability and promise to improve human-robot interaction. The study not only shows that sensor-based gesture recognition is feasible and efficient, but it also creates new opportunities for development and broader application across other industries. The capabilities and integration of robotics in daily life are expected to advance with further invention and refinement in this field, producing progressively more complex and accessible robotic solutions.

2.4.2 Alternate Design

"Semi-Automatic Wheel Chair"
To sum up, the semi-automatic wheelchair project offers a thorough method of improving mobility options for people with disabilities through the use of cutting-edge technology and the promotion of inclusivity. The initiative seeks to promote sustainable practices while catering to the varied demands of its target audience by evaluating user adoption rates, affordability, accessibility, technical improvements, environmental impact, and user happiness. Additionally, by placing a strong emphasis on inclusive participation and educational results, the project not only seeks to enhance user quality of life but also advances the development of assistive technology knowledge and skills. All things consid-

ered, the project is a major step toward creating a society that is more open and accessible and is consistent with the ideas of sustainable development and innovations.

2.4.3 Future scope

"Hand Gestured Wheel Chair"
Future developments in downsizing, artificial intelligence, machine learning, and sensor precision could greatly expand the potential applications of controlled hand gesture robot technology. Improved sensor responsiveness and precision may result in even more accurate control, increasing its uses in complex manufacturing processes and delicate medical procedures. By allowing adaptive learning from user gestures, integration with AI and machine learning may enhance the system's customizability and intuitiveness. Furthermore, the technology's increased portability and accessibility due to component shrinkage may encourage broader applications in consumer electronics, medical devices, and personal assistive technologies. As technology advances, it has the potential to completely transform how people engage with robots. Robotic systems will become more responsive, intuitive, and easily incorporated into many facets of daily life and business.

2.4.4 Alternate Design

"Semi-Automatic Wheel Chair"
The semi-automatic wheelchair project has a bright future ahead of it, with many improvements and extensions possible. First off, adding cutting-edge sensor technology like lidar or computer vision could make it possible for the wheelchair to recognize and avoid obstacles on its own, improving both safety and usability. Furthermore, real-time tracking and remote monitoring might be made possible by adding connectivity elements like GPS or IoT capabilities, giving caregivers vital information and peace of mind. Additionally, investigating strong and lightweight materials for wheelchair design may increase the wheelchair's lifetime and portability. Furthermore, broadening the project's scope

through collaborations with governmental and healthcare institutions may enable greater uptake and influence. Last but not least, ongoing research and development will be necessary to keep up with new developments in technology and consumer demands, guaranteeing that the semi-automatic wheelchair stays at