VOICE CONTROLLED WHEELCHAIR WITH BLUETOOTH NAVIGATION FOR ENHANCED MOBILITY

***Abstract*:**

This project showcases a voice-controlled wheelchair with Bluetooth navigation, intended to provide a user-friendly and efficient mobility solution. The wheelchair is mostly controlled by vocal commands such as go, stop, left, and right, which allows individuals with limited motor ability to maneuver with ease. The system incorporates speech recognition technology, ensuring an accurate and timely response to voice inputs. Furthermore, for greater control flexibility, the wheelchair can be operated via Bluetooth connectivity, acting as a remote-controlled system. This function allows caretakers or users to navigate the wheelchair using a smartphone app or an external controller, offering an alternative mode of operation.

One of the most important safety features included in this system is fall detection, which continuously monitors the user's location. In the event of an accidental fall from the wheelchair, the system is programmed to identify the anomaly and send a warning, ensuring prompt assistance. This proactive strategy greatly improves user safety and emergency response methods.

The project uses embedded technologies, wireless connectivity, and sophisticated control mechanisms to create a wheelchair that is not only accessible, but also safe and dependable. The combination of voice recognition, Bluetooth-based remote navigation, and fall detection transforms this wheelchair into a smart assistive gadget that meets the demands of physically challenged people.By incorporating cutting-edge technology, this project intends to deliver a cost-effective, efficient, and autonomous mobility solution for those with mobility limitations, increasing their overall quality of life.

In conclusion- The development of a voice-controlled wheelchair with Bluetooth navigation represents a significant advancement in assistive mobility solutions for physically challenged individuals. By integrating voice recognition technology, the system enables hands-free operation, allowing users to navigate effortlessly using simple voice commands. The addition of Bluetooth-based remote navigation enhances flexibility, enabling caregivers or users to control the wheelchair remotely for added convenience. A critical safety feature, fall detection, ensures continuous monitoring of the user's position, triggering alerts in case of accidental falls to facilitate immediate assistance. This combination of intelligent control, wireless communication, and safety mechanisms makes the wheelchair a smart, reliable, and user-friendly mobility aid. The project successfully addresses the challenges faced by individuals with limited mobility, enhancing their independence, safety, and overall quality of life. With further advancements, such as AI-based obstacle detection and automated path navigation, this system has the potential to become an even more versatile and efficient assistive device in the future.

Keywords—Voice-Controlled Wheelchair, Bluetooth Navigation, Assistive Mobility Device,Speech Recognition, Wireless Communication,Remote-Controlled Wheelchair,Fall Detection System, Safety Monitoring.

I. INTRODUCTION

Mobility aid is essential for people with physical limitations since it directly affects their freedom and quality of life. Traditional wheelchairs, while enabling basic mobility, frequently rely on human effort or physical support from caretakers, restricting the user's liberty. To address these issues, this project introduces a Voice-Controlled Wheelchair with Bluetooth Navigation, which is intended to improve accessibility, convenience of use, and safety for those with mobility disabilities. The wheelchair includes a voice recognition technology that allows users to control mobility using simple vocal commands like go, stop, left, and right. This hands-free action is especially useful for people with poor upper-body strength or dexterity.[5][2]

In addition to voice control, the wheelchair has Bluetooth-based remote navigation, which allows users or caregivers to control it using a smartphone app or remote device. This capability offers an alternate control mode, ensuring simplicity and versatility in a variety of contexts. One of the most important safety improvements in this system is its fall detection function, which detects when the user falls from the wheelchair and sends an alert. This function is critical for providing immediate assistance, lowering the hazards associated with falls, and improving overall safety.[7]

This smart wheelchair, which incorporates speech recognition, wireless networking, and safety monitoring, seeks to improve the mobility experience for physically challenged individuals. It decreases reliance on caregivers, boosts user autonomy, and assures safety via intelligent monitoring. Implementing such a system not only improves daily mobility, but it also helps people with impairments live more inclusive and independent lives.[3]

NEED FOR PROPOSED WORK:

Traditional wheelchairs, whether manual or electric, need either physical effort or joystick-based control,[5] which may be impractical for those with significant mobility limitations, neurological problems, or ailments that impair their motor skills. To bridge this gap and improve accessibility, there is an increasing demand for enhanced assistive mobility solutions with simple and intuitive control mechanisms.

In this project, The proposed Voice-Controlled Wheelchair with Bluetooth Navigation is intended to address these issues by including voice command capabilities, which allows users to control the wheelchair with simple spoken instructions like "go," "stop," "left," and "right."[1][3] This reduces the need for manual effort and facilitates mobility for people who have restricted hand or arm movement. The wheelchair also includes Bluetooth-based navigation, which allows for remote control via a smartphone application or a dedicated Bluetooth device. This feature enables caretakers or family members to assist the user in traversing difficult or busy environments, increasing the wheelchair's adaptability in real-world situations

This project holds One of the most pressing concerns for wheelchair users is safety, namely the potential of accidental falls from the chair. Many existing wheelchair designs lack an integrated fall detection system, which might lead to delays in medical care in the event of an emergency. To reduce this risk, the proposed wheelchair includes fall detection technology, which detects a fall and sends a warning to caretakers or emergency personnel. This feature improves the system's overall safety and reliability by guaranteeing that the user receives prompt support when necessary.

II. LITERATURE REVIEW

Ang Jia He ,et al.,(2024) [1] published in International Journal on Robotics, Automation and Sciences. The paper examines several sensor technologies and control approaches for mobile robots with obstacle detection systems, focusing on the strengths and weaknesses of sensors such as LiDAR, radar, ultrasonic, infrared, and computer vision. It also goes over control methods like hand gestures, voice control, infrared remote control, Bluetooth mobile control, and Wi-Fi mobile control, emphasizing the importance of selecting the right sensor and control method for specific applications to improve safety and efficiency in robotics and autonomous navigation systems.

Shubh Srivastava ,et al.,(2020) [2] published in International Research Journal of Engineering and Technology. The paper addresses the creation of a voice-controlled robot automobile with Arduino to save manual labor and improve user convenience. The system is based on an Arduino microcontroller, motor drivers, and a Bluetooth module, which allows users to operate the car using voice commands via an Android smartphone. The hardware contains the HC-05 Bluetooth module, L293D motor driver IC, and DC geared motors.

Ayush Ubale, Pranavya M U ,et al.,(2022) [3] published in International Journal of Engineering Applied Sciences and Technology. The paper describes a voice-controlled car that utilizes MQTT server technology to facilitate human jobs in an AI-driven world. The vehicle is controlled by human voice instructions sent using a robust Android mobile application produced with Android Studio software and a Wi-Fi network. The system runs on the NodeMCU ESP8266 microcontroller, which includes firmware for the ESP8266 Wi-Fi module and ESP-12 module hardware.

Darunjeet Bag, et al.,(2023) [4] published in *Design and Control Advances in Robotics*. IGI Global. The paper discusses the development of a low-cost human-machine interface system to help disabled individuals control their wheelchairs using EEG signals, head movements, and facial expressions. The Fast Fourier Transformation (FFT) approach is used to filter the brain signal activity that is obtained by placing electrodes on the subject's scalp. Power Spectral Density (PSD) is utilized to extract features, and the Random Forest method is applied for classification.

Preet Milind Derasari,et al.,(2022) [5] published in Wireless Personal Communications. The study describes a motorized wheelchair system that can be controlled wirelessly using a glove. The system has automatic obstacle avoidance and employs the Bluetooth Low Energy standard for wireless control. Dual ultrasonic sensors are used to identify obstacles, and the glove controls the wheelchair's movement via conductive ink. The microprocessor uses inputs from the glove and sensors to determine the wheelchair's direction. The goal is to create an intuitive and pleasant control mechanism for motorized wheelchairs, making them more accessible and usable for people with impairments.

Clément Favey,et al.,(2021) [6] published in MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations. The study describes the creation of a novel negative obstacle sensor for augmented electric wheelchairs, which aims to improve the safety and mobility of users with motor, cognitive, and visual impairments. The sensor detects dangerous height differences, such as curbs and stairs, using optical triangulation with several laser beams.

Malik Haddad, et al.,(2021) [7] published in Intelligent Systems and Applications: Proceedings of the Intelligent Systems science Volume.The paper describes a new system for steering a powered wheelchair that employs a Sharp IR sensor and a Raspberry Pi to address difficulties raised by occupational therapists and carers at Chailey Heritage Foundation/School. The system substitutes lever switches, which frequently slipped and made distracting clicking noises, with an electronic circuit made out of a Sharp IR sensor, an Analog to Digital converter, relays, and a Raspberry Pi. The IR sensor detects movement, and the Raspberry Pi interprets it to generate wheelchair steering signals.

C. R. Rathish,et al.,(2020) [8] published in International journal on human computing studies. The paper addresses the creation of an IoT-enabled wheelchair fall detection and health monitoring system. This technology is designed to detect when a patient falls out of their wheelchair and to continuously check their health. It detects falls using an accelerometer sensor and delivers SMS or phone alerts to the right person. The system also uses voice recognition to automate the operation of lighting and fans, and it constantly monitors the patient's temperature and pulse.

Mohammed Kutbi,et al.,(2023) [9] published in Journal of Intelligent & Robotic Systems. The research describes a unique technique to controlling a robotic wheelchair utilizing egocentric computer vision, giving users numerous levels of autonomy and navigation skills that are suited to their specific needs and preferences. The device uses a head-mounted camera to capture the user's perspective, allowing for natural motion control with small head motions. This solution incorporates a consumer depth camera and a laptop, allowing the wheelchair to move independently to locations, items, or people without the need for hands.

DaLuca Maule, et al.,(2023) [10] published in MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations. The study introduces RoboEYE, a semi-autonomous, gaze-driven wheelchair intended for home usage to help those with severe motor limitations. The technology incorporates an eye tracker, a monitor, and a 3D camera into a normal motorized wheelchair, allowing users to operate it by looking at different parts of the monitor. RoboEYE has two driving modes: direct control, in which the user continually controls the wheelchair's progress by gazing at the monitor, and semi-autonomous control, in which the user selects a destination point and the system navigates to that location.

III. METHODOLOGY

The proposed system is a voice-controlled wheelchair with Bluetooth navigation designed to enhance accessibility for physically challenged individuals. This smart wheelchair operates through voice commands such as “go,” “stop,” “left,” and “right,” enabling hands-free movement for users with limited mobility [1][3]. Additionally, the system incorporates a Bluetooth-based remote control mechanism, allowing caregivers or users to control the wheelchair via a mobile application or an external Bluetooth module. This dual-mode navigation ensures flexibility, making the wheelchair suitable for diverse user needs and environments.[5]

At the core of the system lies a microcontroller unit (MCU), such as an Arduino or Raspberry Pi, which acts as the central processing unit for interpreting and executing commands. The voice recognition module (such as the HM2007 or EasyVR) processes speech inputs, converting them into corresponding control signals that drive the wheelchair’s motor driver circuit. The motor driver (L298N or similar) facilitates the movement of DC motors attached to the wheels, ensuring smooth and precise navigation.

For Bluetooth navigation, a Bluetooth module (e.g., HC-05 or HC-06) is integrated into the system, enabling seamless wireless communication between the wheelchair and a smartphone or remote-control device [2]. The mobile application allows users or caregivers to send directional commands over a Bluetooth Low Energy (BLE) network, ensuring real-time control with minimal latency.To enhance user safety, the wheelchair is equipped with a fall detection mechanism, utilizing accelerometers and gyroscopic sensors (such as the MPU6050 or ADXL345). These sensors continuously monitor the wheelchair’s orientation and detect any sudden tilt or abnormal motion indicative of a fall. Upon detecting a fall, the system can trigger an emergency alert system, which may include an audible alarm or an automatic notification to caregivers via Bluetooth or GSM-based messaging.[8]

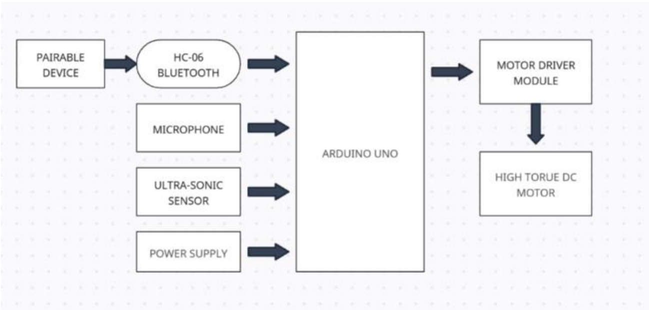
Furthermore, the wheelchair incorporates obstacle detection sensors, such as ultrasonic or infrared (IR) sensors, to prevent collisions in real-time. These sensors scan the surroundings and send feedback to the microcontroller, which can prompt an automatic stop or reroute the wheelchair’s movement when an obstacle is detected.

IV. EXISITING METHOD

Traditional wheelchairs primarily rely on manual propulsion or joystick-based electronic control for mobility. While these methods offer a degree of independence, they often pose challenges for individuals with severe motor impairments, limited upper body strength, or neuromuscular disorders. To address these limitations, researchers and developers have introduced various control mechanisms, including voice recognition, brain-computer interfaces (BCI), and sensor-based automation. In existing automated wheelchair systems, joystick-controlled electric wheelchairs are widely used. These wheelchairs use potentiometers and Hall effect sensors to detect directional input from the user. The microcontroller processes this input to drive motors accordingly, allowing movement in different directions. However, for users with restricted hand mobility, joystick control remains a significant barrier.[6]

Patients relying on a caretaker for wheelchair movement face several disadvantages, including loss of independence, delayed response times, and restricted accessibility when the caretaker is unavailable. The physical strain on the caretaker, risk of human error, and communication barriers further complicate mobility, especially for patients with speech or cognitive impairments. Additionally, dependence on assistance can reduce a patient’s confidence and self-esteem while also increasing long-term financial costs for hiring dedicated caretakers.[10]

V. BLOCK DIAGRAM



The block diagram represents a voice-controlled and Bluetooth-enabled wheelchair system, which enhances mobility for individuals with physical disabilities by integrating wireless control, voice recognition, and obstacle detection. The system is powered by an Arduino Uno microcontroller, which processes inputs from multiple components and controls the movement of the wheelchair accordingly. A pairable device, such as a smartphone or remote controller, communicates wirelessly via an HC-06 Bluetooth module, allowing caregivers or users to control the wheelchair remotely.

To enhance safety, an ultrasonic sensor is integrated to detect obstacles in the wheelchair's path. This sensor continuously monitors the surroundings and sends distance data to the Arduino. If an object is detected within a predefined range, the system can automatically stop or adjust movement to avoid collisions.The power supply ensures that all components receive the necessary electrical energy to operate efficiently. Once the Arduino processes input signals, it sends control instructions to a motor driver module (such as L298N or L293D). This module regulates the power and direction of high-torque DC motors, which drive the wheelchair forward, backward, left, or right as per user commands.[6]

VI.APPENDIX

1. Microcontroller Unit (MCU) – Arduino

The microcontroller receives voice commands via a speech recognition module and processes them to generate appropriate control signals for the motor driver circuit.

2. Voice Recognition Module – Elechouse V3 / HM2007

A dedicated voice recognition module, such as Elechouse V3 or HM2007, is employed to capture and process voice commands. This module is pre-trained to recognize specific commands like "GO," "STOP," "LEFT," and "RIGHT."

3. Bluetooth Module – HC-05 / HC-06

For remote-controlled functionality, a Bluetooth communication module, such as HC-05 or HC-06, is integrated. This module facilitates wireless connectivity between the wheelchair and an external controller, such as a smartphone application or a Bluetooth-enabled joystick.

4. Motor Driver Module – L298N / TB6612FNG

The wheelchair's movement is powered by DC motors, which require precise control over speed and direction. A motor driver module, such as L298N or TB6612FNG, acts as an interface between the microcontroller and the high-power DC motors.

5. DC Motors – 12V/24V Geared Motors

To drive the wheelchair, high-torque geared DC motors (typically 12V or 24V, 200–500 RPM) are used. These motors provide the necessary power to propel the wheelchair smoothly while maintaining stability.

6. Ultrasonic Sensors (HC-SR04) for Obstacle Detection

To prevent collisions and enhance safety, ultrasonic sensors such as HC-SR04 are installed at the front and sides of the wheelchair. These sensors continuously monitor the surroundings and alert the system to obstacles in the path.

7. Power Supply Unit – Rechargeable Battery (12V, 24V Li-Ion/Lead-Acid)

A reliable power source is essential for seamless operation. A rechargeable lithium-ion or lead-acid battery (12V or 24V, 7Ah to 12Ah) is used to power the microcontroller, motor driver, voice module, and other sensors.

VII.CIRCUIT DIAGRAM

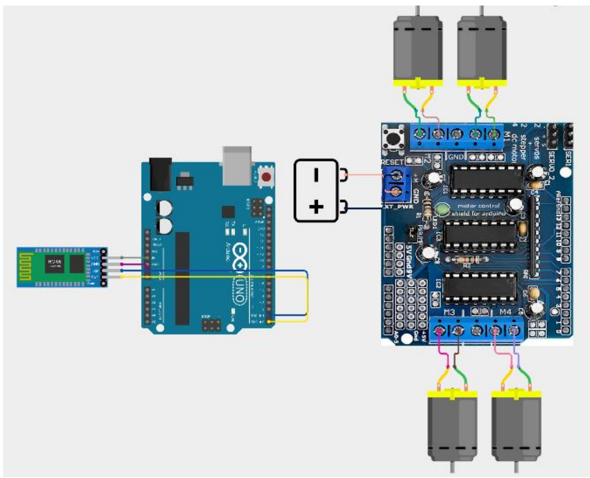


Fig: Circuit diagram [2]

The circuit includes an Arduino UNO Board, HC-05/HC-06 Bluetooth Module, L293D Motor Driver IC, two DC Geared Motors with 200 RPM, and a 9V battery. The Arduino's TX and RX pins correspond to the RX and TX pins of the Bluetooth module. The Bluetooth Module is supplied with 5V. The left DC engine corresponds to pins 3 and 6 of L293D, while the right DC engine corresponds to stick numbers 14 and 11 of L293D. Arduino advanced pins 2,3,4,5 correspond to L293D 2, 7, 10, and 15, respectively. The L293D IC Pins 2, 5, 12, and 13 are GND, while 9, 1, and 16 are powered by 5V. However, pin 8 of the L293D receives 9V directly.

VIII.FUTURE SCOPE

1. Integration with AI and Machine Learning
   - Implement AI-based voice recognition for personalized command adaptation.
   - Use machine learning to predict user preferences and improve response accuracy.
2. IoT Connectivity for Remote Monitoring
   - Connect the wheelchair to a cloud-based system for real-time health monitoring.
   - Enable caregivers to track location, battery status, and emergency alerts via a mobile app.
3. Obstacle Detection and Autonomous Navigation
   - Integrate LiDAR or ultrasonic sensors for obstacle detection and automatic path correction.
   - Implement SLAM (Simultaneous Localization and Mapping) for autonomous movement in complex environments.
4. Brain-Computer Interface (BCI) Integration
   - Develop a system where users can control the wheelchair using brain signals (EEG-based control) for patients with severe disabilities.
5. Enhanced Fall Detection and Safety Features
   - Improve fall detection with AI-based posture analysis.
   - Add an automatic braking system to prevent tipping over in rough terrain.

IX.RESULT AND DISCUSSION

The voice-controlled wheelchair with Bluetooth navigation successfully enhances mobility and accessibility for physically challenged individuals. The system responds accurately to voice commands such as "go," "stop," "left," and "right," enabling seamless navigation without the need for manual control. Additionally, the Bluetooth-based remote-control functionality provides an alternative navigation mode, ensuring greater flexibility for caregivers or users who prefer remote operation. The integration of a fall detection mechanism further enhances user safety by promptly identifying accidental falls from the wheelchair.

Experimental results indicate that the system demonstrates high responsiveness and reliability in both voice and Bluetooth-controlled modes. The voice recognition module efficiently distinguishes commands even in moderate background noise, though its performance may slightly degrade in highly noisy environments. The Bluetooth navigation system maintains a stable connection within an effective range, ensuring smooth and uninterrupted control.

Overall, the developed wheelchair system significantly improves mobility, accessibility, and safety for individuals with physical disabilities, making it a viable solution for real-world applications. Future enhancements could focus on optimizing voice recognition under noisy conditions and extending Bluetooth range for increased usability.

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