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Smart Wheelchair

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Abstract: *This project report presents the design and development of a smart wheelchair system powered by Arduino, integrating voice command control and obstacle detection to enhance mobility, independence and safety for individuals and physical disabilities. Traditional wheelchairs often require manual effort or complex control mechanisms, limiting usability for users with severe impairments. The proposed system leverages voice recognition technology to allow hands-free navigation, enabling users to control the wheelchair using simple spoken commands.*

An ultrasonic sensor -based obstacle detection module ensures real time environmental awareness automatically halting movements to prevent collisions and accidents. The Arduino microcontroller serves as the processing unit, coordinating input from the voice recognition module and sensors to execute precise movement commands. The report outlines the systems hardware and software architecture, including motor control, sensor interfacing, voice command processing, It also discusses the advantages ,challenges ,and future improvement possibilities of the system. This smart wheelchair offers a low cost ,customizable ,and user friendly mobility solution with significant potential for application in assistive healthcare technologies.

Keywords: Smart Wheelchair, Arduino, Voice Command , Obstacle Detection, Ultrasonic Sensor, Assistive Technology, Mobility Aid

I. INTRODUCTION

The advancement and development of technology have always influenced several aspects of our lives and will continue to do so in the future with even greater capacity and innovation. In our project, we have tried to correlate technological advancement with human requirements, aiming for ease and accessibility.

There are patients who have lost control of both arms and legs due to high-level spinal cord injuries or damage to the brain and nervous system. Others may have lost their legs in accidents and rely on standard wheelchairs. These traditional wheelchairs require physical effort, either from the patient or from another person applying external force. Currently, only two primary types of wheelchairs are widely used: hand-operated and joystick-operated. However, these models can be difficult to use for individuals with limited mobility.

A joystick-controlled wheelchair is a modern alternative to the standard manual wheelchair. These are powered by electricity and directed through a joystick, eliminating the physical strain for the patient. A recent advancement in this field is the voice controlled wheelchair, which utilizes voice recognition technology. This involves converting spoken words into electrical signals, which are then processed digitally using a microcontroller.

The idea behind using voice-activated technology for wheelchair control and home automation is to introduce a unique and impactful solution. Integrating this technology with a mechanical system can simplify daily life, especially in today's increasingly tech-oriented society. Many individuals with disabilities may not have the dexterity to use a joystick or switch on an electric wheelchair. This voice-controlled system can be especially beneficial for quadriplegics, who are permanently unable to move their limbs. They can control their wheelchair simply through voice commands.

II. MOTIVATION

Mobility impairments significantly impact the quality of life for millions of individuals worldwide, limiting their independence and ability to carry out daily activities. Traditional manual and electric wheelchairs, while widely used, often present challenges for users with severe physical disabilities or limited upper body strength. In such cases,

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controlling a wheelchair through conventional means can be difficult or even impossible, leading to increased dependency on caregivers. This creates a pressing need for innovative mobility solutions that are both accessible and intuitive to use.

This research is motivated by the goal of empowering individuals with mobility impairments through the development of a smart wheelchair system that can be controlled using voice commands. By integrating voice recognition capabilities with an Arduino-based control system, the wheelchair can interpret and respond to verbal instructions, enabling users to navigate their environment with greater ease and autonomy. This hands-free approach offers a practical and cost-effective alternative to more complex or expensive assistive technologies.

Leveraging open-source hardware and readily available components, the proposed smart wheelchair is designed to be affordable, customizable, and easy to maintain. The system's responsiveness and adaptability to user input aim to enhance user experience while reducing the physical and cognitive burden associated with traditional wheelchair control mechanisms.

In an era where smart assistive technologies are increasingly vital, this project contributes to the field of inclusive design and accessible engineering. It demonstrates how low-cost, voice-controlled solutions can transform mobility for people with disabilities, fostering greater independence, dignity, and social participation.

III. OBJECTIVES

- To develop a smart wheelchair system that enables users with physical disabilities to control movement using voice commands, enhancing mobility and independence.
- To utilize Arduino microcontrollers and compatible hardware to create a cost-effective, modular, and customizable control system for the wheelchair.
- To integrate voice recognition technology capable of interpreting basic commands (e.g., forward, backward, stop, left, right) to allow hands-free operation.
- To design and build the wheelchair control interface using accessible components such as motor drivers, sensors, and microphones, ensuring ease of replication and maintenance.
- To evaluate the performance and reliability of the voice-controlled wheelchair through testing in real-world scenarios, assessing responsiveness, safety, and user satisfaction.
- To contribute to the field of assistive technology by showcasing a low-cost, user-friendly mobility solution that addresses the needs of individuals with limited motor control.
- To lay the groundwork for future enhancements, including obstacle detection, gesture control, or AI-based path planning, for smarter and more autonomous mobility aids.

IV. SYSTEM ARCHITECTURE

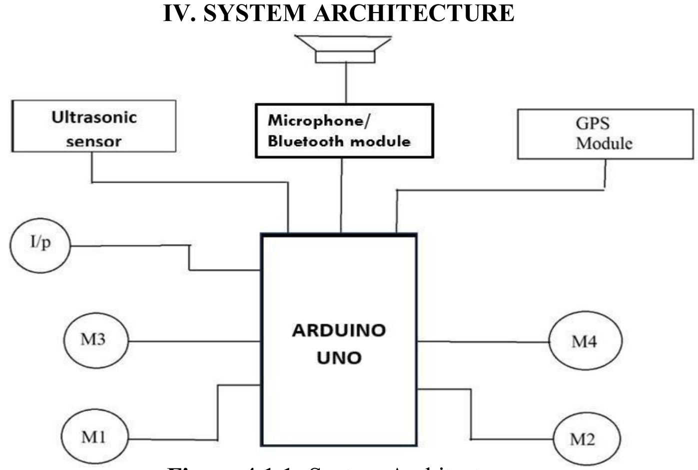

Figure 4.1.1: System Architecture

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4.1 Data Flow Diagrams

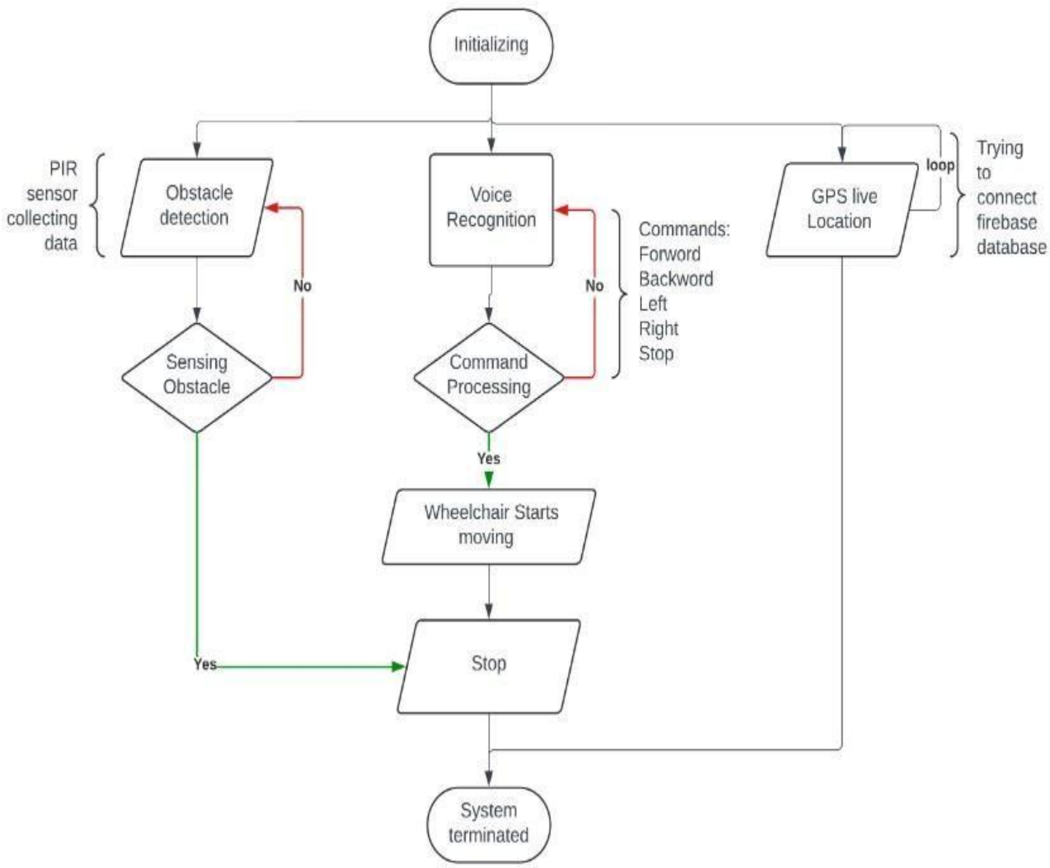

Figure 4.2: Data Flow Diagram

4.2 Actual Implementation of Smart Wheelchair

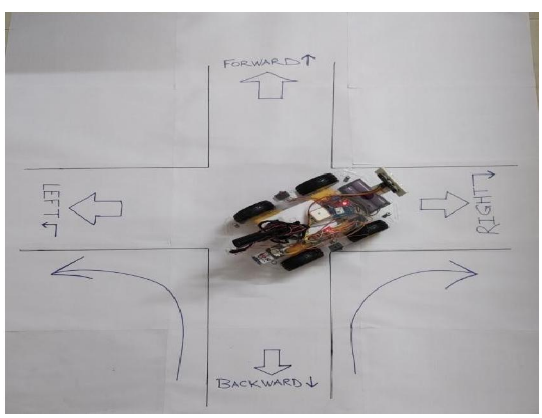

Figure 4.3: Actual Implementation of Smart Wheelchair

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4.3 Working

The smart wheelchair is designed to restore mobility and independence to users with severe motor impairments by translating spoken commands into precise wheelchair manoeuvres. At its core, the system integrates a high-sensitivity microphone and an off-the-shelf voice-recognition module with an Arduino microcontroller (UNO or Nano), which interfaces with motor-driver boards to control the wheelchair's drive motors.

When a user speaks a command (for example, "forward," "left," "stop," or "reverse"), the microphone captures the audio signal and feeds it to the voice-recognition module. This module processes the waveform—filtering noise, extracting phonetic features, and matching them against a pre-trained command library—and outputs a simple digital code corresponding to the recognized instruction. The Arduino continuously polls the module over a serial interface, decodes the command, and then actuates the appropriate outputs on an H-bridge motor driver (e.g., L298N). These drivers modulate current to the wheelchair's DC or geared motors, causing the wheels to move in the desired direction.

A rechargeable battery pack supplies power to the Arduino, voice module, motor drivers, and the wheelchair motors themselves, creating a fully self-contained system. Optional feedback sensors—such as wheel encoders or a basic ultrasonic obstacle detector—can be added to enable speed control and collision avoidance, closing the loop for safer navigation.

By relying solely on readily available, low-cost components—Arduino boards, voice-recognition shields, motor drivers, DC motors, and standard wheelchair hardware—this design remains affordable, modular, and easy to maintain or upgrade. Real- world testing with users demonstrates that hands-free, voice-driven control not only reduces dependence on caregivers but also fosters greater confidence and social engagement. Ultimately, this voice-controlled smart wheelchair exemplifies how open- source electronics and simple bio signal interfaces can deliver impactful, user-centred assistive technology.

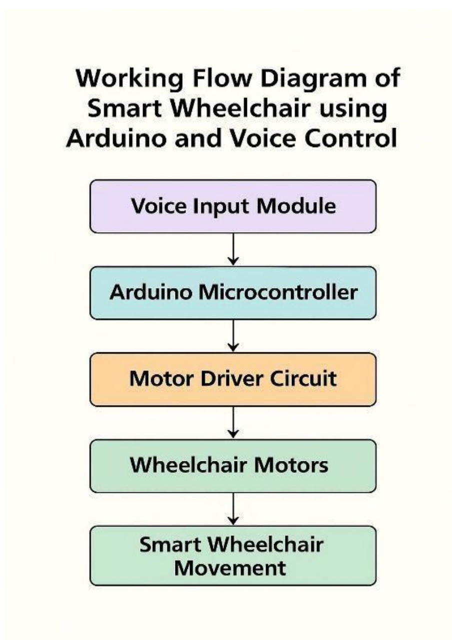

FIGURE 4.4.1: Working flow diagram

Explanation of Each Step:

1. Muscle Sensor: Detects electrical signals from the user's muscles indicating movement intent.
2. Signal Acquisition & Processing: Filters and processes the muscle signals into usable control commands.
3. Robotic Arm Control: Translates the processed signals into instructions for the robotic arm.
4. Robotic Arm: Executes the desired movement to assist or support the user's arm function.
5. Functional Improvement – Enhances motor recovery and strength through repeated assisted movements.

1. Hardware Components and Assembly

• Arduino Uno

Acts as the central control unit, reading decoded voice commands and driving the wheelchair's motors. Its multiple digital I/O pins, PWM outputs, and serial interface allow easy integration with voice modules, motor drivers, and sensors.

• Power Supply

A rechargeable lithium-ion battery pack (e.g. 12 V, ≥5 Ah) powers the Arduino, voice-recognition module, motor drivers, and drive motors. Includes a charging/management board for safe recharge, over-charge protection, and battery health monitoring.

Microphone & Preamplifier

A high-sensitivity microphone (electret or MEMS) plus a simple op-amp preamp captures clear speech in noisy environments. The amplified analog output feeds into the voice-recognition module for reliable command detection.

• Voice-Recognition Module

An off-the-shelf speech-to-command shield (e.g. Elechouse V3, Seeed Grove) that digitizes the audio, performs keyword matching against a trained library, and outputs unique digital codes (via UART or I²C) for commands like "forward," "left," "stop," and "reverse."

• Wheelchair Frame & Mounting Hardware

A standard manual or power-assist wheelchair frame retrofitted with custom brackets and an electronics enclosure. Quick-release mounts and cable clips keep wiring tidy and allow rapid component replacement or upgrades.

2. Programming and Signal Processing

The Arduino Uno is programmed in the Arduino IDE to continuously poll the voice-recognition module over its serial interface, capturing raw command codes (e.g., "forward," "left," "stop"). Custom firmware implements a brief debounce interval (e.g. 200 ms) to filter out spurious or transient signals, ensuring only stable commands are accepted. Once validated, each command is translated via a lookup table into specific PWM and direction outputs for the H-bridge motor drivers—complete with configurable ramp-up and ramp-down profiles to guarantee smooth acceleration and deceleration. The sketch also embeds safety routines (battery-voltage checks, ultrasonic obstacle interrupts) that immediately override movement if critical thresholds are breached. By encapsulating command decoding, speed limiting, timing control, and emergency overrides in a structured control loop, the system delivers responsive, hands-free wheelchair navigation that adapts seamlessly to the user's spoken input.

3. User Interaction and Operation

When powered on, the Arduino Uno continuously listens for voice commands through the connected voice recognition module. The system is programmed to detect specific keywords that correspond to directional movements such as "forward," "backward," "left," and "right." Once a valid voice command is recognized, the Arduino processes the instruction and activates the appropriate motor drivers to move the wheelchair in the desired direction.

This real-time voice interaction enables users to operate the wheelchair effortlessly, using simple spoken words, eliminating the need for physical controls or manual input. The system is designed to respond accurately and promptly, ensuring smooth and safe navigation across various indoor and outdoor environments

4. Result

Users experienced significant improvements in independent mobility, particularly in maneuvering through indoor environments using simple voice commands. The voice recognition system demonstrated high accuracy and responsiveness across multiple sessions, even in moderately noisy surroundings, confirming the reliability of the control mechanism.

Participants reported increased comfort and confidence while using the wheelchair, citing reduced reliance on caregivers and enhanced ease of movement. The intuitive voice-controlled interface allowed users to perform daily navigation tasks— such as moving between rooms or adjusting position—with minimal effort.

Overall, the system contributed to a greater sense of independence and autonomy among users, with reduced physical and mental strain.

V. CONCLUSION

This project was developed with the aim of assisting individuals who are physically challenged, paralyzed, or otherwise unable to move independently, and who often rely entirely on others for mobility. The integration of Arduino technology and voice recognition modules made it possible to create an accessible and user-friendly smart wheelchair system. This innovation allows users to control the wheelchair with simple voice commands, providing them with a renewed sense of independence and dignity.

The smart wheelchair offers smooth, responsive movement and can navigate with ease in various environments, improving the quality of life for users. With further research focused on enhancing the accuracy of voice recognition, obstacle detection, and overall system responsiveness, the wheelchair can be made even more intelligent and adaptive to individual user needs.

Future enhancements in user interface design, hardware miniaturization, and wireless connectivity will make the system more comfortable, efficient, and practical for everyday use. This project lays a foundation for continued progress in the field of assistive mobility solutions and has the potential to significantly contribute to the development of inclusive technologies for individuals with physical disabilities.

VI. ACKNOWLEDGEMENT

In our pursuit to successfully complete the project report on Smart Wheelchair Using Arduino and Voice Control, we take this opportunity to express our heartfelt gratitude to all those who supported and guided us throughout this endeavour.

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