Voice Controlled Wheel Chair

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***Abstract*—Mobility is a fundamental necessity for individuals with physical disabilities, and as- sistive technologies play a crucial role in enhancing their independence. This project focuses on developing a Voice-Controlled Wheelchair that enables users to navigate using simple voice commands. The system utilizes a Raspberry Pi 4 for voice recognition and command processing, and an Arduino Nano as the main microcontroller to control the movement of the wheelchair through a BTS7960 motor driver. The Raspberry Pi 4 processes the user's voice commands such as "Forward," "Reverse," "Left," "Right," and "Stop" using advanced speech recognition algorithms. These interpreted commands are transmitted to the Arduino Nano, which in turn controls the BTS7960 motor driver to drive the 24V wiper motors, ensuring smooth and reliable motion. Experimental testing under various environmental conditions showed high command recognition accuracy (around 96 percentage in quiet environments and 85 percentage in noisy environments), with a quick response time of approximately 0.8 seconds and efficient battery operation lasting about 3.5 hours per charge. The system offers a cost-effective, user-friendly, and practical solution compared to commercially available smart wheelchairs. Future developments include integrating AI-based adaptive control, IoT connectivity for remote monitoring, and enhanced power management systems. This project contributes to advancing assistive mobility solutions, aiming to improve the independence and quality of life of individuals with physical disabilities**

***Index Terms*—Voice-controlled wheelchair, Raspberry Pi 4, Arduino Nano, BTS7960 motor driver, speech recognition, as- sistive technology, embedded systems, mobility aid, automation, rehabilitation engineering.**

I. INTRODUCTION

Mobility plays a crucial role in ensuring independence and improving the quality of life for every individual. However, for people with physical disabilities, moving from one place to another without assistance remains a major challenge. Tradi- tional manual wheelchairs require continuous physical effort, while even joystick-controlled electric wheelchairs may not be suitable for individuals with severe mobility impairments

Identify applicable funding agency here. If none, delete this. or lim- ited hand movement. To overcome these challenges, the development of intelligent and assistive technologies has become a key area of research in the field of rehabilitation engineering. The Voice-Controlled Wheelchair is designed to provide an innovative mobility solu- tion that enables users to control the wheelchair through simple voice commands. This approach not only enhances user independence but also ensures ease of operation without the need for physical effort. The system integrates speech recognition, embedded control, and motorized actuation to create a reliable, safe, and user-friendly assistive device. In this project, a Raspberry Pi 4 is used as the main processing unit to recognize and interpret the user's voice commands. The Raspberry Pi processes the spoken instructions using built-in or external speech recog- nition algorithms and generates appropriate con- trol signals. These signals are then transmitted to an Arduino Nano, which acts as the main microcontroller responsible for executing the movement commands. The BTS7960 motor driver receives control signals from the Arduino and drives the 24V wiper motors, enabling the wheelchair to move forward, backward, left, right, or stop according to the user's instructions. The combination of Raspberry Pi 4 and Arduino Nano provides an efficient and flex- ible control architecture. The Raspberry Pi handles computationally heavy tasks like voice processing, while the Arduino ensures fast and reliable control of the motors. The BTS7960 motor driver, with its high

current- handling capability, allows smooth operation of the 24V wiper motors, which offer sufficient torque for wheelchair movement. This integration ensures accurate control, respon- siveness, and safety during operation. The system has been de- signed keeping affordability and practicality in mind. Un- like commercial smart wheelchairs that are often expensive, this prototype offers a cost- effective solution using easily available components. The project also focuses on simplic- ity of design, allowing easy maintenance and future enhancements. The voice-controlled operation eliminates the need for complex control mechanisms, making it ideal for users with limited upper limb mobility. In addition to enhancing accessibility, this project contributes to the field of assistive robotics and embedded systems. The integration of automation, speech recognition, and motor control demonstrates the real-world application of theoretical engineering con- cepts. Furthermore, it opens opportunities for future advancements such as AI- based adaptive voice recognition, IoT-based health and lo- cation monitoring, and solar-powered operation for extended battery life. In conclusion, the Voice-Controlled Wheelchair aims to empower individuals with disabilities by offering them a reliable, efficient, and user-friendly mobility solution. Through the combination of Raspberry Pi 4, Arduino Nano, and BTS7960 motor driver,the project successfully demon- strates how modern embedded technologies can be applied to improve human life and promote independent living.

II. LITERATURE REVIEW

A number of studies have been conducted on the devel- opment of voice-controlled wheelchairs and assistive mobility systems. The following section summarizes key research con- tributions in this field.

1) Design of Voice-Controlled Smart Wheelchair (Ali A. Abed, 2015) Developed using an Arduino and HM2007 speech pro- cessor for Arabic language commands. Achieved 97% recognition accuracy in quiet conditions but showed reduced accuracy in noisy environments and language dependency issues.
2) Voice-Controlled Intelligent Wheelchair (Masato Nishimori et al., 2007) Introduced a grammar-based recognition system using the “Julian” parser to control a wheelchair in Japanese. Achieved 98% accuracy but required a laptop interface, limiting embedded usability.
3) Voice-Controlled Wheelchair for Physically Disabled and Blind People (Hariharan S. et al., 2025) Combined Arduino/Raspberry Pi control with ultrasonic sensors and Google Cloud Speech-to-Text for multi- language voice control. Improved accessibility but faced network dependency and cost issues.
4) Design of Voice-Controlled Smart Wheelchair for Physically Challenged Persons (Khagendra Joshi et al., 2021) Implemented Bluetooth-based voice control with obsta- cle avoidance and line-following. Enhanced autonomy but suffered from communication delays and lacked AI adaptability.
5) A Wavelet and Neural Network-Based Voice Inter- face System for Wheelchair Control (Ha, Tran, and Dissanayake, 2005) Used continuous wavelet transform with neural networks for improved accuracy and noise resistance. However, it was computationally demanding for embedded systems.
6) Design of Voice-Controlled Smart Wheelchair for Physically Challenged Persons (Khagendra Joshi et al.,2017) Proposed a solar-powered, voice-controlled wheelchair offering affordable operation. However, it lacked adapt- ability in noisy conditions.
7) Voice Controlled Wheel Chair System (Mohammad Ilyas Malik, Tanveer Bashir, and Omar Farooq Khan, 2007) Developed a wheelchair using Arduino UNO, Bluetooth (HC-05), and ultrasonic sensors for obstacle detection. Integrated Android-based voice commands for move- ment control, achieving high accuracy and independence at low cost.
8) Developing a Voice-Controlled Wheelchair with En- hanced Safety through Multimodal Approach (Sahan Priyanayana and Jayasekara, 2011) Combined voice and joystick control with a safety algorithm to prevent accidental movements, improving reliability.

9) Voice-Controlled Wheelchair with Home Automation (Shoeb Khan et al., 2024) Integrated ESP32 and CNN-based wake word detec- tion for smooth control, achieving 95% accuracy but increased complexity.
10) Voice-Controlled Smart Electric-Powered Wheelchair Based on Artificial Neural Network (Mohammed H. Jabardi, 2017) Utilized an ANN-based system for adaptive speech recognition, enhancing accuracy but requiring more processing power.
11) A Voice-Controlled Wheelchair for Physically Chal- lenged People with Therapy Unit (Muneera T. N. and Dinakardas C. N., 2019) Integrated a therapy unit with vibration and servo motor stimulation to reduce limb numbness, improving comfort and safety.
12) Voice-Controlled Wheelchairs: Fine Control by Humming (Nathalia Peixoto et al., 2013) Enabled control using humming-based input via an accelerometer, providing noise-resistant and intuitive operation.

The reviewed works show progressive improvements in voice recognition, control reliability, and safety features. How- ever, limitations such as noise sensitivity, high computational demand, and lack of real-time adaptability remain open chal- lenges that this project aims to address.

III. OBJECTIVE OF WORK

The primary objective of this project is to design and develop a voice-controlled wheelchair that enables individuals with physical disabilities to move independently using simple voice commands. The system aims to provide a cost-effective, reliable, and user-friendly mobility solution that enhances accessibility and quality of life. The specific objectives of the project are: 1. To design a wheelchair control system that responds accurately to voice commands for directions such as forward, reverse, left, right, and stop. 2. To implement a speech recognition system using Raspberry Pi 4 for effi- cient pro- cessing and interpretation of verbal instructions. 3. To integrate an Arduino Nano microcontroller for executing movement commands and controlling the motors through the BTS7960 motor driver. 4. To employ 24V wiper motors for smooth, powerful, and stable movement of the wheelchair.

5. To develop a compact and energy-efficient system with optimal power utilization and long battery life. 6. To ensure user safety and operational reliability under different environ- mental conditions. 7. To create an affordable prototype that demonstrates the potential of embedded systems in assistive technology and can be easily replicated or upgraded for real- world applications. This project is a voice-controlled dual-motor driver system that uses a Raspberry Pi, Arduino Nano, and BTS7960 motor drivers to control the movement of a robot through voice commands. The system operates through several key stages: power supply, in- put processing, command interpretation, and motor driving. A 24V DC power supply is used to operate the high-power motors, while a voltage regulating circuit steps down the voltage to 5V DC to power the Arduino Nano, Raspberry Pi, and other control electron- ics. The input section consists of a microphone connected to the Raspberry Pi, which captures the user's voice commands such as "forward," "backward," "left," "right," and "stop." The Raspberry Pi processes these commands using speech recognition and then converts them into corresponding serial commands that are sent to the Arduino Nano through UART serial communication. The Arduino Nano acts as the main motor control unit, receiving the serial data from the Raspberry Pi and interpreting each command to control the direction and movement of the motors. For instance, the character 'F' corre- sponds to forward motion, 'B' to backward, 'L' to left turn, 'R' to right turn, and 'S' to stop. Based on the received command, the Arduino generates appropriate PWM (Pulse Width Modulation) and enable signals to control the BTS7960 motor driver modules. The BTS7960 is a high-power H-Bridge motor driver capable of handling large currents up to 43A, making it ideal for driving heavy DC motors. Each BTS7960 module controls one motor, with input pins (RPWM, LPWM, REN, LEN) connected to the Arduino for speed and direction control, and output pins (M+, M) connected to the motor terminals. When the Arduino sends control signals, the BTS7960 modules drive the motors accord- ing to the command: both motors rotate forward for forward movement, both reverse for backward movement, and one motor stops or reverses

while the other runs forward for left or right turns. When a stop command is issued, both motors halt immediately. This integrated setup enables smooth and responsive robot motion entirely through voice commands. In summary, the user's voice is captured and processed by the Raspberry Pi, converted into serial control signals sent to the Arduino Nano, which then generates motor control signals for the BTS7960 drivers to operate the motors using a 24V sup- ply. This coordination between the Raspberry Pi, Arduino Nano, and BTS7960 modules allows for efficient and accurate voice- controlled robotic movement.

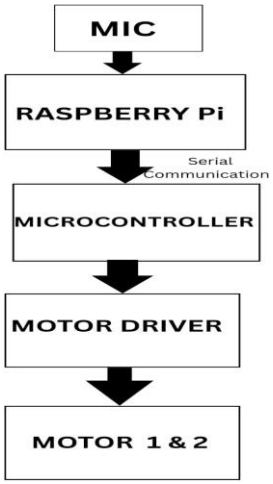

Fig. 1. Block diagram

IV. METHODOLOGY

The overall system consists of the following main compo- nents: Microphone, Raspberry Pi 4, Arduino Nano, BTS7960 Motor Driver, and 24V Wiper Motors. The working process can be explained step-by-step as follows: 1. Microphone (MIC): The microphone captures the voice commands of the user such as "forward," "backward," "left," "right," and "stop." The captured audio signals are sent to the Raspberry Pi for processing. 2. Raspberry Pi 4: The Raspberry Pi acts as the central processing unit for speech recognition. It processes the input voice signal using suitable speech recognition soft- ware and converts the spoken command into a text instruction. This instruction is then transmitted to the Arduino Nano via serial communication. 3. Microcontroller (Arduino Nano): The Arduino Nano receives the command from the Raspberry Pi and determines which motor action to execute. It generates appropriate control signals for the BTS7960 motor driver based on the command received. 4. Motor Driver (BTS7960): The motor driver acts as a power amplifier. Since the Arduino cannot directly drive the motors due to its low current output, the BTS7960 motor driver provides the necessary voltage and current required to operate the 24V wiper motors safely and efficiently. 5. Motors (Left and Right): The two wiper motors drive the wheelchair according to the received commands: Forward: Both motors rotate forward. Backward: Both motors rotate in reverse. Left: Left motor stops, right motor rotates forward. Right: Right motor stops, left motor rotates forward. Stop: Both motors stop.

A. Circuit Diagram

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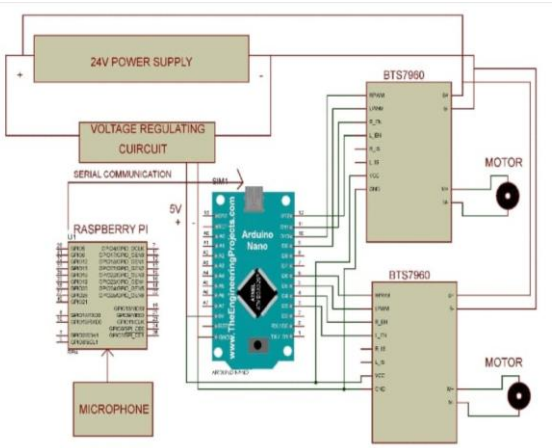

Fig. 2. Circuit Diagram

down the voltage to 5V DC to power the Arduino Nano, Raspberry Pi, and other control electronics. The input section consists of a microphone connected to the Raspberry Pi, which captures the user's voice commands such as "forward," "back- ward," "left," "right," and "stop." The Raspberry Pi processes these commands using speech recognition and then converts them into corresponding serial commands that are

sent to the Arduino Nano through UART serial communication. The Arduino Nano acts as the main motor control unit, receiving the serial data from the Raspberry Pi and interpreting each command to control the direction and movement of the motors. For instance, the character 'F' corresponds to forward motion, 'B' to back- ward, 'L' to left turn, 'R' to right turn, and 'S' to stop. Based on the received command, the Arduino generates appropriate PWM (Pulse Width Modulation) and enable signals to control the BTS7960 motor driver modules. The BTS7960 is a high-power H-Bridge motor driver capable of handling large currents up to 43A, making it ideal for driving heavy DC motors. Each BTS7960 module controls one motor, with input pins (RPWM, LPWM, REN, LEN) connected to the Arduino for speed and direction control, and output pins (M+, M) connected to the motor terminals. When the Arduino sends control signals, the BTS7960 modules drive the motors ac- cording to the command: both motors rotate forward for forward movement, both reverse for backward movement, and one motor stops or reverses while the other runs forward for left or right turns. When a stop command is issued, both motors halt immediately. This integrated setup enables smooth and responsive robot motion entirely through voice commands. In summary, the user's voice is captured and processed by the RaspberryPi, converted into serial control signals sent to the Arduino Nano, which then generates motor control signals for the BTS7960 drivers to operate the motors using a 24V sup- ply. This coordination between the Raspberry Pi, Arduino Nano, and BTS7960 modules allows for efficient and accurate voice-controlled robotic movement.

B. Control Part

The control system of the voice-controlled wheelchair is designed to enable seamless and hands-free mobility for the user. It consists of two main controllers: the Raspberry Pi 4 and the Arduino Nano, working together to process commands and drive the motors. The Raspberry Pi 4 acts as the high-level controller, capturing and interpreting voice commands from the user. These commands, such as "forward," "backward," "left," "right," and "stop," are converted into digital signals and sent to the Arduino Nano via serial communication. The Arduino Nano serves as the low-level controller. It receives the commands and controls the 24V wiper motors through the BTS7960 motor driver. The driver allows precise speed and direction control using PWM signals. The 24V 30Ah battery powers the motors directly, while a buck converter steps down the voltage to 5V to safely power the Raspberry Pi and Arduino Nano. This architecture ensures reliable motor operation, precise control, and a smooth response to user com- mands.

C. Power Circuit Part

The power circuit of the voice-controlled wheelchair ensures that all components receive stable and appropriate voltage levels. The 24V 30Ah battery acts as the primary power source, supplying the necessary current to drive the high- torque 24V wiper motors. A buck converter steps down the 24V supply to 5V, which powers the Raspberry Pi 4 and Arduino Nano safely. The BTS7960 motor driver receives 24V from the battery to control the motors efficiently, while the buck converter guarantees that the electronics operate at a safe voltage. This configuration ensures reliable operation of both the motors and control electronics without damage or voltage instability.

V. ACKNOWLEDGMENT

We would like to express our sincere gratitude to our project guide, Dr. Mary P. Varghese, Professor, Department of Electrical and Electronics Engineering, for her valuable guidance, advice, and constant encouragement throughout the course of this work. Her support and insightful suggestions have been instrumental in the successful completion of this project.

We are also grateful to all the faculty members of the Department of Electrical and Electronics Engineering for their continuous support and cooperation. We extend our heartfelt thanks to our friends and classmates for their help, motivation, and encouragement during the development of this project.

We also wish to express our gratitude to Dr. Mary P. Vargh- ese, Head of the Department of Electrical and Electronics Engineering, and to our Principal, Dr. Sunitha C., for their support and encouragement.

Finally, we express our deepest gratitude to God Almighty for His abundant blessings, guidance, and strength, without which this work would not have been possible.

VI. CONCLUSION

This paper presents the design and development of a voice-controlled wheelchair intended to enhance mobility and independence for individuals with physical disabilities. The proposed system utilizes a Raspberry Pi 4 for voice recognition and an Arduino Nano for motor control, with a BTS7960 motor driver operating high-torque 24V wiper motors. The integration of these components provides an efficient, low-cost, and user-friendly solution for real-time motion control through simple voice commands. The system aims to overcome the limitations of conventional wheelchairs by offering hands-free operation and improved accessibility. Future work will focus on integrating obstacle detection, IoT-based monitoring, and AI-enhanced speech recognition to further improve the safety, adaptability, and intelligence of the wheelchair.

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