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Smart Voice Controlled Wheelchair for Physically Disabled People

Sandip Shinde[1], Jagdeep Singh[2], Rani Jivtode[3], Himanshu Khare[4]
Vishwakarma Institute of Technology, Pune Department of Computer Engineering Pune, India

Abstract: In this groundbreaking study, we introduce a state-of-the-art, user-friendly smart voice-controlled wheelchair designed specifically for individuals with physical disabilities. Leveraging advanced technologies, including the powerful Arduino Uno microcontroller, precise ultrasonic sensors for obstacle detection, and seamless Bluetooth connectivity, our wheelchair system redefines the paradigm of mobility solutions. An intuitive mobile application, available for download on popular platforms such as the Play Store, complements the hardware, enabling effortless control and customization through natural voice commands. This paper meticulously details the design, implementation, and evaluation of our smart voice-controlled wheelchair, emphasizing its innovative features and discussing compelling avenues for future improvements.

Keywords: Smart Wheelchair, Voice Control, Arduino Uno, Bluetooth Connectivity, Ultrasonic Sensors, Mobile Application.

I. INTRODUCTION

In our unwavering commitment to enhancing mobility and independence for individuals with physical disabilities, we present a groundbreaking smart voice-controlled wheelchair seamlessly integrated with a cutting-edge Bluetooth module. Our wheelchair system harmoniously combines the power of the Arduino Uno microcontroller, ultrasonic sensors, and Bluetooth technology, offering a holistic and intuitive means of transportation.

By addressing the limitations of traditional wheelchairs, our innovation empowers users to navigate their environments with unprecedented control and customization options.

The incorporation of a Bluetooth module enables wireless communication between the wheelchair and external devices, such as smartphones and tablets. Our dedicated mobile application, driven by intuitive voice commands, ensures effortless control and real-time monitoring of the wheelchair's status and performance.

II. LITERATURE REVIEW

Various studies underscore the pivotal role of independent mobility, encompassing powered wheelchairs, manual wheelchairs, and walkers, in enhancing the lives of individuals with disabilities. Independent mobility not only amplifies vocational and educational opportunities but also fosters self-reliance and self-esteem. It is instrumental in early learning, breaking the cycle of deprivation, and preventing learned helplessness, particularly among young people. For the elderly, independent movement is a cornerstone for aging in place, significantly impacting their self-esteem and overall well-being [1]. Mobility difficulties often lead to challenges in activities of daily living (ADL) and instrumental ADL, contributing to social isolation and mental health issues. The impaired mobility, especially among individuals with conditions such as low vision, spasticity, tremors, or cognitive deficits, necessitates dependence on others for mobility assistance.

Traditional manual or self-automated wheelchairs cater to many, yet a segment of the disabled community finds them challenging to use independently [2]. Researchers have explored diverse technologies originally developed for power wheelchairs to address specific challenges. These innovations aim to ensure collision-free travel, assist in task performance (e.g., navigating doorways), and autonomously transport users between locations. Additionally, the integration of voice-based technology has emerged as a pioneering solution, allowing precise control without the need for manual dexterity [3].

The integration of voice-based technology in wheelchair control represents a significant leap forward, positioning this work ahead of conventional solutions. This innovative approach not only simplifies daily life for individuals with disabilities but also captures the interest of modern society.

Overcoming the limitations of traditional control methods, such as joystick interfaces, this novel technology opens doors to enhanced accessibility and inclusivity [4].

III. METHODOLOGY

A. System Architecture

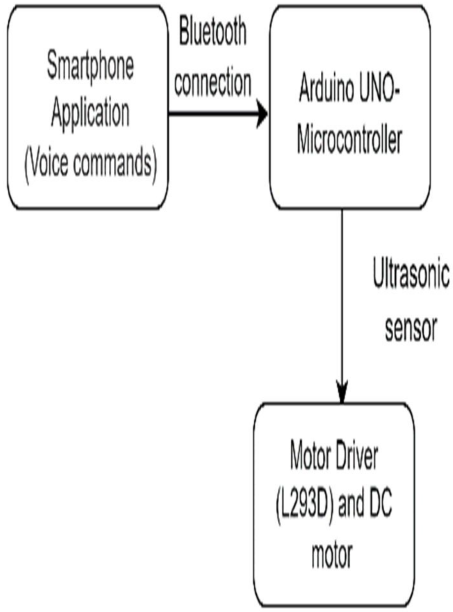

Fig.1. Block diagram

1) *Arduino Uno Microcontroller Integration*

a) The Arduino Uno microcontroller serves as the central processing unit, adeptly interpreting user voice commands and orchestrating precise wheelchair movements.

Fig.2. Arduino Uno microcontroller.

b) Utilizing the Arduino IDE, the microcontroller was programmed with meticulous attention to command parsing and real-time responsiveness, ensuring optimal performance.

2) *Bluetooth Module and Mobile Application*

a) A high-performance Bluetooth module, operating within the 2.4 GHz frequency range, establishes a robust wireless bridge between the Arduino Uno microcontroller and the purpose-built mobile application.

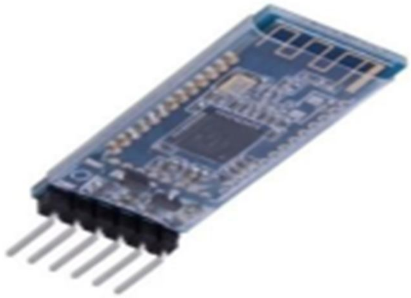

Fig.3. Bluetooth Module.

b) Fig 4 shows the interface of smartphone application, the mobile application meticulously crafted and available on prominent platforms like the Play Store, enables users to issue intuitive voice commands ("forward," "backward," "left," "right," and "stop") for effortless wheelchair navigation.

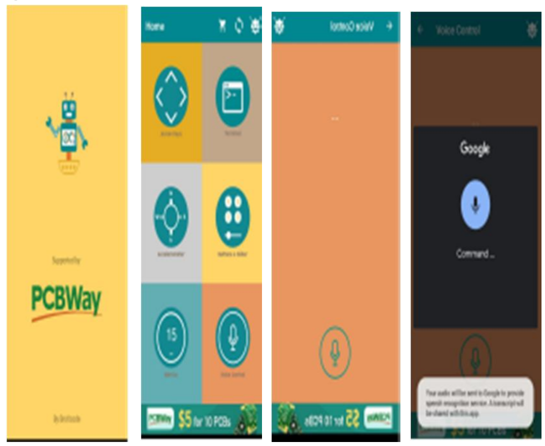

Fig.4. Interface of Smartphone application

3) *Ultrasonic Sensors for Obstacle Detection*

a) State-of-the-art ultrasonic sensors are seamlessly integrated into the system to provide real-time obstacle detection capabilities.

b) Through sophisticated signal processing algorithms, the ultrasonic sensors precisely measure distances, enabling the wheelchair to navigate complex environments with unparalleled collision avoidance capabilities.

Fig.5. Ultrasonic Sensors.

4) *Motor Driver (L293D) and DC Motors*

a) The motor driver translates signals from the Arduino Uno into precise movements, allowing the wheelchair to move forward, backward, turn, and stop.

Fig.6. Motor Driver.

B. *Voice Command Integration*

1) *Voice Command Recognition*

a) The mobile application incorporates an advanced voice command recognition system, specifically engineered for simplicity and accuracy.6

b) Basic yet crucial commands such as "forward," "backward," "left," "right," and "stop" are effortlessly recognized within the application, ensuring a natural and intuitive interaction paradigm.

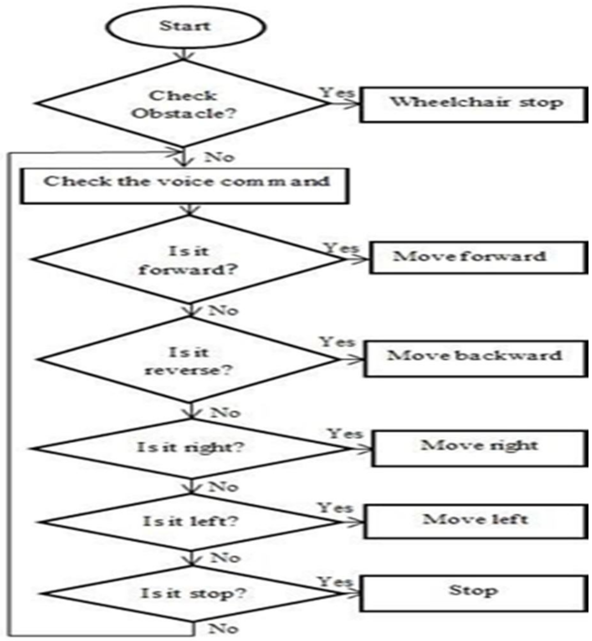

Fig.7. Voice Control System Flow

2) *User Interaction and Control*
a) Users seamlessly interact with the system by delivering voice commands via the mobile application's intuitive interface.
b) The simplicity and effectiveness of voice commands empower users, especially individuals with physical disabilities, fostering an unprecedented level of control and independence in their mobility.

C. *System Integration and Testing*
1) *Hardware And Software Integration*
a) Rigorous integration protocols are meticulously established, fostering seamless communication between the Arduino Uno microcontroller, Bluetooth module, and the mobile application.
b) Careful consideration is given to data exchange protocols, ensuring real-time transmission of commands and feedback, thereby enhancing the system's responsiveness.

2) *Usability Testing*
a) Comprehensive usability tests, conducted with individuals having physical disabilities, serve as a testament to the system's efficacy and user-friendliness.
b) User feedback and performance metrics are thoroughly analyzed, steering iterative design enhancements aimed at refining the system's responsiveness and user experience.

IV. HARDWARE DESCRIPTION

Our hardware description section provides a detailed exposition of the key components driving our smart wheelchair. The Bluetooth module, operating within the 2.4 GHz frequency range, establishes secure wireless communication, enabling real-time data exchange and performance monitoring. The ultrasonic sensor, utilizing high-frequency sound waves, detects obstacles and provides crucial feedback for safe navigation. The motor driver (L293D) acts as the powerhouse, translating commands from the Arduino Uno microcontroller into precise motor movements, ensuring seamless mobility in all directions.

V. RESULT AND DISCUSSION

The hardware implementation of the smart voice-controlled wheelchair successfully integrated cutting-edge technologies, including the Arduino Uno microcontroller, Bluetooth module, and ultrasonic sensors, to create a functional and intuitive mobility solution for individuals with physical disabilities (see Fig. 8).

The wheelchair's ability to detect obstacles in real-time using ultrasonic sensors ensured safe navigation and collision avoidance, enhancing user confidence and independence.

The interface of the smartphone application (Fig. 4) provided a user-friendly platform for controlling and customizing the wheelchair's movements through voice commands. This seamless interaction between the user and the wheelchair marked a significant advancement in the field of assistive technology.

The smart wheelchair operates through a user-friendly mobile application where voice commands are inputted (see Fig. 7). These commands are transmitted via Bluetooth to the Arduino Uno microcontroller (Fig. 2), which processes them along with data from ultrasonic sensors (Fig. 5) detecting obstacles. The Arduino Uno makes intelligent decisions, coordinating movement commands with obstacle detection. Signals are then sent to the motor driver (Fig. 6), enabling the wheelchair to move or stop as instructed. The user receives feedback through the mobile app (Fig. 4), ensuring awareness of the wheelchair's status and surroundings. This integrated system ensures safe, intuitive, and independent mobility for individuals with physical disabilities.

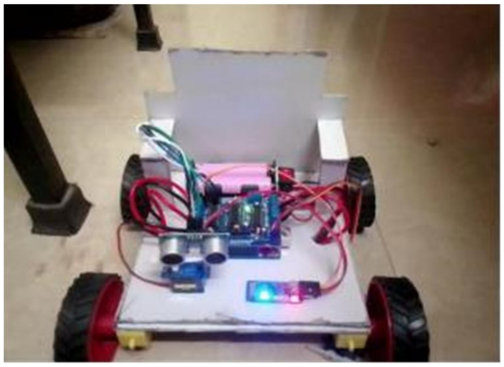

Fig.8. Voice control wheelchair model.

VI. WORKING OF WHEELCHAIR

The smart wheelchair operates through a user-friendly mobile application where voice commands are inputted (Fig. 7). These commands are transmitted via Bluetooth to the Arduino Uno microcontroller (Fig. 2), which processes them along with data from ultrasonic sensors (Fig. 5) detecting obstacles. The Arduino Uno makes intelligent decisions, coordinating movement commands with obstacle detection. Signals are then sent to the motor driver (Fig. 6), enabling the wheelchair to move or stop as instructed. The user receives feedback through the mobile app (Fig. 4), ensuring awareness of the wheelchair's status and surroundings. This integrated system ensures safe, intuitive, and independent mobility for individuals with physical disabilities.

VII. FUTURE SCOPE

Our paper opens avenues for transformative research and development. Advanced voice recognition algorithms and machine learning integration can elevate the wheelchair's responsiveness and adaptability. Sensor fusion, incorporating ultrasonic sensors with infrared sensors and cameras, promises enhanced obstacle detection and decision-making capabilities. Exploring energy-efficient mechanisms and integrating smart home systems or IoT platforms are potential avenues for future enhancements, ensuring sustained usability and seamless integration with users' environments.

VIII. CONCLUSION

Our smart voice-controlled wheelchair represents a paradigm shift in assistive technologies (Fig. 8). By combining innovative hardware components with advanced software solutions, we have created a mobility solution that not only addresses existing limitations but also anticipates future needs. Our commitment to enhancing the lives of individuals with physical disabilities drives us to continuously explore new horizons, ensuring that our assistive technologies are not just tools but empowering companions on their journey toward independence and mobility.

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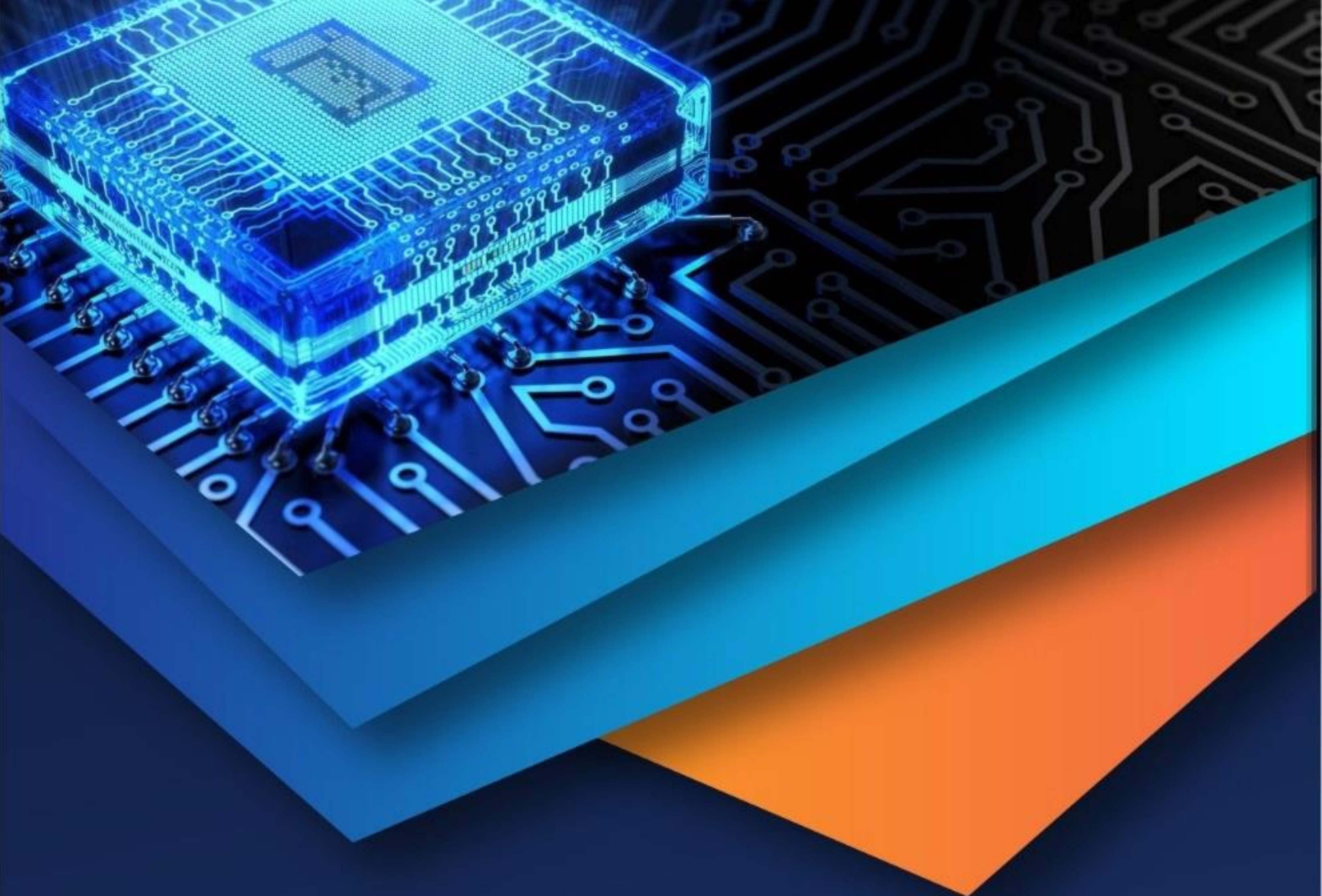

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