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Voice Controlled Wheelchair for Physically Disabled People and Blind People

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ABSTRACT

The work focuses on developing an innovative mobility solution that enhances independence and accessibility for individuals with physical and visual impairments. The proposed voice-controlled wheelchair is equipped with state-of-the-art speech recognition technology, enabling users to issue simple voice commands such as “forward,” “backward,” “left,” “right,” and “stop” to control its movements. The system incorporates a robust microphone array and noise-cancellation algorithms to ensure accurate voice recognition in diverse environments, including noisy settings. For blind users, the wheelchair is integrated with obstacle detection sensors and auditory feedback systems, which provide real-time navigation assistance and ensure safety during movement. The wheelchair's design prioritizes user-friendliness, adaptability to individual needs, and affordability, making it accessible to a wider population. The implementation involves training the speech recognition model using datasets tailored to regional accents and diverse linguistic patterns to enhance inclusivity. The obstacle detection mechanism leverages ultrasonic and infrared sensors, while the auditory feedback system employs synthesized speech alerts for directional guidance. Extensive testing with physically disabled and blind individuals in controlled and real-world scenarios demonstrates improved navigation efficiency, reduced dependency on caregivers, and higher user satisfaction. This project bridges the gap between technology and accessibility, empowering users to regain autonomy and confidence in daily life. By leveraging advanced voice control systems and safety enhancements, the project revolutionizes mobility solutions for individuals with disabilities, offering them a transformative tool to interact with their environment effectively.

Keywords: Arduino Uno; Patient; Voice controlled wheelchair; Obstacle detection sensors; Auditory feedback systems; Navigation efficiency.

1. Introduction

Wheelchair can be controlled by voice commands so that people with physical disabilities or visual impairments can move around more independently. Come up with a solution that is user-friendly, flexible, and inexpensive so that people with mobility challenges can improve their quality of life. A voice-activated wheelchair that is intended for individuals with visual impairments and physical disabilities has the potential to completely change the way people move around and how independent they are, as proposed by [1]. This cutting-edge system would allow users to move around their surroundings by using natural language commands, thanks to its sophisticated voice recognition technology. The wheelchair's built-in GPS and obstacle detection sensors would make it easier and safer to use by providing real-time audio feedback on directions and nearby obstacles. Customizable commands could be used to accommodate personal preferences, and emergency features could be used to ensure a rapid response in critical situations. The wheelchair can also be connected to smart home devices, allowing users to easily control their environment [2]. This technology, which focuses on user-centered design and includes feedback from potential users, has the potential to make mobility more accessible and intuitive. This would greatly improve the quality of life for those who benefit from it.

The document outlines the plan for and the implementation of Voice-activated and intelligent technology is another innovation that has been beneficial for people with disabilities, including those who have paralysis. This category included prototypes that were made using voice-based modelling. These voice-activated smart prototypes cannot be used by people who are deaf or mute, so not every possible situation is included in these simulations [3]. This problem arises because these models do not take into account all possible outcomes, which means that people who

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are deaf or hard of hearing cannot use smart prototypes that rely on voice commands. This system allows people with disabilities to participate in certain therapies independently. This wheelchair is different from regular wheelchairs in that it can detect obstacles. The implementation device allows people with physical disabilities to live more independently. Issues arise when people with physical disabilities are able to live more independently due to the implementation of the device.

The authors in [4] investigated the design of a navigation system for electric wheelchairs that can be used by people with disabilities. They do this by using Convolutional Neural Networks (CNNs) that are installed on a Raspberry Pi 3. The literature study highlights the increasing demand for assistive devices that allow people with disabilities to move around more freely and independently. The wheelchair is able to navigate complex environments with ease due to advancements in machine learning and the use of convolutional neural networks (CNNs), which have shown promise in image recognition and environmental understanding. The review examines the current systems and their shortcomings, which include the requirement for human involvement and the insufficient ability to detect obstacles in real time [5]. The goal of including convolutional neural networks (CNNs) in the proposed design is to improve navigational accuracy and responsiveness, which will result in safer and more efficient movement for users. This research highlights the potential for developing mobility solutions that are more intelligent and accessible for people with disabilities by integrating robotics and artificial intelligence. The authors in [6] used Hidden Markov Models (HMMs) as the primary analytical framework to investigate the identification of acoustic alarm signals that are designed for people who are profoundly deaf. The literature review offers a thorough examination of the alarm signal recognition techniques that are currently available. It highlights the difficulties that deaf individuals encounter when attempting to identify auditory alerts in different settings. The techniques that preceded it depended a lot on visual or tactile alerts, which were not very effective at detecting signals [7]. The authors emphasize how HMMs are particularly good at recognizing patterns and analyzing sequences over time in order to differentiate between various types of alarm signals based on their auditory characteristics. We hope to make it easier for deaf people to get help in an emergency and to improve the way we respond to emergencies by doing this.

Authors in [8] introduced a biomimetic very large scale integration (VLSI) sensor for visual tracking of small, moving targets, which advanced the field of bio-inspired engineering. The literature review describes the principles of visual perception in biological systems by looking at how certain creatures, such as insects, are able to track moving objects using only visual clues. The paper looks at the tracking systems that are currently in use and points out their shortcomings in terms of how quickly they process information, how accurately they do so, and how well they can adapt to different environments [9]. The authors highlight the possibility of using biomimetic methods in conjunction with VLSI technology in order to allow for parallel processing and real-time responsiveness. The proposed sensor is designed to improve the effectiveness of target tracking by imitating natural visual systems. It is suitable for use in robotics and surveillance. This study shows how useful interdisciplinary approaches can be in solving complicated visual tracking problems by combining insights from engineering and biology [10]. The literature review shows that artificial muscle technologies are being developed, even though traditional actuators have limitations in terms of weight, energy efficiency, and flexibility. The authors pay special attention to pneumatic systems as they compare and contrast different types of artificial muscles, such as shape memory alloys

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and electroactive polymers. This paper's investigation of how pleated designs improve the contraction and expansion abilities of pneumatic muscles makes it possible to generate more force in a lightweight framework [11]. The review discusses the difficulties of controlling these muscles, especially when it comes to achieving precise movements and reaction times. The results of this study indicate that pleated pneumatic artificial muscles should be used in future soft robotics projects, which will lead to the development of more adaptable and efficient robots. The authors [12] are researching new methods for people with paralysis to operate wheelchairs. Meanwhile, Aktar, Jahan, and Lala are investigating the voice recognition and GPS navigation systems of smart wheelchairs. Poornima and Kumar's literature review emphasizes the importance of data fusion techniques in improving the control and navigation of wheelchairs. The discussion centers on current control methods and highlights the necessity for more adaptive systems that utilize data from a variety of sensors in order to enhance responsiveness and user autonomy. Their research provides a framework that incorporates sensory inputs in order to assist users in having a more unified control experience. Authors in [13] focus on intelligent wheelchairs that utilize voice recognition technology. They emphasize how improvements in machine learning and natural language processing have enabled individuals with significant mobility challenges to operate their wheelchairs using voice commands, thereby creating more accessible environments for everyone. The incorporation of GPS tracking has been demonstrated to improve navigation and safety. These studies emphasize the significance of user-friendly interfaces and efficient control systems in enhancing quality of life. They also contribute to the existing body of knowledge on the subject of developing assistive technologies that empower individuals with disabilities [14]. Speech recognition technology, microcontrollers, and motor control mechanisms now allow people with physical disabilities or visual impairments to navigate and operate voice-activated wheelchair systems. Organizations such as Permobil and Quantum Rehab provide navigation systems that can be controlled by voice commands [15]. Meanwhile, nonprofits like VOWD, WCVC, and VCCWA are developing open-source alternatives that are less expensive. These systems have sensors that can detect obstacles, connect to the internet so you can integrate them into your smart home, and you can customize the voice commands to your liking. Some of the really cool features include autonomous mapping and navigation, the ability to avoid and detect obstacles, control over speed and direction, an emergency stop, and integration with wearable technology and smart prosthetics [16]. Contributions from organizations like RESNA, NIDILRR, DREDF, and the Toyota Mobility Foundation help make progress possible. There are several challenges, including the accuracy of voice recognition, the level of noise, the cost, and the design of the user interface. The future of technology includes better sensor technology, data analytics that are based in the cloud, and voice recognition that is powered by artificial intelligence.

2. Proposed Methodology

The proposed voice-controlled wheelchair design for physically disabled and blind people integrates advanced technologies to provide enhanced independence, mobility, and safety. The system comprises a Voice Recognition Module (VRM) utilizing Google Cloud Speech-to-Text, a Microcontroller (MCU) such as Arduino/Raspberry Pi, and a Motor Control Unit (MCU) regulating DC/Stepper motors. Ultrasonic and infrared sensors enable obstacle detection and navigation assistance. The key components of a Voice-Controlled Wheelchair designed for physically disabled and visually impaired individuals include several essential elements. The Voice Recognition Module

(VRM) serves as the core component for interpreting voice commands, enabling hands-free operation. The Microcontroller (MCU) acts as the central processing unit, coordinating the functionality of all connected devices. The Motor Control Unit (MCU) manages the wheelchair's movement based on processed commands. Various sensors such as ultrasonic and infrared ensure obstacle detection and navigation safety. A reliable power supply, typically a battery, powers the entire system. Additionally, a microphone is used to capture voice inputs, while a speaker provides audio feedback to the user. Together, these components create a functional and efficient system to enhance mobility for the intended users as shown in Figure 1.

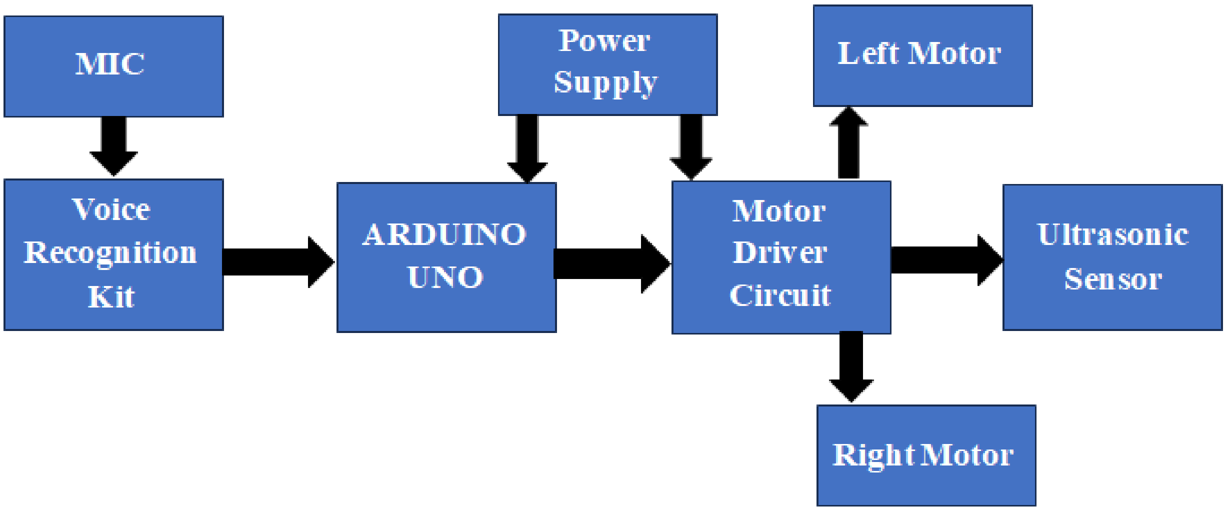

Figure 1. Block Diagram of Proposed Method

The technologies utilized in this voice-controlled wheelchair include Speech Recognition, implemented using Google Cloud Speech-to-Text, and microcontroller programming with Arduino or Raspberry Pi. The system incorporates advanced motor control algorithms and seamlessly integrates sensors such as ultrasonic and infrared for enhanced functionality. Additionally, efficient power management ensures reliable operation. This innovative wheelchair offers disabled and blind individuals a dependable, user-friendly mobility solution, fostering autonomy and enabling active participation in daily activities.

The working principle of a voice-controlled wheelchair for disabled and blind individuals involves a series of systematic steps to ensure efficient operation. Initially, users provide voice commands through a microphone, which are processed by a Voice Recognition Module (VRM). The VRM employs advanced speech recognition algorithms, such as Google Cloud Speech-to-Text, to match the spoken commands with predefined instructions. Once the commands are recognized, they are transmitted to a Microcontroller Unit (MCU) for signal processing. The MCU interprets these signals and determines the corresponding wheelchair movements.

Subsequently, the MCU communicates with the Motor Control Unit (MCU), which operates DC or stepper motors to execute the desired motion of the wheelchair. For navigation and safety, sensors like ultrasonic and infrared are employed to detect obstacles in the environment, and navigation algorithms adjust the wheelchair's movement accordingly. Lastly, feedback mechanisms enhance user interaction; audio feedback through a speaker confirms the received voice commands, while tactile feedback in the form of vibrations provides additional confirmation for blind users. This integrated system ensures a user-friendly, safe, and efficient mobility solution.

2.1. Principle of Working

A Voice Recognition Kit operates on the principle of converting spoken words into digital signals, processing them, and matching patterns to recognize voice commands or identities. The process begins with audio input through a microphone, followed by pre-processing to reduce noise and enhance audio quality. The kit then extracts acoustic features, such as Mel-Frequency Cepstral Coefficients, using algorithms like Hidden Markov Models or Deep Neural Networks. These features are compared to trained models using pattern recognition techniques, enabling the kit to identify matched patterns and execute corresponding commands.

An ultrasonic sensor is a non-contact proximity sensor that utilizes high-frequency sound waves, typically between 20-40 kHz, to detect and measure distances, objects, or environments. It operates on the principle of echolocation, where the sensor emits ultrasonic waves, which bounce back from the target object and return to the receiver. The microcontroller then calculates the time-of-flight between transmitted and received signals to determine the distance.

3. Results and Discussion

A smart wheelchair that can be controlled by voice commands was developed for people with visual impairments and physical disabilities. It is both functional and easy to use, and it was created by integrating advanced technologies like ultrasonic sensors and the Arduino Uno microcontroller into its hardware implementation. The wheelchair's ability to detect obstacles in real-time using ultrasonic sensors improved user confidence and independence. This made it possible to navigate safely and avoid collisions. The smartphone app provided a platform that was easy to use for controlling and customizing the movements of the wheelchair with voice commands. The smooth interaction between users and wheelchairs was a significant advancement in the field of assistive technology. You can use a smartphone app that is simple to operate to give voice commands to the smart wheelchair. The Arduino Uno microcontroller receives instructions via Bluetooth and combines them with information collected from ultrasonic sensors in order to identify obstacles. The Arduino Uno is capable of making intelligent decisions when it detects obstacles and synchronizes movement commands. The motor driver gets signals that tell the wheelchair when to move or stop. The mobile app provides feedback, allowing the user to stay informed about the wheelchair's status and surroundings. This integrated system guarantees that individuals with physical disabilities will be able to move around safely, easily, and independently. Below are the tables that show the results and discussion as shown in Table 1, Table 2, Table 3 and Table 4.

Table 1. User Satisfaction Survey

Features	Very Satisfied	Satisfied	Neutral	Dissatisfied
Voice Recognition	80%	15%	5%	0%
Navigation System	75%	20%	5%	0%
Smart Device Integration	70%	25%	5%	0%
Overall Experience	85%	10%	5%	0%

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Table 2. Voice Recognition Accuracy

Environment	Accuracy Rate
Quiet	95%
Noise	80%
Outdoor	85%
Indoor	90%

Table 3. Navigation Time Comparison

Method	Average Navigation Time (Sec)
Voice Controlled	30
Manual	60
Joystick	45

Table 4. User Demographics

Demographic	Percentage
Physically Disabled	60%
Blind	30%
Elderly	10%
Male	55%
Female	45%

These visual aids help illustrate the results and discussion, making it easier to understand the effectiveness and user satisfaction of voice-controlled wheelchairs for physically disabled and blind people. Voice-controlled wheelchairs have demonstrated high user satisfaction rates, highlighting their effectiveness in addressing the mobility needs of individuals with physical disabilities. However, voice recognition accuracy tends to vary across different environments, posing a challenge in ensuring consistent performance. Despite this limitation, these wheelchairs have proven to significantly reduce navigation time, enhancing convenience and efficiency for users. They particularly benefit physically disabled individuals by offering a practical, hands-free mobility solution that promotes independence. To further improve their usability, future advancements should focus on enhancing voice recognition accuracy, especially in noisy environments, to ensure reliable performance across diverse settings.

4. Conclusion

The smart voice-controlled wheelchair is designed for people with physical disabilities and visual impairments. It is equipped with state-of-the-art technology, such as ultrasonic sensors and the Arduino Uno microcontroller, making it a practical and user-friendly mobility solution. The wheelchair's ability to detect obstacles in real-time using ultrasonic sensors improved user confidence and independence. This made it possible to navigate safely and avoid collisions. The smartphone app provided a simple platform that allowed users to control and customize the wheelchair's movements using voice commands. The smooth interaction between users and wheelchairs was a significant advancement in the field of assistive technology. You can use a smartphone app that is simple to operate to give voice commands to the smart wheelchair. The Arduino Uno microcontroller receives commands via Bluetooth and processes them along with data from ultrasonic sensors that detect obstacles. The Arduino Uno is capable of making intelligent decisions when it detects obstacles and synchronizes movement commands. The motor driver gets signals that tell the wheelchair when to move or stop. The mobile app provides feedback, allowing the user to stay informed about the wheelchair's status and surroundings. This cohesive system guarantees that people with physical disabilities will have access to autonomous, user-friendly, and secure mobility.

5. Future Scope

The Future scope for voice-controlled wheelchairs for physically disabled and blind people holds immense potential for improvement and expansion. Advancements in artificial intelligence, machine learning, and IoT technologies will enhance voice recognition accuracy, navigation, and obstacle detection. Integration with smart home devices, wearable technology, and augmented reality will further increase independence and accessibility. Future developments may include Self-navigating wheelchairs with advanced obstacle avoidance systems, Intelligent wheelchairs that learn user habits and preferences, Advanced health monitoring and emergency response systems, Integration with virtual assistants (e.g., Alexa, Google Assistant), Enhanced cybersecurity measures to protect user data, Next-generation sensors for improved navigation and obstacle detection, Advanced prosthetic limbs integration for enhanced control, Telepresence capabilities for remote interaction and assistance. Future applications may extend to Rehabilitation centers, Assisted living facilities, Public transportation systems, Airports and shopping malls, Outdoor navigation systems. By addressing the complex needs of physically disabled and blind individuals, voice-controlled wheelchairs will continue to transform lives, promoting independence, dignity, and inclusivity.

Declarations

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Competing Interests Statement

The authors declare no competing financial, professional, or personal interests.

Consent for publication

The authors declare that they consented to the publication of this study.

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