VOICE CONTROLLED WHEELCHAIR SYSTEM

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Abstract: Many people with disabilities typically depend on other individuals to assist them with everyday activities, especially when it comes to moving from one location to another. For example, a person who uses a wheelchair will always need assistance from another person to get the wheelchair moving. By using a voice-activated controller, the person would have greater independence than if they had to rely on another person. Thus, the goal of this project is to develop a wheelchair control system where the movement of the wheelchair will be done using voice commands. The wheelchair control system will consist of a microcontroller, a voice recognition device via Google Assistant, and a motor control interface board for controlling the movement of the wheelchair. By following the commands given through Google Assistant to the wheelchair control system, the user will have the ability to control the movement of the wheelchair using only voice commands. The wheelchair control system will include the ability to control forward and reverse movement, left and right turning and stop. All functions of the wheelchair control system will be operated using a PIC microcontroller manufactured by Microchip Technology. The PIC microcontroller will communicate with the voice recognition device via Bluetooth and will perform the commands from the voice recognition system according to the numbers assigned to those commands. After the user provides a voice command, the voice recognition device will determine which output command will activate the appropriate left and right motor depending on the voice command given by the user. This project will be completed using the C programming language.

***Index Terms*:** Voice Controlled Wheelchair, Voice Recognition, Google Assistant, Bluetooth Communication.

1. INTRODUCTION

The project involves designing a motorized wheelchair controlled by voice for people with a physical disability or handicap so that they can move freely and independently without relying on someone else. Speech recognition is used to provide input commands to control the movement of the wheelchair through voice control. An Android-based phone sends the voice commands to the wheelchair's control system via HC-05 Bluetooth technology. The Bluetooth module receives the commands wirelessly and converts them into data that can be processed by the ATmega328 microcontroller. The microcontroller processes these commands, then uses motor driver circuits to activate the appropriate DC motors, which are connected to the wheels of the wheelchair. Each of these DC motors can rotate in both the forward and reverse directions, allowing the wheelchair to move forward or backward, as well as left, right, and stop based on the user's spoken command.

The control of the wheelchair is achieved by integrating multiple components — the hardware for the overall system, various programming languages, interfacing between components and systems, and finally, testing each of these components to ensure a safe and reliable system for moving the wheelchair. In the past, people had to either use their muscles or move the joystick attached to their electric wheelchairs to control their wheelchairs. This use of one or more forms of effort is not feasible for people with very limited physical capabilities. Furthermore, there are many other challenges associated with the use of manual and powered wheelchairs, such as difficulty hearing or seeing, which limit the effectiveness of both physical and electronic control methods. As an emerging technology, voice command technologies are changing the way many users can control assistive devices, including power wheelchairs, without having to rely on physical effort. By allowing users to control a wheelchair through voice-commanding, this offers benefits of reduced physical effort and increased independence and convenience in mobility.

This project demonstrates how developers can use technology, including speech recognition, Bluetooth communication, and microprocessor-based embedded system (or "smart") technology, to integrate multiple systems into practical solutions for providing assistive devices to disabled individuals, thereby improving quality of life. The objective of this project is to create a voice-operated motorized wheelchair that enables persons with physical disabilities or impairments to move on their own. Using speech recognition technology, the wheelchair is operated via voice commands. A command is issued using an android smartphone, and the command is wirelessly transmitted via an HC-05 Bluetooth module to an ATmega328 microcontroller. The ATmega328 microcontroller processes the voice command (and controls the wheelchair's direction of travel) as well as operates the wheelchair's two DC motors using two motor driver circuits. The wheelchair is capable of forwards, backwards, left, right, and stopping movements. In addition, the wheelchair has additional safety features (such as obstacle detection) that enhance the wheelchair's usability. This project consists of four phases: hardware, software, interfacing, and testing; each phase serves to promote the successful operation of the wheelchair system. The voice-controlled motorized wheelchair provides a new mode of mobility and independence for individuals with limited mobility compared to traditional manually operated or joystick-operated wheelchairs because it reduces the amount of physical effort required and is easier to use.

2.PROBLEM STATEMENT

Individuals who have severe disabilities are greatly impacted by physical barriers. This is evidenced by the difficulty that many people with complex disabilities face in using common manual-assistive devices (manual) and the impact this has on their ability to maintain independence from having to rely on others to assist them.

The users of an assistive device such as this should expect consistent operation through simple, easily understood commands so as to provide independent mobility**,** safety, and enhancement of current barriers to physical access**.**

3.LITERATURE REVIEW

[1] G. Uday Kiran, N. Nithesh Chakravarthi, K. R. Radhakrishnan (2013) Proposed a voice and vision-controlled wheelchair system. Combined voice commands with camera-based navigation. Improved mobility for disabled users using dual control techniques.

[2] Shwetha V., Vaibhav Mani, Aditya Kumaran (2018) Developed a voice-controlled wheelchair using speech recognition APIs (CMU Sphinx). Focused on hands-free control for physically disabled individuals. Introduced key phrase detection for accurate command recognition.

[3] M. S. Arsha, A. Remya Raj, S. R. Pooja, Rugma Manoj, S. A. Sabitha, Shimi Mohan (2020) Designed a low-cost Arduino-based voice-controlled wheelchair. Features: Voice recognition module, Ultrasonic sensors for obstacle detection, Battery monitoring system, Emphasized affordability and practical implementation.

[4] Shoeb Khan, Neamat Ansari, Md. Mudassir, Safi Nazimuddin (2024) Proposed a voice-controlled wheelchair integrated with home automation. Used machine learning and AI-based speech recognition. Enabled users to control both wheelchair and home devices via voice.

[5] R. JAMUNA, K. BHARATH (2025) The main objective of our project is to design a wheel chair for physically disabled persons, controlled by voice input. The entire system is controlled by the PIC (16F877A) microcontroller and the voice recognition IC (HM 2007) is used, which is capable of storing voice signals, and generating good recognition performance on highly disordered speech.

[6] Poornima Hanabar, Swati Goni, Sakshi Mane, Pragati A Asude (2025) This paper presents the design and development of a voice-controlled wheelchair aimed at supporting individuals with physical impairments. The system enables the user to direct movement using voice commands, reducing dependence on physical controls. The architecture integrates an embedded microcontroller, speech recognition hardware, and motor drivers to process commands and control motion. Additional safety features such as obstacle detection and emergency stop mechanisms enhance reliability.

[7] Author Hariharan Set at 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.

Collectively, past studies show that:

Improvement in Mobility & Independence.

Feasibility of Voice Recognition.

Cost-Effective Solutions.

Integration of Advanced Technologies.

Safety Enhancements.

Challenges Identified:

voice-controlled wheelchair systems are effective, affordable, and continuously improving. While earlier systems focused on basic voice control, recent advancements have made them smarter, safer, and more user-friendly, though challenges like noise sensitivity still remain.

4.RESEARCH METHODOLOGY

This project involved developing a prototype of a voice-controlled wheelchair system utilizing an integrated approach toward designing both hardware and software subsystems for the prototype. The system utilizes voice recognition technology to receive and process a user's voice commands, which are communicated to a microcontroller for controlling the wheelchair's movement.

Testing of this prototype system was performed under several different conditions to analyze the system for performance, including accuracy, responsiveness, and safety. Additionally, this prototype will be evaluated after testing based on how well it recognizes voice commands, operates reliably, and allows the user to operate it easily after giving a voice command.

4.1 Research Approach

In this project, voice control will be used in a wheelchair as part of an experimental applied research approach which aims to integrate voice recognition Technologies and Embedded Systems to solve mobility Issues.

The project's approach is to design a prototype, implement voice commands, and conduct tests on the prototype in various real-world environments. Performance results from testing will be documented for analysis to enhance system functionality regarding accuracy, reliability, and overall performance.

4.2 Requirement Analysis

For the voice-controlled wheelchair system to work properly, it requires both hardware and software. The hardware that will be used includes a microphone, microcontroller (such as Arduino), motor driver(s), wheels, a power supply, and sensors ensuring safety. The software needed includes voice recognition modules, code to process commands, and control algorithms for moving the wheelchair.

The wheelchair system must be user-friendly, accurate at recognizing commands spoken by users, and responsive to the user's command with very little lag time. Additionally, the system must be safe to use, reliable in operation, and able to work in multiple types of environments. Lastly, it must also be able to handle background noises while operating.

4.3 System Architecture

1.Input Module
Microphone captures the user's voice commands
Voice input is sent to the speech recognition system
2. Speech Recognition Module
Converts voice commands into digital signals
Identifies commands like forward, backward, left, right, stop
3. Control Unit (Microcontroller)
Acts as the brain of the system (Arduino)
Processes recognized commands
Sends control signals to motor driver
4. Motor Driver Module
Receives signals from the microcontroller
Controls speed and direction of motors
5. Actuation System (Motors & Wheels)
DC motors drive the wheelchair
Executes movement based on commands
6. Power Supply
Battery provides power to all components
7. Safety & Sensor Module
Ultrasonic/IR sensors detect obstacles
Prevents collisions and ensures safe navigation.

4.4 System Implementation

1. Hardware Implementation
Assemble components such as microphone, microcontroller (Arduino), motor driver, DC motors, battery, and sensors
Connect motor driver to motors and microcontroller
Install sensors for obstacle detection
2. Software Implementation
Program the microcontroller using Arduino IDE
Implement speech recognition using a voice module or mobile app (via Bluetooth)
Define commands like forward, backward, left, right, stop
3. Communication Setup
Use Bluetooth/Wi-Fi module (e.g., HC-05) to transmit voice commands
Ensure proper pairing between mobile device and microcontroller
4. Control Mechanism
Microcontroller processes received commands
Sends signals to motor driver for movement control
Adjusts speed and direction of motors
5. Safety Implementation
Integrate ultrasonic/IR sensors
Program automatic stopping when obstacles are detected
6. Testing and Integration
Test individual modules (voice, motors, sensors)
Integrate all components and perform system testing
Check accuracy, response time, and safety features
7. Final Prototype
Ensure smooth operation of wheelchair using voice commands
Optimize performance for real-time.

4.5 Functional Modules

1. Voice Input Module
Captures user voice commands through microphone
Sends input to processing unit
2. Speech Recognition Module
Converts voice into digital commands
Identifies instructions like forward, backward, left, right, stop
3. Control Module (Microcontroller)
Processes commands and makes decisions
Sends signals to motor driver
4. Motor Control Module
Controls speed and direction of motors
Executes movement commands
5. Communication Module
Uses Bluetooth/Wi-Fi (e.g., HC-05)

Transfers commands from mobile to system
6. Obstacle Detection Module
Uses ultrasonic/IR sensors
Detects obstacles and avoids collisions
7. Power Supply Module
Provides power to all components
Ensures continuous system operation
8. User Interface Module
Allows user interaction (mobile app or voice system)
Provides easy control and accessibility

4.6 System Testing

Unit Testing: Check individual components like sensors, motors, and microphone
Voice Testing: Verify accuracy of voice command recognition
Communication Testing: Test Bluetooth/Wi-Fi connectivity
Movement Testing: Ensure proper direction and speed control
Obstacle Testing: Check sensor-based obstacle detection and stopping
Integration Testing: Test complete system working together
Safety Testing: Ensure safe and reliable operation

4.7 Evaluation

Voice-Controlled Wheelchair System Evaluating Performance includes Discussion of Accuracy, Response Time, Reliability and Safety.

Voice-Controlled Wheelchair Systems have been evaluated for performance based upon Four Factors: Accuracy; Response Time (or Delay); Reliability; and Safety.

Tests are performed to confirm the effectiveness of Voice Command Recognition and to ensure that there is no Delay between Commands and Actions (Execution). The performance has also been evaluated under varying Environmental Conditions (e.g., Presence of Noise or Obstructions) to measure its consistent operation from one environment to another. Finally, User-Friendliness and Ability to Use (Ease of Operation) are assessed in Order to ensure a physically challenged Person can operate the System in a comfortable manner. Overall, the Evaluation of System provides Confirmation of Application and Service in a Reliable, Effective, & Safe Manner for Providing Individuals Access to Versatile and Independent Mobility.

5.SYSTEM DESIGN

5.1 Flowchart

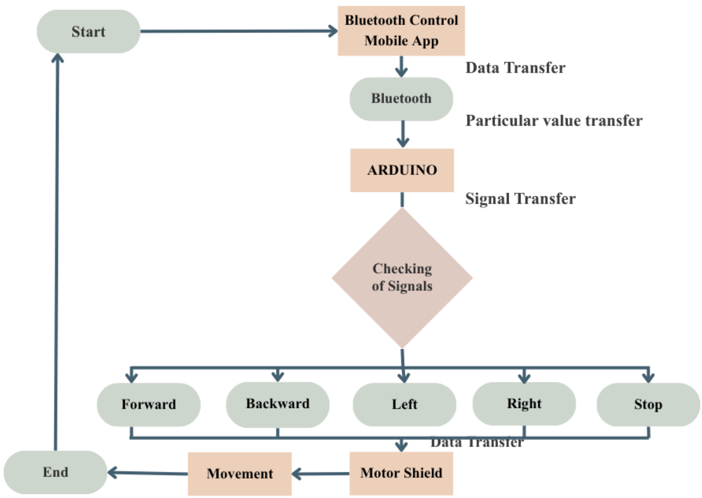

Fig 1

This flowchart portrays the processes involved with using a Bluetooth-controllable mobility device (wheelchair). The process of operation begins with the initiation of the system when all components have been powered on and are ready to go through interaction from a user using an app on their mobile device via Bluetooth control – utilizing commands of moving forwards, backwards, left & right, or stopping either using buttons or voice commands. These commands are transmitted wirelessly from the Bluetooth module connecting the mobile device to the hardware system in a communication format.

Once the command is sent to Arduino as the primary controller of the system, the Arduino will process the information from the incoming data stream by determining exactly what has been requested by the user (the signal checking function of the command). The Arduino will then choose one appropriate action from the set of available commands for movement. After determining which command was issued by the user, the arduino will send control signals to the motor shield (motor driver). The motor shield is responsible for supplying power and/or controlling direction of the motors, which can't be done directly by the arduino itself. The motors are responsible for performing the desired movements of the chair (forward, reverse, left turn, right turn and stop). The system continues to run in a loop after the action is completed until it receives another command from the user. This allows the user to maintain smooth operating conditions and control the chair in real-time, thus making it effective and easy to use by people who have trouble moving about.

5.2 System Flow Description

Starting from the mobile Bluetooth controlled application, commands are sent from the app to the Arduino via Bluetooth. Data is received by the Arduino and incoming signals are verified by the system on what action to take. The system determines how to move, forward or backwards or left/right or stop based on the signal received. Once the command has been chosen, the command is transmitted from the Arduino to the motor shield which then directs the motors to run in the proper direction to create the desired movement.

Start

Initialize system components

- Power ON Arduino
- Initialize Bluetooth module
- Initialize motor driver (motor shield)
- Establish connection with mobile app

Wait for user input

- Open Bluetooth-controlled mobile app
- Wait for voice command input

Voice command processing

- User speaks a command (e.g., Forward, Backward, Left, Right, Stop)
- Mobile app converts voice to text/command value

Data transmission

- Mobile app sends command via Bluetooth
- Bluetooth module receives the command

Send command to controller

- Bluetooth passes received data to Arduino

Signal checking

- Arduino reads incoming data
- Compare command with predefined instructions:
    - If command = "Forward"
    - If command = "Backward"
    - If command = "Left"
    - If command = "Right"
    - If command = "Stop"

Decision & action

- If Forward → Move wheelchair forward
- If Backward → Move wheelchair backward
- If Left → Turn wheelchair left
- If Right → Turn wheelchair right
- If Stop → Stop all motors

Motor control

- Arduino sends signals to motor shield
- Motor shield drives motors accordingly

Movement execution

- Wheelchair performs the desired movement

Check for next command

- Continue receiving new commands
- Repeat steps 4–10

End condition

- If system is turned OFF or disconnected → Stop motors
- End program

6. RESULTS AND DISCUSSION

The voice activated wheelchair operates as intended by responding accurately and with minimal timing delay to basic directional commands (e.g., forward, backward, left, right) in quiet settings, effectively communicating between the system and the individual experiencing functional limitations. Performance may degrade somewhat when used in noisy environments due to limitations in voice recognition technology. The obstacle avoidance feature prevented accidents so users were safe while using the wheelchair. Overall, the project was found to be efficient, easy to use, and has many opportunities for continued improvements of independent mobility.

6.1. System Interface and Implementation Results

6.1.1 Wheelchair

Fig 1.1

Fig 1.2

6.1.2 Commands

Fig 1.3

Fig 1.4

The image above shows how the voice control function of a wheelchair system works through a phone application. The user interface features a voice control function where a user can voice a command. Once activated, the microphone will display a pop-up indicating that Google's Speech Recognition service is listening for audio input from the end user. When an individual gives a command (e.g. "forward", "backward", "left", "right" or "stop") using their voice, Google converts the spoken command to text and then displays the command (e.g., "backward") on the screen for the end user. The text is the end user's spoken command and has been converted from audio to text via Google's Speech Services (noting that Google is responsible for the audio-to-text conversion and transmission to application). After the application receives confirmation from Google that the command was recognized, the application processes this object text and transmits an appropriate control instruction to the Arduino controller via Bluetooth. The Arduino interprets the control instruction and sends a signal to the motor driver to move the wheelchair in the desired location.

7.FUTURE SCOPE

The future potential of voice-controlled wheelchair systems is extremely positive with improvements in technology. As we move forward in time, future enhancements of the system may include integrating advanced artificial intelligence and machine learning algorithms for better recognition of voice commands under noisy conditions as well as recognizing different accents. Further developments regarding the Internet of Things (IoT) will provide the ability for users to connect seamlessly with their smart home devices such as lights and fans, allowing them to control these devices from their wheelchair.

Future designs of use of autonomous navigation systems possibly utilizing camera systems, GPS, and other advanced sensing technology may permit the wheelchair to navigate with little or no need for continuous input from the user.

Brain-computer interfaces (BCI) may provide an alternate means of wheelchair control for users unable to speak. Improvements in battery technology will increase the range of operation for the wheelchair, as well as improve user comfort and portability through more compact and lighter weight designs. Henceforth, there will be more intelligent, reliable, and accessible voice-controlled wheelchairs, resulting in greater independence and a higher quality of life for users.

8.CONCLUSION

The wheelchair project showcases the deployment of voice technology (speech recognition), embedded systems, and wireless technologies to design an assistive device to enhance mobility for those with disabilities. Users can operate this device using only verbal commands, thus reducing their physical effort while enhancing their independence. The hardware/software components of this system were developed successfully and operate on a microcontroller platform that allows for real-time synchronization between input, processing, and output. Functions such as Bluetooth communications, control of motors, and obstacle detection sensors enable accurate movement while providing maximum safety.

System testing in controlled environments demonstrated acceptable levels of performance for speech recognition accuracy, speed of response, and overall reliability, yet real-world testing revealed additional challenges leading to speech recognition interference due to background noise and limitations on the ability to recognize commands based on different factors (i.e., age, gender).Future enhancements to the system that will enhance its usability include enhancement of the existing system with noise-canceling technology; implementation of AI based speech recognition algorithms; and integration with mobile devices and GPS systems. These improvements indicate the potential for wide-spread acceptance by end-users as an effective assistive technology thus improving the quality of life for all users of the wheelchair.

9.REFERENCES

[1] Clark, J. A., & Roemer, R. B. (1977). Voice controlled wheelchair. IEEE Transactions on Biomedical Engineering.
[2] Kiran, G. U., Chakravarthi, N. N., & Radhakrishnan, K. R. (2013). Voice and vision-controlled wheelchair for disabled. International Journal of Engineering Research & Technology (IJERT).
[3] Shwetha, V., Mani, V., & Kumaran, A. (2018). Voice controlled wheelchair using speech recognition. International Journal of Engineering and Technology (IJET).
[4] Arsha, M. S., Raj, A. R., Pooja, S. R., Manoj, R., Sabitha, S. A., & Mohan, S. (2020).
Design and implementation of voice-controlled wheelchair. International Journal of Research in Engineering, Science and Management (IJRESM).
[5] Abdulghani, A., et al. (2020).
Smart wheelchair control using neuro-fuzzy system. Sensors Journal.
[6] Cao, Y., et al. (2021).
Voice-controlled wheelchair integrated with rehabilitation training. Biomedical Engineering.
[7] Khan, S., Ansari, N., Mudassir, M., & Nazimuddin, S. (2024).
Voice controlled wheelchair with home automation using machine learning. ResearchGate Publication.
[8] Gupta, R., et al. (2024).
Smart modular wheelchair with voice control and obstacle detection. African Journal of Biomedical Research.
[9] Sarai, P., et al. (2025).
Hybrid voice and mobile app-controlled wheelchair system. International Journal of Scientific Research.
[10] Ali, A. (2015).
Design of voice controlled smart wheelchair system. ResearchGate Publication.