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Design and Development of a Smart Wheelchair using Voice Commands

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***Abstract*— Development of a voice recognition based intelligent wheelchair system for physically handicapped people who are unable to drive the wheelchair by hand is represented in this paper where the patient can operate the wheelchair using voice commands. Physically challenged persons those who are suffering through different physical disabilities face many challenging problems in their day to day life for commutating from one place to another and even sometimes they need to have to be dependent on other person to move from one place to another.**

People with certain lifelong disabilities brought on by accidents, paralysis, or old age sometimes rely on others for assistance. There are a lot of disabled people in the world today who have trouble moving around or going about their daily lives. These people are primarily reliant on other people for support.

But they can become self-independent and accomplish some everyday activities on their own with the support of assistive gadgets. The system integrates Arduino Uno as the primary controller, interfacing with an HC-05 Bluetooth module to receive voice commands from a smartphone.

The movement of the wheelchair is controlled by geared DC motors, which are driven by an L293D motor driver. The wheelchair can move forward, backward, left, and right based on user commands. To ensure safety, an ultrasonic sensor is incorporated for real-time obstacle detection, preventing collisions by stopping or redirecting movement when an obstacle is detected.

This voice-controlled smart wheelchair provides an affordable, user-friendly, and efficient alternative to conventional powered wheelchairs. By integrating voice control with obstacle detection and wireless communication, the system enhances user independence and safety. Future improvements may include AI-based navigation, GPS tracking, and IoT integration for advanced mobility solutions.

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***Index Terms*— Voice Recognition, Intelligent Wheelchair, Physically Handicapped, Disability Support, Arduino Uno, HC-05 Bluetooth Module, Geared DC Motors, L293D Motor Driver, Ultrasonic Sensor, Obstacle Detection, User Commands, Wireless Communication, AI-Based Navigation, GPS Tracking, IoT Integration, Assistive Technology, Mobility Solutions, User Independence, Safety Enhancement.**

I. INTRODUCTION

People with arm and hand impairments find it difficult to utilize a standard wheelchair since their hands are incapable of operating it and cannot move it in any direction. As a result, a voice operated wheel chair is designed to overcome such people's difficulties and enable them to manage the wheelchair. The wheelchair will be controlled by voice instructions using the input provided [1]. The Arduino will handle all of the user's desired directives. Each direction's instructions are written in the form of a program in the Arduino itself. The HC05 Bluetooth module will do speech recognition. Arduino then receives the output from this module. The Arduino's pre-written algorithms assist Arduino in converting these vocal commands into significant output, and the wheelchair will move appropriately [2].

People will gain independence by using a wheelchair control system. The wheelchair control system makes use of a speech recognition technology to trigger and control all of its motions. The technology allows users to operate the wheelchair by just speaking into the wheelchair's microphone. The fundamental movement functions are forward and reverse motion, left and right turns, and stop [3]. The spoken words are sent to the speech recognition processor via a flexible microphone that can be bent to the user's specifications. Many physically handicapped people are unable to move any limbs below the neck. As a result, manual and even joystick-controlled wheelchairs are out of the question for these individuals. As a result, the development of voice-activated wheelchairs will answer the question of quadriplegic patients movement and make them independent of mobility [4].

The primary goal of this technology is to increase autonomy, reduce dependence on caregivers, and improve the quality of life for individuals with mobility impairments. Additionally, it offers a more intuitive and user-friendly alternative to traditional joystick-controlled wheelchairs. The heart of this system lies the Arduino Uno, a microcontroller that serves as the brain of the wheelchair [5]. The Arduino Uno processes incoming voice commands, coordinates sensor data, and controls motor functions, making it an ideal choice for a project that balances performance with affordability. Voice commands are transmitted to the Arduino Uno via the HC-05 Bluetooth module, a compact and reliable wireless communication device. The HC-05 establishes a seamless connection between the wheelchair and an external input device, typically a smartphone (e.g., Google Voice). The wheelchair's movement is powered by geared DC motors, which provide the necessary torque and speed to drive the wheels effectively [6].

Geared motors are chosen for their ability to deliver high power output while maintaining energy efficiency, a critical factor for battery-operated devices like wheelchairs. These motors are controlled by the L293D motor driver, an integrated circuit that acts as an intermediary between the Arduino and the motors. The L293D enables precise control over motor direction and speed by amplifying the Arduino's low-power signals into the higher currents required to operate the motors [7]. This combination ensures smooth and responsive movement, aligning with the user's voice commands. The integration of the Arduino Uno, ultrasonic sensor, L293D motor driver, geared DC motors, and HC-05 Bluetooth module exemplifies the power of embedded systems in assistive technology. Each component plays a distinct yet interconnected role: the Arduino provides processing power, the Bluetooth module enables communication, the ultrasonic sensor ensures safety, and the motor driver and DC motors deliver mobility [8].

Figure 1. Development of the smart wheel chair [7]

II. Methodology and its Overview

The development of the smart wheelchair using voice commands follows a structured methodology that includes hardware design, software implementation, integration of components, testing, and evaluation. The methodology ensures that the system is efficient, reliable, and user-friendly. The primary approach involves using an Arduino Uno as the central controller, interfacing with a Bluetooth module, motor driver, DC motors, and ultrasonic sensor to provide seamless mobility and safety for the user. The Fig. 1 shows the development of the smart wheel chair [7].

III. System Design and Architectures

The system architecture consists of multiple modules that work together to facilitate voice-controlled wheelchair navigation. The design follows a modular approach, ensuring ease of maintenance, troubleshooting, and scalability. The primary components of the system are [13]

- Voice Command Module: Uses a smartphone-based voice recognition application that sends commands via Bluetooth to the wheelchair.
- Microcontroller Unit (Arduino Uno): Acts as the central processing unit that interprets voice commands and controls the wheelchair's movement.
- Motor Control System (L293D Motor Driver & Geared DC Motors): Enables directional movement of the wheelchair based on the processed voice commands.
- Obstacle Detection Module (Ultrasonic Sensor): Continuously scans the surroundings and stops movement when an obstacle is detected.
- Power Supply System: Provides the necessary power to run the components efficiently.

IV. Implementation Steps

The development process is divided into several phases to ensure smooth implementation [14]

A. Hardware Implementation

- Chose Arduino Uno as the primary controller due to its compatibility with multiple sensors and ease of programming.
- Integrated HC-05 Bluetooth module for wireless communication.
- Connected L293D motor driver to control geared DC motors for movement.
- Installed an ultrasonic sensor at the front of the wheelchair for obstacle detection.
- Circuit Design and Wiring:
- Developed the circuit schematic for component connections.
- Ensured proper voltage and current distribution to avoid power fluctuations.
- Assembled components onto a prototype board before integration into the wheelchair.

B. Software Implementation

Programming the Arduino Uno uses the following steps [15]

- Developed an Arduino-based C++ program to process received voice commands and control motor movements accordingly.
- Integrated Bluetooth communication protocol to receive signals from the smartphone.
- Implemented motor control logic to move the wheelchair in different directions (forward, backward, left, right, stop).
- Added an obstacle detection algorithm using ultrasonic sensor data to prevent collisions.
- Voice Command Processing:
- Used Google Voice Recognition API or custom app to recognize and convert speech into text commands.
- Sent the recognized command via Bluetooth to the Arduino for execution.
- Implemented a command validation mechanism to avoid misinterpretation.

C. Integration and Testing

- Hardware and Software Integration [16]
- Connected all electronic components to the Arduino Uno.
- Tested real-time Bluetooth communication between the smartphone and the wheelchair.
- Verified the proper functioning of motor control and obstacle detection.
- Testing and Debugging:

- Conducted unit testing on each component to identify potential issues.
- Performed integration testing to ensure all modules function together as expected.
- Evaluated real-world performance by testing the wheelchair in different environments.

D. Safety Features Implementation

- Obstacle Detection and Collision Prevention [17]
- Configured the ultrasonic sensor to stop the wheelchair when an obstacle is detected within a predefined range.
- Added auditory and visual alerts (buzzer and LED) to notify the user of nearby obstacles.
- Emergency Stop Mechanism:
- Integrated an emergency stop command that allows users to halt the wheelchair immediately in case of an emergency.

E. Final Evaluation and Optimization

- Conducted user testing with volunteers to ensure ease of use and efficiency [18]
- Optimized motor speed and response time for smoother navigation.
- Enhanced voice recognition accuracy by training the system with various speech patterns.

V. Block-Diagram

The block-diagrammatic representation of the proposed systems consists of hardware & software components which are discussed as below [19].
Hardware Components - The smart wheelchair system integrates various electronic components to facilitate voice-controlled mobility. Below are the primary hardware components used in the project

A. Arduino Uno (Microcontroller Unit)

- Serves as the brain of the system, processing commands and controlling the wheelchair's movement.
- Receives input from the Bluetooth module (HC-05) and ultrasonic sensor.
- Sends signals to the L293D motor driver to control the DC motors.
- Features multiple GPIO pins for interfacing with various peripherals.

VI. Conclusions

The development and implementation of the MedDrip Auto system mark significant advancements in intravenous therapy management, enhancing both patient safety and hospital efficiency. The integration of an infrared sensor and microcontroller-based alert mechanism not only mitigates the risk of common IV therapy issues such as air blockages and flow rate errors but also ensures the timely refill of IV bags. This smart system allows for continuous monitoring, reducing the need for constant manual checks and freeing up healthcare personnel to attend to other critical patient care tasks. Moreover, the LCD display and potential for IoT integration promise a future where remote monitoring can further streamline hospital operations and response times, making IV therapy safer and more efficient.
Additionally, the practical implementation of MedDrip Auto through hardware tests and experimental validation showcases its reliability and effectiveness in real-world settings. The use of affordable and accessible components, such as LEDs and buzzers for alerts, ensures that the system can be easily adopted in various healthcare environments without significant financial burden. As we look to the future, the possibilities for enhancements like AI integration for predictive analytics or comprehensive IoT systems indicate that MedDrip Auto is not only a current solution but also a foundational technology for further innovations in medical device development. This system sets a new standard in healthcare technology, emphasizing the importance of automated solutions in enhancing patient care and operational efficiency.

References

[1] Wieczorek, B.; Kukla, M.; Rybarczyk, D.; Warguła, Ł., "Evaluation of the Biomechanical Parameters of Human-Wheelchair Systems during Ramp Climbing with the Use of a Manual Wheelchair with Anti-Rollback Devices", Appl. Sci. 2020, 10, 8757.

[2] Amin MS, et.al., "Smart Wheelchair-An Implementation of Voice and Android Controlled System", 2021 International Conference on Digital Futures and Transformative Technologies (ICoDT2). IEEE, 2021.

[3] Këpuska, V., Bohouta, G., "Comparing speech recognition systems", (Microsoft API, Google API and CMU Sphinx). Int. J. Eng. Res. Appl. 2017, 7, 20–24.
[4] Ahmed, Foez, et.al., "Design and Development of a Smart Wheelchair for the Disabled People", 2021 International Conference on Information and Communication Technology for Sustainable Development (ICICT4SD). IEEE, 2021.
[5] Health Crisis Virtual Reality Rehabilitation", Journal of Machine and Computing, vol.5, no.1, pp. 561-575, January 2025, doi: 10.53759/7669/jmc202505044.
[6] Behera, A.P., Chauhan, T.R., et.al., "NSGA-III and MOACO-based decision-making framework for optimizing time, cost, quality, and carbon footprint in bridge construction: A hybrid approach, Asian Journal of Civ Eng (2025). doi : 10.1007/s42107-025-01311-0
[7] https://justdoelectronics.com/iot-based-smart-wheelchair-for-disabled-people/
[8] Tian Jipeng & et.al., "Development of a Robotic Part Fixture Mechanism for PNP Operation in an Industrial Scenario", 5th IEEE International Conference on Communication and Electronics Systems (ICCES-2020), Coimbatore, Tamil Nadu, India, pp. 131-135, 10-12 June 2020 DOI: 10.1109/ICCES48766.2020.9138086
[9] Joshi S. Milind & et.al., "PID Control of a Double Link (2-link) Flexible Robotic Manipulator (2-DOF) in the 3 DE Space", The 4th IEEE International Conference for Convergence in Technology (I2CT), Mangalore, Karnataka, India, pp. 1-7, 27-28 October 2018, doi: 10.1109/I2CT42659.2018.9058215
[10] Sangeetha K. Siri, Arun Kumar, Rakesh Kumar, Puneeth Kumar & et.al., "Development of an efficient radio communication scheme for a mobile automated vehicular system First South Central Asian Himalayas Regional IEEE / IFIP International Conference on INTERNET AH – ICI 2009, Hyatt Regency, Kathmandu, Nepal, Ministry of Environment Science and Technology, National Information Technology Center, Institute of Engineering IOE Nepal, Nepal College of Information Technology, pp. 1-4, 3-5 November 2009, doi: 10.1109/AHICI.2009.5340300,
[11] Ashok Kusagur, Gopala et.al., "Simulation & Implementation of Shortest Path Algorithm with a Mobile Robot Using Configuration Space Approach", IEEE International Conference on Advanced Computer Control, Singapore, ICACC-2009, pp. 197-201, 22-24 January 2009, Published by IACSIT, Int. Association of Computer Science & Information Technology, Singapore Institute of Electronics, Published by IEEE Computer Society – California, USA, doi: 10.1109/ICACC.2009.155
[12] Ravi Rayappa, M. Mahesh & et.al., "Design & Development of a GSM Based Vehicle Theft Control System", IEEE International Conference on Advanced Computer Control, Singapore, ICACC-2009, pp. 148-152, 22-24 January 2009, Published by IACSIT, Int. Association of Computer Science & Information Technology, Singapore Institute of Electronics, Published by IEEE Computer Society – California, USA, doi: 10.1109/ICACC.2009.154
[13] Harish Patil, Raju Yanamashetti, & et.al., "A novel design and implementation of a 3-φ inverter system", 3rd IEEE Conference on Industrial Electronics and Applications, Singapore, 2008, pp. 1458-1463, 3-5 June 2008, doi: 10.1109/ICIEA.2008.4582761
[14] G. Arvind Kumar & et.al., "Design of an Efficient & Minimal-Marginal Routing Algorithm in Networks", Third IEEE International Conference on Wireless Communication and Sensor Networks, Indian Institute of Information Technology, Allahabad, Uttar Pradesh, India, pp. 79-82, 13-15 December 2007, doi: 10.1109/WCSN.2007.4475752.
[15] Rajeev Gupta, M. Umapathy & et.al., "Multivariable control of a smart structure using periodic output feedback", 7th IEEE International Conference on Control, Automation, Robotics and Vision, ICARCV 2002, Marina Mandarin, Singapore, Paper ID 1283, pp. 1481-1486, vol. 3, 2-5 December 2002, doi: 10.1109/ICARCV.2002.1234991
[16] Rajeev Gupta, Bijnan B., A.M. Kulkarni, & et.al., "Design of Decentralized Power System Stabilizer for Multi-Machine Power System Using Periodic Output Feedback Technique", 7th IEEE International Conference on Control, Automation, Robotics and Vision, ICARCV 2002, Marina Mandarin, Singapore, Paper ID 1003, pp. 1676-1681, vol. 3, 2-5 December 2002, doi: 10.1109/ICARCV.2002.1235027.
[17] Saurabh Jain, et.al., "Active Vibration Control of Glass-Epoxy Composite Box Beam Using Output Feedback", IEEE International Conference on Industrial Technology, Hotel Renaissance, Mumbai, India, pp. 2200-2205, 15-17 December 2006, doi: 10.1109/ICIT.2006.372528
[18] S. Neduncheliyan, et.al., "Enhanced protocols for pedagogical through mobile learning", IEEE International Conference on Intelligent and Advanced Systems, Kuala Lumpur, Malaysia, pp. 468-473, 25-28 November 2007, doi: 10.1109/ICIAS.2007.4658432
[19] D. Lamani, Ramegowda & et.al., "Fractal Dimension with Object Rotation: A Case Study with Glaucoma Eye," 2014 Fifth International Conference on Signal and Image Processing, BNMIT, Bangalore, India, 8-10 January 2014, pp. 111-116, doi: 10.1109/ICSIP.2014.22