Voice-Controlled Assistive Wheelchair for Physically Challenged Person Using ESP32

[1]Gunji Amulya, [2]Kadali Nohitha,[3]Kodiga Chandana Sasi,[4]Katta Renuka,[5]B. Mohan Rao,

[1,2,3,4]U. G Student, Dept ELECTRONICS AND COMMUNICATION ENGINEERING, St. Ann's College of Engineering and Technology, (Autonomous)Chirala, Bapatla Dist, Andhra Pradesh – 523187, India

[5]Assistant Professor, Dept ELECTRONICS AND COMMUNICATION ENGINEERING, St. Ann's College of Engineering and Technology (Autonomous), Chirala, Bapatla Dist, Andhra Pradesh – 523187, India

Abstract: The integration of voice control technology into assistive mobility devices has significantly improved the independence and quality of life of physically challenged individuals. This paper presents a Voice Controlled Wheelchair using ESP32 that enables users to navigate the wheelchair through spoken commands. The system incorporates a voice recognition module, ESP32 microcontroller, motor drivers, and obstacle detection sensors to provide safe and efficient movement. Additional safety features such as obstacle avoidance and emergency stopping mechanisms ensure reliable operation. The proposed system offers an affordable, user-friendly, and intelligent mobility solution for individuals with severe physical disabilities.

KEYWORDS- Voice Controlled Wheelchair, ESP32, Voice Recognition, Assistive Technology, Obstacle Detection, Smart Wheelchair, Motor Driver, Mobility Assistance, Wireless Control, Rehabilitation Engineering.

INTRODUCTION

Physical disabilities resulting from accidents, aging, paralysis, spinal cord injuries, and neurological disorders often limit an individual's ability to move independently. Traditional wheelchairs require manual operation or assistance from caregivers, which can reduce the user's independence and quality of life. Although electric wheelchairs provide improved mobility, conventional control methods such as joysticks may not be suitable for individuals with severe physical impairments. To address these challenges, voice-controlled wheelchairs have emerged as an effective solution that allows users to control movement through simple voice commands. The proposed ESP32-based voice-controlled wheelchair integrates speech recognition, wireless communication, and obstacle detection technologies to provide safe, efficient, and autonomous mobility assistance.

RELATED WORK

Numerous smart wheelchair systems have been developed using voice recognition, Bluetooth communication, artificial intelligence, and obstacle detection technologies. Existing systems focus on enabling independent mobility through voice commands and wireless control mechanisms. Some solutions utilize mobile applications and Bluetooth communication, while others incorporate path-planning algorithms and autonomous navigation. Although these systems significantly improve mobility assistance, many suffer from high costs, complex hardware configurations, and limited accessibility. Therefore, there is a need for a cost-effective, reliable, and easy-to-use wheelchair system that combines voice recognition, wireless communication, and safety features in a single platform.

LITERATURE SURVEY

Several researchers have proposed voice-controlled wheelchair systems to improve mobility for physically challenged individuals. Jenina R. Amoguis et al. developed a voice-controlled wheelchair using the EasyVR voice recognition module, ultrasonic sensors, and a microcontroller, enabling quadriplegic patients to navigate independently while ensuring safety through obstacle detection. Mohamed R. Abdelkader et al. introduced an AStar algorithm-based voice-controlled wheelchair that combines ultrasonic sensors, gyroscopes, rotary encoders, and Bluetooth communication to automatically determine the shortest path to a destination. Tan Kian Hou, Yagasena, and Chelladurai developed an Arduino-based voice-controlled wheelchair that supports multilingual voice recognition and Bluetooth communication while maintaining low implementation costs. Sasireka Murugaiyan and colleagues proposed a wheelchair system using Arduino, Bluetooth modules, and DC motors with additional features such as automatic lighting and manual control options. Md. Abdullah Al Rakib and co-authors developed a smart wheelchair with voice and button control mechanisms to enhance mobility and user convenience. These studies demonstrate the growing importance of intelligent wheelchair technologies in improving accessibility and independence for disabled individuals.

EXISTING METHOD

Traditional wheelchairs rely on manual operation or joystick-based controls for movement. These systems require significant physical effort and may not be suitable for individuals suffering from paralysis, severe limb disabilities, or neurological disorders. Existing electric wheelchairs improve mobility but often depend on wired control mechanisms, expensive hardware, or complicated navigation systems. Additionally, many conventional systems lack advanced safety features such as obstacle detection and voice-based interaction, limiting their usability for severely disabled users.

PROPOSED METHOD

The proposed Voice Controlled Wheelchair utilizes an ESP32 microcontroller as the central control unit. A voice recognition module captures and processes user voice commands such as forward, backward, left, right, and stop. The ESP32 interprets these commands and generates appropriate control signals for the motor driver, which drives the wheelchair motors accordingly. Ultrasonic sensors continuously monitor the surrounding environment to detect obstacles and prevent collisions. In case of obstacles or emergency situations, the system automatically stops the wheelchair to ensure user safety. The wireless communication capability of the ESP32 enhances system flexibility and enables efficient control. This design provides a low-cost, intelligent, and user-friendly mobility solution for physically challenged individuals.

SYSTEM ARCHITECTURE

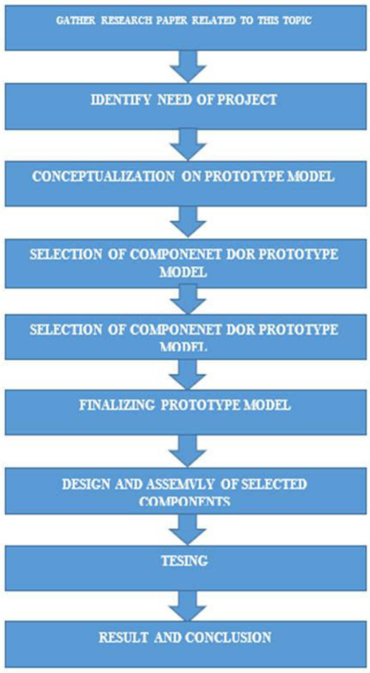

Fig.1 System Architecture

MODULE DESCRIPTION

ESP32 Controller Module: The ESP32 microcontroller serves as the central processing unit of the wheelchair system. It processes voice commands, controls motor operations, and manages communication between various system components.

Voice Recognition Module: The voice recognition module captures spoken commands from the user and converts them into digital signals. These signals are processed by the ESP32 to control wheelchair movement.

Ultrasonic Sensor Module: The ultrasonic sensor continuously monitors the environment for obstacles. It measures the distance between the wheelchair and nearby objects to prevent collisions and improve safety.

Motor Driver Module: The motor driver receives control signals from the ESP32 and drives the DC motors accordingly. It controls the speed and direction of wheelchair movement.

DC Motor Module: The DC motors provide mechanical movement to the wheelchair. Based on user voice commands, the motors rotate in different directions to move the wheelchair.

Bluetooth Communication Module: The Bluetooth module enables wireless communication between external devices and the wheelchair system. It can be used for additional control and configuration purposes.

Power Supply Module: The power supply unit provides the required electrical energy for the ESP32, sensors, and motors. It ensures stable operation of the entire system.

Obstacle Detection Module: This module combines ultrasonic sensing and control logic to detect obstacles in the wheelchair's path. When an obstacle is detected, the system automatically stops movement to avoid accidents.

Emergency Stop Module: The emergency stop module immediately halts wheelchair movement during unsafe conditions or unexpected situations. This enhances user safety and system reliability.

RESULTS AND DISCUSSION

The proposed ESP32-based voice-controlled wheelchair successfully responded to voice commands and enabled smooth wheelchair navigation. The voice recognition module accurately interpreted user instructions, while the ESP32 effectively controlled motor movements. The ultrasonic obstacle detection system successfully identified nearby obstacles and prevented collisions through automatic stopping mechanisms. Experimental results demonstrated improved mobility assistance, enhanced user independence, reliable operation, and cost-effective implementation. The system proved to be a practical alternative to traditional joystick-controlled wheelchairs, particularly for individuals with severe physical disabilities.

CONCLSUION AND FUTURE SCOPE

The ESP32-based voice-controlled wheelchair provides an efficient and affordable mobility solution for individuals with physical disabilities. By integrating voice recognition, wireless communication, obstacle detection, and motor control technologies, the system enhances user independence and accessibility. The implementation successfully demonstrated reliable voice-based navigation while maintaining user safety through obstacle avoidance features. In the future, artificial intelligence, machine learning-based voice recognition, GPS navigation, smartphone integration, and autonomous path planning can be incorporated to further improve wheelchair intelligence, safety, and user convenience.

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