

Design and Fabrication of Smart Wheelchair

B. Vaishnavi Bai (3BR19EE017), Bibi Ayesha Siddika (3BR19EE019), Dakshayini Singh R (3BR19EE026), Firdose Jahan (3BR19EE027)

Department of Electrical and Electronics Engineering
Ballari Institute of Technology and Management, Ballari, Karnataka, India

ABSTRACT

Wheelchairs are important mobility aids for people with lower-limb disabilities; however, conventional manual wheelchairs require considerable physical effort and motorized smart wheelchairs are often expensive. This paper presents the design and fabrication of a low-cost smart wheelchair based on voice control, Bluetooth communication, ultrasonic obstacle detection, and GSM-based emergency notification. The proposed system uses an Android mobile phone as the user interface, an HC-05 Bluetooth module for wireless communication, an Arduino microcontroller for command processing, and an L298 motor driver for controlling the DC motors. Voice commands received from the mobile application are interpreted by the controller to produce forward, reverse, left, and right movements. An ultrasonic sensor continuously monitors the region in front of the wheelchair and stops the wheelchair when an obstacle is detected. An emergency switch is also incorporated to activate the GSM module and send an alert message to a predefined contact. The fabricated prototype successfully demonstrated voice-controlled movement, obstacle detection, and emergency-alert functionality. The report indicates a voice-command recognition performance of more than 95% under proper vocalization, with an overall reported project cost of approximately ₹10,000 including the wheelchair.

Keywords— Smart wheelchair, voice control, Arduino, Bluetooth, HC-05, ultrasonic sensor, GSM, DC motor, assistive technology.

INTRODUCTION

People with temporary or permanent physical disabilities often depend on relatives, nurses, or caregivers for mobility. Manual wheelchairs require physical effort and become difficult to operate over long distances or inclined surfaces. Conventional powered wheelchairs can overcome some of these limitations, but sophisticated smart wheelchair systems are generally expensive. The project therefore focuses on developing a comparatively economical wheelchair that reduces user effort and improves mobility and safety. The source report identifies high cost, manual effort, limited suitability for long distances and inclines, and safety concerns around wheelchair users as important problems.

Voice-based human-machine interaction provides an alternative to conventional hand-operated control. In the proposed system, the user gives movement commands through an Android mobile phone. The command is transmitted wirelessly through Bluetooth to an HC-05 receiver mounted on the wheelchair. The Arduino controller processes the received command and controls the bidirectional DC motors through an L298 motor-driver circuit. This arrangement allows the user to control the wheelchair without continuous manual operation.

Safety is incorporated through an ultrasonic obstacle-detection mechanism. The HC-SR04 sensor measures the distance between the wheelchair and an object, and the controller stops the motors when an obstacle is detected in front of the chair. The system also includes an emergency switch connected to a GSM module. When the user encounters an emergency, pressing the switch activates the GSM system to send an alert message to a family member or predefined contact.

The main objective of the proposed work is therefore to design and fabricate a motorized wheelchair that combines voice-based wireless control with obstacle detection and emergency communication while maintaining a relatively low implementation cost.

LITERATURE SURVEY

Voice-controlled wheelchair systems have been developed to provide an alternative to conventional joystick- and manually operated wheelchairs, particularly for people with limited physical mobility. Liu *et al.* investigated voice-based wheelchair control and demonstrated the feasibility of using speech recognition for human-machine interaction in assistive mobility systems [1]. Other studies have integrated Arduino controllers, ultrasonic sensors, and motor-control circuits to achieve voice-controlled movement with obstacle avoidance. These approaches reduce the physical effort required by users and provide a convenient means of controlling wheelchair movement [2], [3].

Intelligent wheelchair research has also focused on autonomous and semi-autonomous navigation using cameras, sonar sensors, infrared sensors, bump sensors, and laser-based mapping. The Intelligent Wheelchair System developed at Osaka University incorporated camera-based perception, head-gesture control, target tracking, sonar, and infrared sensing [4]. Similarly, the Rolland wheelchair platform investigated autonomous navigation, dead reckoning, landmark detection, wall following, trajectory playback, and laser mapping [5]. Although these systems provide advanced navigation and safety features, their use of sophisticated sensing and control mechanisms can increase system complexity and cost.

Recent smart-wheelchair approaches have explored mutual control, semi-autonomous control, and decentralized autonomous control to assist users in obstacle avoidance and navigation [6], [7]. Voice recognition has also been investigated as an effective input method for users who may have difficulty operating conventional joystick controls [8]. However, achieving a balance between functionality, reliability, and affordability remains an important challenge. Therefore, the proposed work combines voice control, Bluetooth communication, ultrasonic obstacle detection, and GSM-based emergency notification using an Arduino-based controller and comparatively low-cost hardware. This integration aims to provide an economical and user-friendly mobility solution while improving the safety of wheelchair users.

PROBLEM STATEMENT

Many wheelchair users experience difficulty operating conventional manual wheelchairs because of limited physical strength or upper-limb disabilities. Manual operation also requires considerable effort and is unsuitable for long distances or inclined surfaces. Although electric and smart wheelchairs provide improved mobility, their relatively high cost limits accessibility. In addition, wheelchair users can face collision risks because the wheelchair may be below the normal sightline of pedestrians and motorists.

OBJECTIVES

1. To design and fabricate a low-cost smart wheelchair that can be operated through voice commands using an Android mobile phone and Bluetooth communication for forward, reverse, left, and right movement.
2. To improve the safety of the wheelchair by incorporating ultrasonic obstacle detection and a GSM-based emergency alert system to prevent collisions and notify a predefined contact during emergencies.

PROPOSED SYSTEM

The proposed system is a low-cost smart wheelchair designed to provide easy and safe mobility for physically challenged users. The system uses an Arduino controller as the main processing unit, an HC-05 Bluetooth module for wireless communication, and an Android mobile phone for voice-command input. The user provides commands such as forward, reverse, left, and right through the mobile application. The received Bluetooth commands are processed by the Arduino, which controls the DC motors through an L298N motor driver to achieve the required wheelchair movement.

For enhanced safety, an HC-SR04 ultrasonic sensor is incorporated to detect obstacles in front of the wheelchair. When an obstacle is detected within the programmed distance, the Arduino stops the motors to avoid collision. An

emergency switch and GSM module are also provided; when the emergency switch is activated, the GSM module sends an alert message to a predefined contact. Thus, the proposed system integrates voice-based control, wireless communication, obstacle detection, and emergency notification into a single wheelchair platform, providing a convenient and comparatively economical assistive mobility solution.

BLOCK DIAGRAM

The Fig 1 shows an Arduino controller as the main control unit, receiving inputs from the Bluetooth module, ultrasonic sensor, GSM modem, and emergency switch.

The controller drives the motor driver and motor wheels, while a rechargeable battery and regulated power supply provide power to all components.

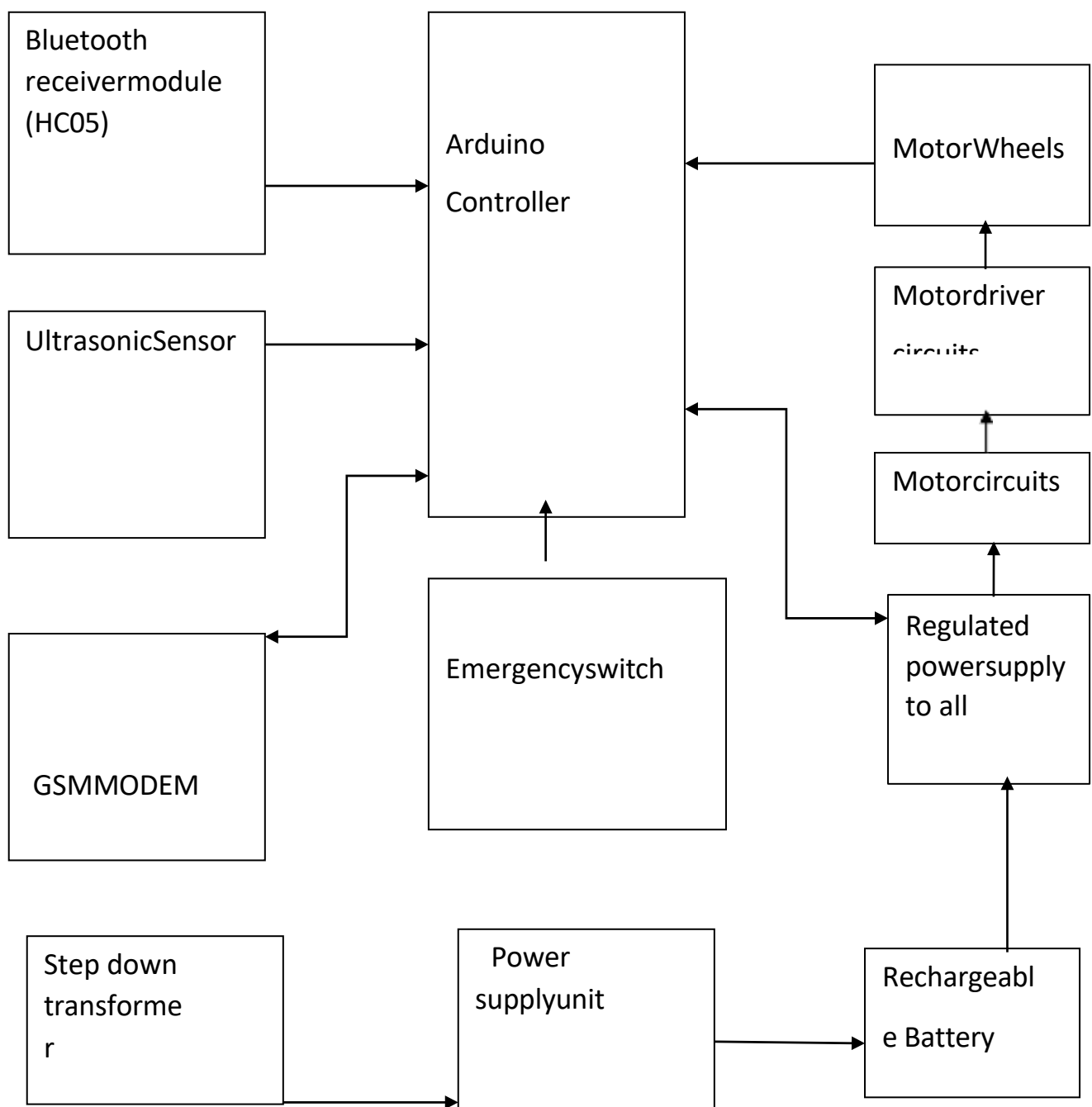


Fig 1:Block diagram of Smart Wheelchair

CIRCUIT DIAGRAM

The Fig 2 shows the Arduino controller interfaced with an ultrasonic sensor, motor driver, and motor wheels for obstacle detection and movement control.

It also includes the power supply circuit and SIM900D GSM module for providing regulated power and sending emergency/status messages.

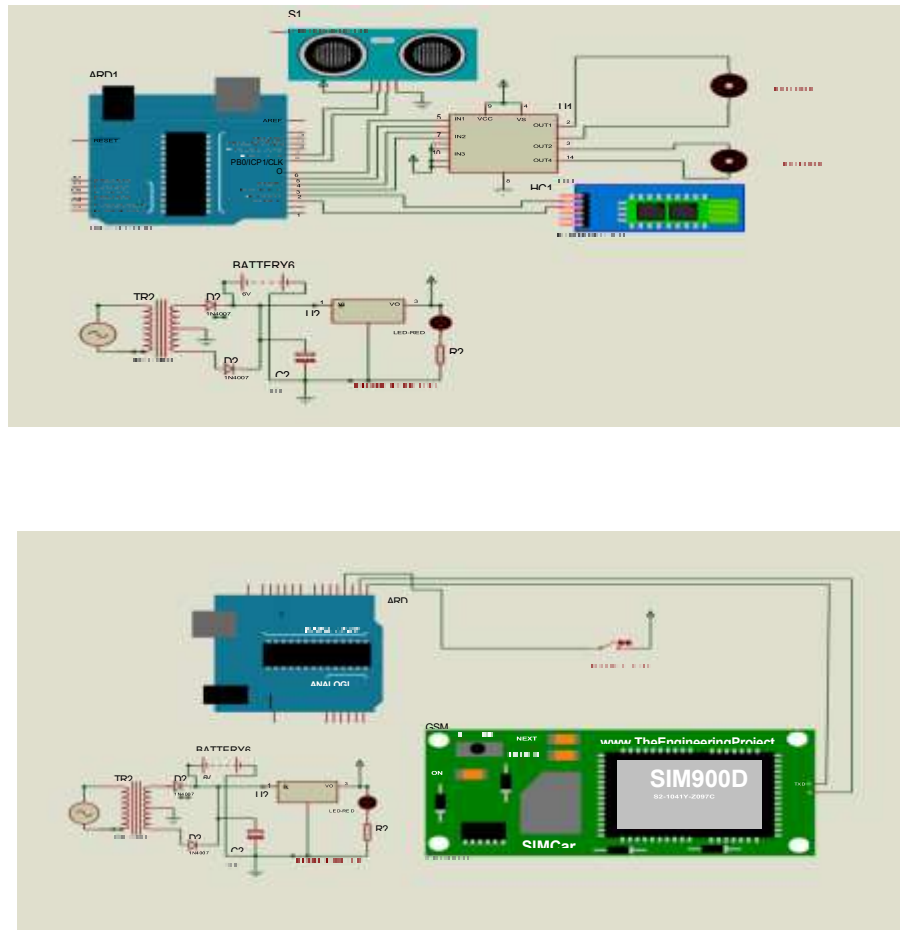


Fig 2 :circuit diagram

RESULTS AND DISCUSSION

The fabricated smart wheelchair successfully demonstrated wireless control using an Android mobile application as shown in fig 3. The implemented system supports forward, reverse, left, and right movement through wireless commands. The use of an existing Android phone reduces the need for a dedicated physical control interface and consequently contributes to the economical nature of the prototype.

The ultrasonic obstacle-detection system was successfully integrated with the controller. When an obstacle is detected in front of the wheelchair, the controller responds by stopping the motors. This provides an additional safety layer during operation. The project report also states that the obstacle-detection function was successfully controlled by the microcontroller during testing.

The voice-recognition system achieved a reported recognition rate of above 90% in one discussed test and the final project conclusion reports that most commands were recognized with an accuracy of over 95% when words were

properly vocalized. The report notes that improperly vocalized words could fail to be recognized, for which the emergency switch provides a backup mechanism. The completed prototype was reported to have a total cost of approximately ₹10,000, including the wheelchair. This relatively low reported cost is one of the important outcomes of the project because the work aims to provide smart assistive mobility at a more accessible cost than sophisticated commercial systems.



Fig 3:smart wheel chair

CONCLUSION

This paper presented the design and fabrication of a smart wheelchair integrating voice-based wireless control, Arduino-based processing, DC motor actuation, ultrasonic obstacle detection, and GSM emergency communication. The prototype provides four-direction movement through commands transmitted from an Android mobile phone via Bluetooth. The ultrasonic sensor provides an automatic stopping mechanism when an obstacle is detected, while the emergency switch provides a means of requesting immediate assistance.

The experimental outcome reported in the project demonstrates successful implementation of the major functions. The voice-control system recognized most commands with a reported accuracy exceeding 95% under proper vocalization, and the total reported project cost was approximately ₹10,000 including the wheelchair. The system therefore demonstrates the feasibility of developing a comparatively economical smart mobility aid. Further improvements in feedback control, IoT connectivity, indoor navigation, health monitoring, solar charging, and advanced mobility mechanisms can enhance the system's reliability and functionality.

REFERENCES

- [1] P. X. Liu, A. D. C. Chan, R. Chen, K. Wang, and Y. Zhu, Proceedings of the 2005 IEEE, Department of Systems and Computer Engineering, Carleton University, Ottawa, 2005.
- [2] D. Vijendra Babu, M. Thilak, A. Karthikeyan, V. Rajendran, and P. Suriyaprakash, "Biometric facial image encryption for secure image storage," *Journal of Chemical and Pharmaceutical Sciences*, vol. 9, no. 4, pp. 2186–2188, 2016.

- [3] D. Gibbon, R. K. Moore, and R. Winski, Eds., *Handbook of Standards and Resources for Spoken Language Systems*. Mouton de Gruyter, 1997.
- [4] D. Vijendra Babu, D. K. Yadav, N. K. Yadav, and V. K. Verma, "MEMS based smart & secure home automation system with multi-way control & monitoring facility using smart phone," *Journal of Chemical and Pharmaceutical Sciences*, Apr. 2015, pp. 357–359.
- [5] B. Gold and N. Morgan, *Speech and Audio Processing*. New York, NY, USA: John Wiley and Sons, 2000.
- [6] D. V. Babu, V. Saravanan, P. Kumar, and S. Singh, "Automated robotic receptionist with embedded touch screen," *Journal of Chemical and Pharmaceutical Sciences*, Apr. 2015, pp. 415–417.
- [7] D. V. Babu, L. N. Reddy, Y. D. K. Reddy, V. Gautham, and K. S. Gopichand, "Acquisition of cardiac signals using sensors in smart phones," *Journal of Chemical and Pharmaceutical Sciences*, Apr. 2015, pp. 436–438.
- [8] "Automatic Speech Recognition," Institute for Signal and Information Processing, Mississippi State University, Apr. 2001