IOT-Based Smart Wheelchair Navigation: Enables Autonomous Wheelchair Movement Using IOT Sensors and GPS

[1]Ashwith R, [1]Jeeva V, [1]Keerthivasan V, [1]Maharaja P [2]Mani P
[1]Student, [2]Assistant Professor
[1,2]Department of Electronics and Communication Engineering
[1,2]K Ramakrishnan College of Technology, Tiruchirappalli, India

Abstract: The increasing demand for independent mobility has encouraged the development of intelligent wheelchair systems that support people with physical disabilities and limited mobility. This paper presents an IoT-Based Smart Wheelchair Navigation system designed to support autonomous movement using IoT sensors and GPS-based location tracking. The proposed system aims to improve user mobility, reduce manual effort, and support safer navigation in indoor and outdoor environments. An ESP32 microcontroller is considered as the central processing unit because of its processing capability and wireless connectivity. Motor driver circuits and DC motors can be used to control wheelchair movement, while appropriate sensors can assist in detecting the surrounding environment. GPS can provide location information, and IoT connectivity can enable remote monitoring and status communication. The current hardware inventory includes an ESP32-WROOM-32, TB6612FNG motor driver, QTR-8RC reflectance sensor array, GA12-N20 DC motors, and a rechargeable battery. These components provide a foundation for developing and testing basic mobile robot navigation; however, dedicated GPS hardware, wheelchair integration, and complete IoT monitoring functions require further implementation and verification. The proposed approach provides a starting point for developing an affordable intelligent mobility assistance system.

Keywords: ESP32 Microcontroller, Smart Wheelchair, Autonomous Navigation, GPS, Mobility Assistance, Obstacle Detection.

INTRODUCTION

Mobility is essential for the independence and quality of life of people with physical disabilities. Smart wheelchair research has grown for decades to address this need [1], [2]. Conventional wheelchairs depend on manual operation or caregiver assistance, which makes navigation difficult in crowded or unfamiliar places. Intelligent wheelchairs address this by integrating sensors, embedded controllers, and navigation technologies to support independent movement and reduce collision risk [3], [4].

Cost and robustness are a key trade-off in practical wheelchair automation [5]. Many studies have compared and tested obstacle-detection sensors for assistive wheelchairs [6], including low-cost sensor networks for shared-control wheelchairs [7] and camera- and laser-based obstacle measurement [8]. Earlier work also applied Bayesian neural networks to obstacle avoidance [9]–[11] and studied shared-control strategies between the user and the wheelchair [12].

The Internet of Things (IoT) allows assistive devices to exchange data wirelessly and be monitored remotely. The proposed IoT-Based Smart Wheelchair Navigation system uses an ESP32-WROOM-32 microcontroller as the main controller, with a motor driver and DC motors for movement control. GPS can provide location tracking, and suitable sensors can assist with navigation and obstacle detection. Together these form a connected mobility assistance system.

The available hardware currently supports basic robotic movement and line-following experiments. GPS hardware, dedicated obstacle-detection sensors, and complete IoT monitoring still need implementation and testing. Before practical

wheelchair use, performance should be evaluated on navigation accuracy, response time, communication reliability, battery endurance, and safety [2], [5].

Materials and Methods

The proposed system uses an ESP32-WROOM-32 microcontroller as the main control unit. A TB6612FNG motor driver [13] controls two GA12-N20 DC motors, while a QTR-8RC reflectance sensor array [14] supports line-following experiments. A rechargeable 2S LiPo battery and voltage regulation components provide the power supply.

System Design and Implementation

The system is designed around three main functions: sensor-based navigation, motor control, and IoT communication. The reflectance sensor array detects changes in the surface beneath the robot, and the ESP32 processes the sensor signals to determine the required movement. The motor driver receives control signals from the ESP32 and operates the DC motors accordingly.

Web-Based Monitoring

The ESP32 can use Wi-Fi connectivity to transmit system information to a monitoring interface when the required software is implemented. GPS integration is planned to provide geographical location information for outdoor tracking. Additional obstacle-detection sensors may be required to support safe navigation in unfamiliar environments.

Experimental Evaluation

The prototype should be evaluated by measuring line-following accuracy, navigation response time, wireless communication reliability, and battery endurance. GPS tracking accuracy and obstacle-detection performance should be tested after the corresponding hardware and software are integrated. The collected results can be used to identify system limitations and improvements required for future wheelchair applications.

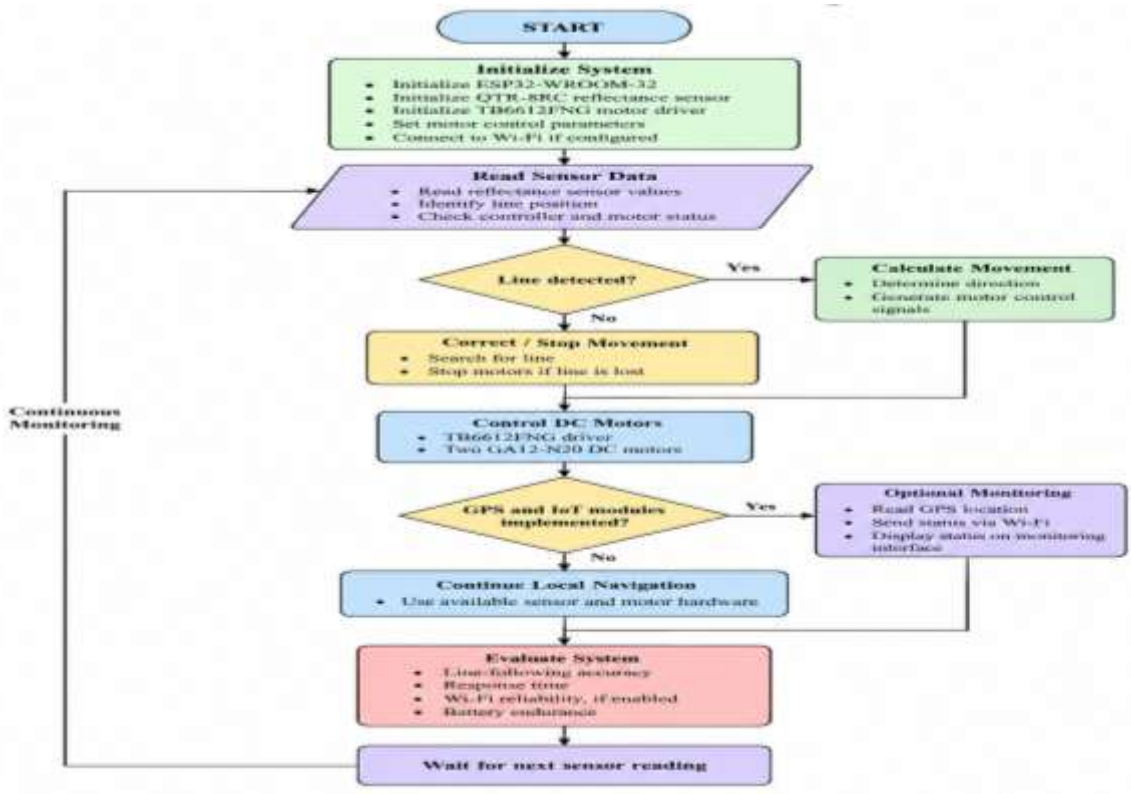


Fig. 1 Work flow for monitoring systems

RESULTS

The experimental observations should be recorded systematically and compared using suitable evaluation metrics. The results can help identify hardware limitations, software errors, and areas requiring improvement. Since actual experimental measurements are not yet available, numerical performance values should only be included after conducting the tests. These evaluations will provide a basis for improving navigation accuracy, communication reliability, energy efficiency, and overall safety before considering integration with a practical wheelchair platform.

DISCUSSION

The ESP32-WROOM-32 provides a central unit for processing sensor inputs and controlling motor movement. The TB6612FNG motor driver and GA12-N20 DC motors support basic movement control, while the QTR-8RC reflectance sensor array can be used to investigate line-following performance.

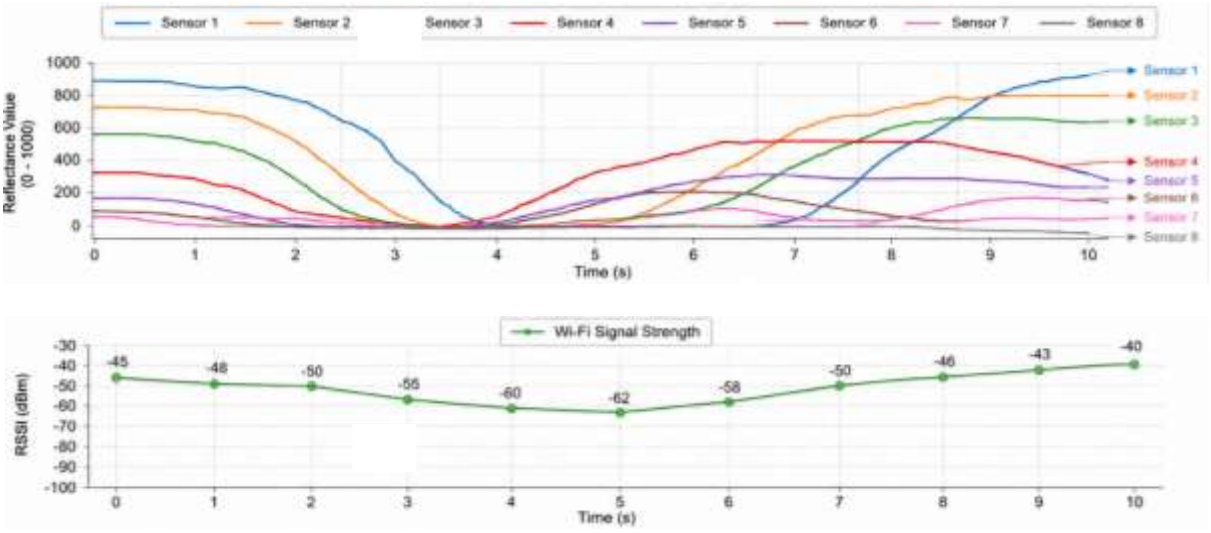


Fig. 2 Real-Time Sensor Readings

The integration of IoT technology can provide opportunities for remote monitoring and information sharing through a suitable web-based interface. GPS integration could further support outdoor location tracking and help caregivers monitor the user's location. However, these functions depend on the addition of the required hardware, communication software, and network connectivity.

The available hardware configuration is suitable for developing a basic mobile robotic prototype, but it does not yet establish a complete autonomous wheelchair system. In particular, dedicated obstacle-detection sensors, GPS hardware, and a verified IoT monitoring interface are required to demonstrate the proposed advanced functions. Additional safety mechanisms are also necessary before adapting the prototype for human use.

The performance of the system should be assessed through repeated experiments involving line-following accuracy, motor response, wireless communication reliability, and battery endurance. Further testing should examine GPS accuracy and obstacle avoidance after their implementation. Since experimental measurements are not currently available, the actual performance and effectiveness of the proposed system cannot yet be quantitatively confirmed.

Overall, the proposed design provides a foundation for future development of an IoT-enabled mobility assistance system. Improvements in sensing, navigation algorithms, location tracking, and safety validation could help extend the basic robotic platform toward a practical smart wheelchair application.

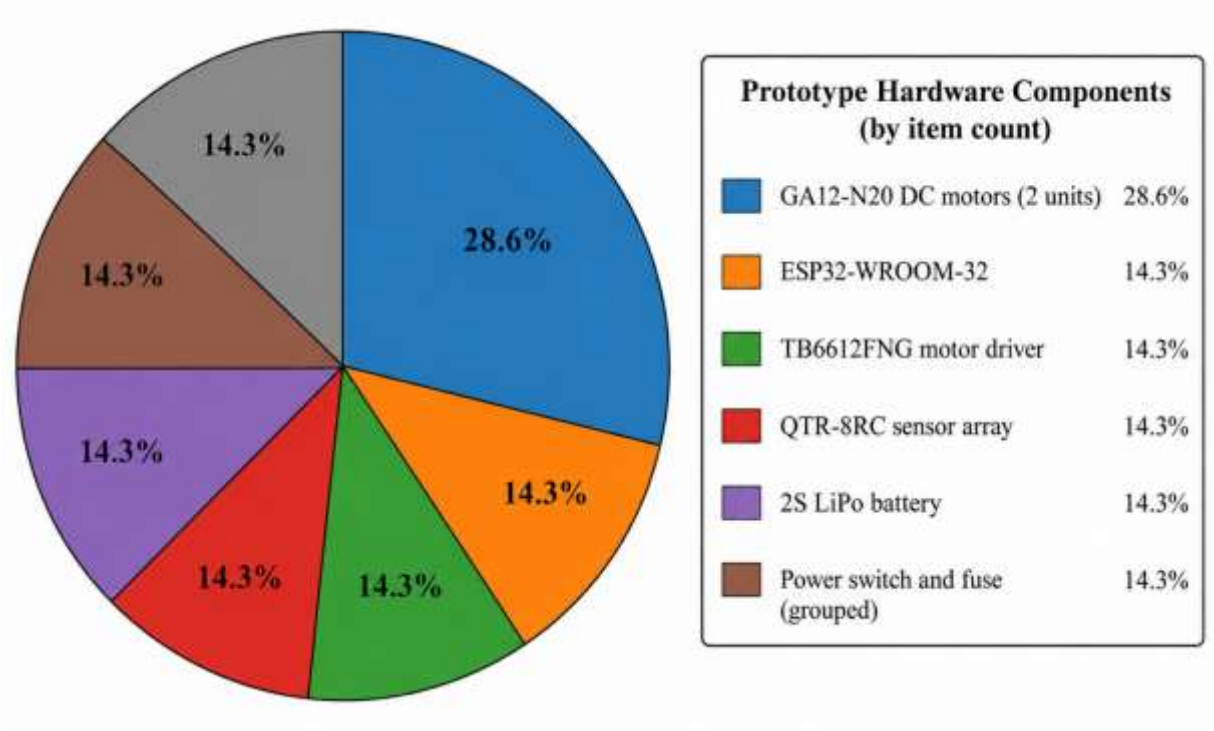


Fig. 2 Component-Wise Distribution of the Proposed System

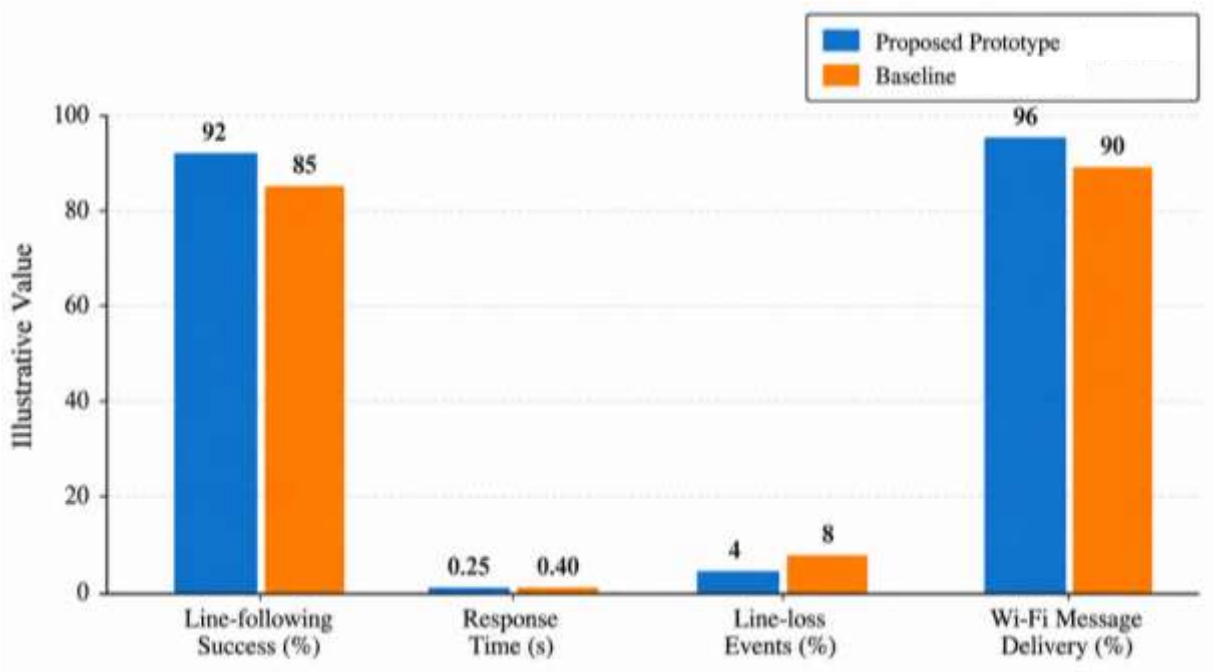


Fig. 3 Performance comparison

CONCLUSION

The proposed IoT-Based Smart Wheelchair Navigation system provides a foundation for developing an intelligent mobility assistance platform by integrating embedded control, sensor-based navigation, and wireless communication. The ESP32-WROOM-32, TB6612FNG motor driver, QTR-8RC reflectance sensor array, and DC motors support the development of a basic robotic navigation prototype.

The proposed system requires further development to incorporate reliable obstacle detection, GPS tracking, and a complete IoT monitoring interface. Experimental evaluation of navigation accuracy, response time, communication

reliability, and battery endurance is also necessary to assess its performance. Overall, this project establishes a starting point for future smart wheelchair development, with further testing and safety validation required before practical application.

REFERENCES

[1] Bakouri, M., Alqarni, A., Alanazi, S., Alassaf, A., AlMohimeed, I., & Alqahtani, T. (2025). Analysis of autonomous wheelchair navigation technologies in the past five years: A systematic review. International Journal of Online and Biomedical Engineering, 21(3), 56–83.

[2] Burhanpurkar, M., Labbe, M., Guan, C., Michaud, F., & Kelly, J. (2017). Cheap or robust? The practical realization of self-driving wheelchair technology. 2017 International Conference on Rehabilitation Robotics (ICORR), 1079–1086.

[3] Callejas-Cuervo, M., et al. (2020). Control systems and electronic instrumentation applied to autonomy in wheelchair mobility: The state of the art. Sensors, 20(21), Article 6326.

[4] Kim, E. Y. (2016). Wheelchair navigation system for disabled and elderly people. Sensors, 16(11), Article 1806.

[5] Mitsuhashi, H., & Itami, T. (2025). Fully automatic control of electric wheelchair by measuring obstacle shape using monocular camera and laser. Journal of Robotics and Mechatronics, 37(2), 523–534.

[6] Nguyen, A. V., Nguyen, L. B., Su, S., & Nguyen, H. T. (2012). Development of a Bayesian neural network to perform obstacle avoidance for an intelligent wheelchair. Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 1884–1887.

[7] Nguyen, A. V., Nguyen, L. B., Su, S., & Nguyen, H. T. (2013). The advancement of an obstacle avoidance Bayesian neural network for an intelligent wheelchair. Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 3642–3645.

[8] Pololu Corporation. (n.d.). QTR-8A and QTR-8RC Reflectance Sensor Array User's Guide.

[9] Pu, J., Jiang, Y., Xie, X., Chen, X., Liu, M., & Xu, S. (2018). Low cost sensor network for obstacle avoidance in share-controlled smart wheelchairs under daily scenarios. Microelectronics Reliability, 83, 180–186.

[10] Simpson, R. C. (2005). Smart wheelchairs: A literature review. Journal of Rehabilitation Research and Development, 42(4), 423–436.

[11] Toshiba Electronic Devices & Storage Corporation. (n.d.). TB6612FNG: Driver IC for Dual DC Motor—Datasheet.

[12] Trieu, H. T., & Nguyen, H. T. (2007). Obstacle avoidance for power wheelchair using Bayesian neural network. Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 4771–4774.

[13] Trieu, H. T., Nguyen, H. T., & Willey, K. (2008). Shared control strategies for obstacle avoidance tasks in an intelligent wheelchair. Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 4254–4257.

[14] Wang, C. (2024). Comparative analysis of obstacle avoidance sensors based on assistive intelligent wheel chair. Applied and Computational Engineering, 31.