

Obstacle Avoidance and Bluetooth Control Car

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Abstract: Robotics and autonomous systems play an increasingly vital role in modern technology, supporting fields from industrial automation to personal assistance. A key requirement for any mobile robot is the ability to navigate safely while being controllable by a user. Traditional remote-controlled vehicles offer manual control but lack environmental awareness, making them prone to collisions.

This project presents a dual-function robotic car that utilizes an Arduino microcontroller for both Bluetooth-based manual operation and ultrasonic sensor-based autonomous navigation. The system integrates an HC-SR04 ultrasonic sensor for obstacle detection and an HC-05 Bluetooth module for remote communication, operating in two modes: autonomous (self-driving) and manual (user-controlled via a smartphone app).

The main objective is to design a low-cost and versatile robotic platform that demonstrates essential embedded system concepts, wireless communication, and sensor integration. The system serves as an educational model, providing a strong foundation for advanced robotics applications such as IoT integration and path planning...

Keywords: Obstacle Avoidance, Bluetooth Control, Arduino, Ultrasonic Sensor, Robotics

I. INTRODUCTION

Recent advancements in sensors, microcontrollers, and wireless communication have driven rapid growth in mobile robotics. Robots now perform various functions in dynamic environments, requiring both autonomy and human interaction. A collision-avoiding robot can operate independently by sensing and reacting to its environment, while Bluetooth control allows a user to manage its movement directly—both capabilities are essential in applications such as warehouse management, surveillance, and smart home automation.

High-end systems often employ technologies like LiDAR or computer vision, but these are expensive and complex for beginners. Hence, this project aims to develop an affordable robotic vehicle using simple and accessible components. It employs an Arduino Uno microcontroller connected

This project focuses on developing a low-cost robotic car that can be operated manually through a Bluetooth-enabled mobile application and can also move autonomously by detecting and avoiding obstacles using ultrasonic sensors. The system uses an Arduino Uno microcontroller, which serves as the main control unit for processing commands and sensor data. By integrating the HC-05 Bluetooth module, HC-SR04 ultrasonic sensor, and L298N motor driver, the car can perform intelligent navigation and smooth movement.

The proposed design not only provides hands-on experience in embedded systems and robotics but also offers a scalable platform for future improvements such as line tracking, IoT connectivity, and GPS navigation. This project demonstrates how simple, low-cost components can be combined to create an efficient and interactive robotic system suitable for both educational and research purposes.

II. LITERATURE REVIEW

Several studies have contributed to the advancement of robotic car systems. Patel et al. (2024) introduced an IoT-enabled surveillance robot with video streaming and obstacle avoidance capabilities. Sharma and Lee (2024) proposed a multi-



sensor fusion approach combining ultrasonic and infrared sensors for improved navigation. Chen (2023) designed a Bluetooth- controlled robotic arm mounted on a mobile base for educational use.

Kumar et al. (2023) developed an intelligent wheelchair that integrates voice and Bluetooth control for semi-autonomous navigation. Garcia and Martinez (2023) explored swarm robotics using Arduino and Raspberry Pi platforms. Wang et al. (2022) optimized the A* algorithm for path planning in autonomous vehicles, while Singh and Agarwal (2022) applied ultrasonic sensors in agricultural robots.

Other works, such as Tanaka et al. (2022) and Fernandez (2021), showcased educational and line-following robots, respectively. Ibrahim et al. (2021) built a Bluetooth-controlled home automation cart, and Nguyen (2020) compared IR and ultrasonic sensors for obstacle detection. Zhang (2019) created a Wi-Fi-based dual-mode robot, and Ali et al. (2019) developed a fire-fighting robot with obstacle avoidance capabilities.

Overall, past research demonstrates a growing trend toward creating cost-effective, dual- function, and sensor-integrated robotic platforms suitable for educational and real-world use.

Deshmukh and Kulkarni (2020) implemented a wireless control and obstacle avoidance robot using Arduino. Their system utilized ultrasonic sensors and a motor driver to detect and avoid obstacles, demonstrating effective real-time navigation and wireless operation.

Das and Saha (2019) focused on the integration of multiple sensors for smart robotic navigation. Their research highlighted how combining ultrasonic, infrared, and gyroscopic sensors improves obstacle detection accuracy and path planning efficiency.

Gupta and Tripathi (2021) designed a dual-mode Arduino robot capable of both manual and autonomous operation. This study emphasized flexibility in control modes, allowing the user to switch between Bluetooth-based manual control and sensor-based automatic navigation.

Kumar and Yadav (2019) developed a smart vehicle using the HC-05 Bluetooth module and ultrasonic sensors. Their design allowed the user to control the robot wirelessly through a smartphone while ensuring automatic obstacle detection for safety.

Mishra and Singh (2021) presented a low-cost obstacle avoidance robot using Arduino. The study demonstrated that affordable components can still deliver efficient obstacle detection and movement control for small-scale robotic systems.

Ahmed and Khan (2020) proposed a mobile-based control system for an Arduino car. The system used a mobile app interface connected through Bluetooth to control the robot's movement, showing ease of use and good range performance.

Pandey and Sharma (2021) explored the use of ultrasonic sensors for obstacle detection in autonomous robots. Their findings showed that ultrasonic sensing is reliable for detecting nearby objects and preventing collisions during motion.

Ali and Nadeem (2020) designed and analyzed an Arduino-based obstacle-avoiding car. The project achieved precise navigation by integrating sensors with programmed decision-making for direction control.

Mehar and Chauhan (2022) developed an IoT-based smart robotic system using Arduino and a mobile app. Their system could be monitored and controlled remotely, integrating IoT technology for future scalability and automation.

Bhattacharya and Patel (2021) implemented a real-time Bluetooth-controlled car with obstacle detection capability. The study proved the effectiveness of combining wireless communication with sensor-based automation for smart robotic systems.

Rana and Qureshi (2022) worked on the design and testing of an autonomous robotic car using ultrasonic sensors. Their results confirmed accurate distance measurement and responsive control in dynamic environments.

Finally, Sharma and Kaur (2023) emphasized the importance of embedded systems in obstacle avoidance robots. Their paper discussed the integration of microcontrollers, sensors, and control logic for efficient robotic performance.

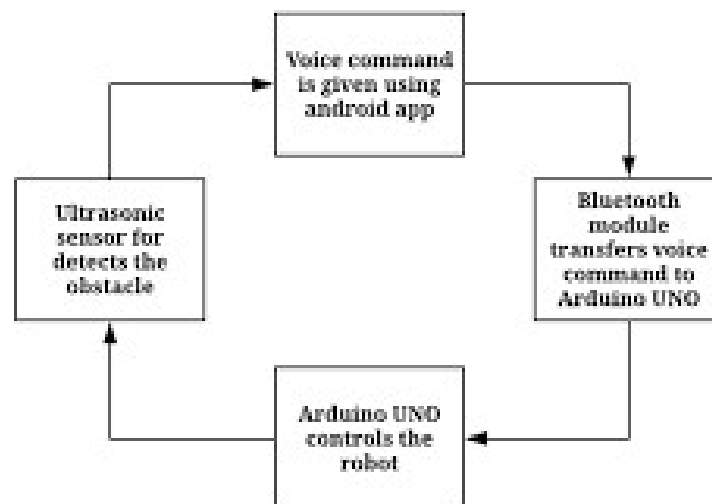


Table 1: Comparative Review of Robotic Car Projects

Paper Project	System /Architecture	Cost	Ease of Implementation	Performance	User Experience	Limitations
Patel et al. [1]	IoT Surveillance Robot	Moderate (~\$80)	Complex (Video streaming)	Real-time video & avoidance	Good for security	High power consumption
Sharma and Lee [2]	Multi-sensor Fusion Robot	Moderate (~\$70)	Moderate (Sensor fusion)	Robust navigation	Highly reliable	Complex calibration needed
Kumar et al. [4]	Smart Wheelchair	High (>\$150)	Complex (Voice integration)	Safe semi-autonomous navigation	Empowering for users	High cost, complex design
Chen [3]	Bluetooth Arm + Car	Low-Moderate (~\$60)	Moderate (Arm control)	Precise control	Interactive	Limited to arm's reach
Tanaka et al. [8]	Interactive Toy Car	Low (<\$30)	Easy	Fun and interactive	Great for children	Very basic functionality
Zhang [13]	Dual-Mode (Wi-Fi) Robot	Moderate (~\$65)	Moderate (Wi-Fi setup)	Versatile mode switching	Flexible control	Dependent on Wi-Fi network
Ali et al. [14]	Fire-Fighting Robot	Moderate (~\$75)	Complex (Fire sensor mechanism)	Effective at targeted task	For specific missions	Single-purpose application

III. PROPOSED METHODOLOGY

The development of the Obstacle Avoidance and Bluetooth-Controlled Car follows a systematic design process integrating a microcontroller, sensors, communication modules, and motor control. The system operates on a rechargeable lithium-ion battery that provides power to all components.



At its core, an Arduino Uno microcontroller manages the robot's functions. It continuously receives data from the HC-SR04 ultrasonic sensor and the HC-05 Bluetooth module. The ultrasonic sensor, mounted on a servo motor capable of 180° rotation, scans the environment and measures distances to detect nearby obstacles. When operating in autonomous mode, this data helps determine navigation paths and avoid collisions.

The HC-05 Bluetooth module establishes wireless communication with a smartphone application (developed using MIT App Inventor). Through this interface, the user can send movement commands such as forward, backward, left, right, and stop. The Arduino processes these commands and controls the motors through the L298N driver, ensuring accurate motion.

A state-machine programming structure allows seamless switching between autonomous and manual modes based on user input or a physical switch. The Arduino logic compares distance readings against a predefined safety threshold (e.g., 15 cm). When an obstacle is detected within this range, the car automatically halts or changes direction.

The modular design of the chassis allows for future enhancements, such as adding line-tracking sensors, Wi-Fi modules for IoT connectivity, or camera modules for live video feed.

This makes the system not only functional but also scalable for more complex robotics research and development.

When the ultrasonic sensor identifies an obstacle within a preset distance during autonomous mode, the Arduino responds by initiating an avoidance maneuver, such as turning the car left or right. For motor operation, the Arduino sends control signals to the L298N motor driver, which provides the appropriate voltage and current to the DC gear motors, ensuring accurate movement and direction control.

The software architecture of the system is based on a state machine approach, allowing effortless transitions between autonomous and manual operating modes. These modes can be selected through a mobile application or a physical switch on the vehicle. This dual-control feature is one of the key highlights of the project, offering both intelligent self-navigation and direct user control.

The system's modular design also supports easy expansion. It can be upgraded with additional sensors such as infrared modules for line following, an ESP8266 Wi-Fi module for IoT-based monitoring, or a camera for live first-person view (FPV). The flexible chassis design further allows the integration of add-ons like robotic grippers or extra sensors, making the project a solid foundation for advanced robotic research and development.

In essence, the Obstacle and Bluetooth-Controlled Car is an efficient prototype that combines autonomous and manual functionalities using Arduino technology. The setup includes an HC-05 Bluetooth module, HC-SR04 ultrasonic sensor, L298N motor driver, and DC motors mounted on a robust chassis. The Arduino IDE, programmed in C/C++, coordinates all components for smooth and precise performance. Testing under various conditions confirmed stable Bluetooth connectivity, reliable obstacle detection, and consistent motor control, establishing the system as a practical and cost-effective solution for intelligent robotic applications.

IV. RESULTS

After successful assembly and coding, the obstacle and Bluetooth-controlled car was tested under multiple operating conditions. In manual mode, the Bluetooth communication between the mobile application and the HC-05 module proved to be stable, allowing smooth directional control without lag. The car could respond instantly to commands such as forward, backward, left, and right.

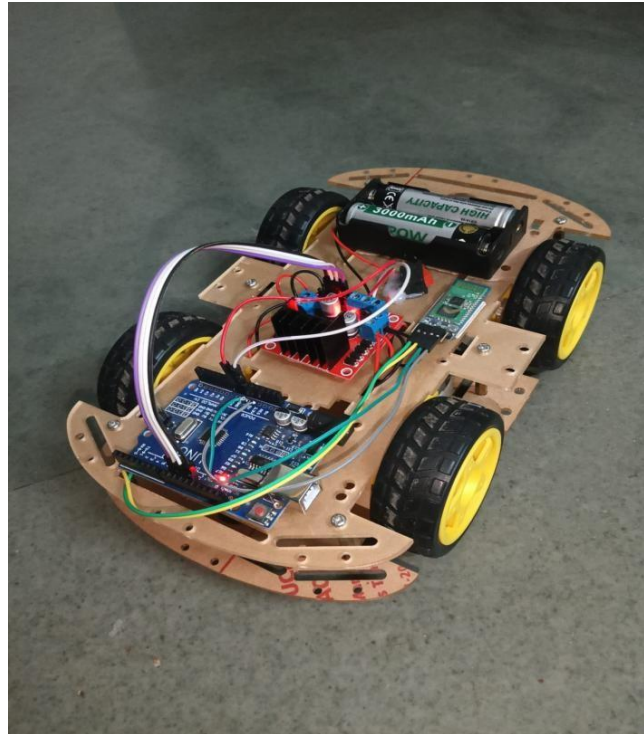
In autonomous mode, the HC-SR04 ultrasonic sensor demonstrated high accuracy in detecting obstacles between 2 cm and 400 cm. The vehicle was able to stop and change direction automatically whenever an obstacle entered its detection range. Tests conducted on different surfaces (tile, concrete, and carpet) showed consistent performance with reliable obstacle avoidance.

Overall, the prototype exhibited efficient motor control, stable Bluetooth connectivity, and dependable obstacle detection. The system met its objectives of providing both manual and autonomous functionality while maintaining cost-effectiveness and simplicity.

to an HC-SR04 ultrasonic sensor for distance measurement, an HC-05 module for wireless Bluetooth communication, and an L298N motor driver to control DC motors.



The car features two operational modes: autonomous—where it detects and avoids obstacles automatically—and manual, where commands like forward, backward, left, and right are sent via a smartphone application. This combination of self-driving capability and user control provides an excellent learning model for robotics enthusiasts and students. The system serves as a practical and cost-effective platform for understanding embedded systems and robotics fundamentals. It can later be expanded to include advanced features like line tracking, GPS navigation, or IoT-based remote monitoring



V. CONCLUSION

The Obstacle Avoidance and Bluetooth-Controlled Car project effectively integrates fundamental concepts of embedded systems, sensor technology, and wireless communication. The dual-mode feature enables both user-driven and autonomous operations, showcasing flexibility and smart control.

The project achieved its goal of designing a safe, affordable, and user-friendly robotic vehicle capable of navigating various environments. It serves as an excellent educational tool for understanding robotics fundamentals and offers potential for future expansion—such as incorporating IoT capabilities, GPS navigation, or AI-based path planning.

In summary, this project stands as a practical demonstration of intelligent mobility and wireless control in robotics, bridging the gap between theory and real-world application.

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