

Trends & Technologies in Obstacle Avoidance Systems Based on Arduino

Diksha Shelke¹, Pratiksha Pawar², Payal Tate³, Prajtkta Shinde⁴, Prof. A. S. Mali⁵

¹²³⁴UG Students, Department of Electronics and Telecommunication Engineering

⁵Assistant Professor, Department of Electronics and Telecommunication Engineering

SKN Sinhgad College of Engineering, Pandharpur

dikshashelke024@gmail.com, pratikshapawar049@gmail.com,

tatepayal2@gmail.com, amruta.mali@sknscoe.ac.in

Abstract: *Robotics and autonomous systems play a crucial role in modern technology, with uses that span from industrial automation to personal assistance. A key requirement for any mobile robot is its capability to navigate its surroundings safely and detect nearby obstacles to prevent collisions. Conventional remote-controlled (RC) vehicles provide manual operation but lack environmental awareness, rendering them susceptible to accidents.*

This project introduces an Obstacle Detector Robot Car constructed using Arduino microcontroller technology. The system is equipped with an HC-SR04 ultrasonic sensor to detect nearby objects and avert collisions. Furthermore, it includes an HC-05 Bluetooth module to facilitate wireless manual control. The robot car functions in two modes: an autonomous mode that allows for obstacle detection and automatic avoidance, and a manual mode that enables control through a smartphone app via Bluetooth.

The Arduino Uno processes sensor data and user commands, managing the motors through a motor driver module. The main goal of this project is to develop a cost-effective, functional robotic system that illustrates essential concepts in embedded systems, sensor integration, and wireless communication. The robot is designed to be educational, user-friendly, and provides a solid foundation for more sophisticated robotics applications such as autonomous navigation and Internet of Things (IoT) connectivity.

By integrating both autonomous and manual modes, the Obstacle Detector Robot Car improves functionality and practical learning opportunities. It is particularly suitable for students, hobbyists, and developers looking for an introduction to intelligent robotic systems and the real-world applications of automation.

Keywords: Obstacle Avoidance, Arduino, Ultrasonic Sensor, Robotics

I. INTRODUCTION

The field of mobile robotics has undergone considerable growth, driven by advancements in sensors, microcontrollers, and communication technologies. Robots are increasingly deployed in dynamic settings where they must engage with their environment and respond to human commands. Autonomous navigation and remote user control are two critical functionalities for these systems. An obstacle-detecting vehicle can function autonomously by utilizing sensors to perceive its surroundings and make decisions to prevent collisions. This capability is vital for applications such as robotic vacuum cleaners, warehouse automation, and autonomous vehicles.

Conversely, Bluetooth control offers a straightforward yet effective means for direct human interaction, which is beneficial in situations that necessitate precise maneuvering, like material transport or remote surveillance. While sophisticated systems employ technologies such as LiDAR, computer vision, or 4G/5G networks, these solutions are often costly and complex for novices or small-scale projects. To tackle this issue, this project presents an economical, dual-mode Obstacle Detector Robot Car constructed with readily available embedded components.



The system is based on an Arduino Uno microcontroller, connected to an HC-SR04 ultrasonic sensor for distance measurement and an HC-05 Bluetooth module for wireless control. An L298N motor driver module regulates the operation of DC gear motors that propel the wheels. The system features two operational modes. In autonomous mode, the robot car consistently scans for nearby obstacles and adeptly avoids them without any user intervention. In manual mode, the user can completely control the car's movement—forward, backward, left, right, and stop—via a Bluetooth-enabled smartphone application. This dual-mode capability renders the project an excellent resource for both educational and demonstration purposes.

In summary, the Obstacle Detector Robot Car provides a thorough platform for grasping fundamental robotics concepts by integrating autonomous sensing and user-driven control.

II. LITERATURE SURVEY

Utilizing IoT technology, Patel et al. [1] created a smart surveillance robot that features live video streaming and obstacle avoidance, underscoring its significance in security and remote monitoring applications. Sharma and Lee [2] applied a multi-sensor fusion approach for autonomous navigation by merging ultrasonic and infrared sensors to enhance environmental awareness. Chen [3] developed a Bluetooth-controlled robotic arm mounted on a mobile platform aimed at educational purposes and basic pick-and-place tasks.

Kumar et al. [4] presented an intelligent wheelchair system that integrated voice and Bluetooth control with semi-autonomous obstacle avoidance, concentrating on assistive technology.

Garcia and Martinez [5] investigated the application of Arduino and Raspberry Pi in swarm robotics, showcasing inter-robot communication and fundamental obstacle avoidance techniques. Wang et al. [6] suggested an improved path-planning algorithm for autonomous vehicles, although it necessitated considerable computational resources. Singh and Agarwal [7] designed an economical agricultural robot for weed detection and removal, employing ultrasonic sensors for boundary management.

Tanaka et al. [8] created an interactive toy car for children, featuring clap-activated movement and basic obstacle detection capabilities. Fernandez [9] engineered a line-following robot equipped with obstacle detection, allowing it to halt and resume its path upon encountering objects. Ibrahim et al. [10] concentrated on Bluetooth-controlled home automation carts intended for the transport of small items within indoor settings.

Nguyen [11] assessed IR and ultrasonic sensors for obstacle detection in miniature robots, concluding that ultrasonic sensors offered superior range and reliability. Okafor and Eze [12] executed a mobile phone-controlled robot utilizing DTMF technology, providing an alternative to Bluetooth-based systems. Zhang [13] unveiled a dual-mode robot capable of both autonomous and manual control via Wi-Fi, delivering functionality akin to this project but with a more advanced design.

Table 1: Comparative Review of Robotic Car Projects

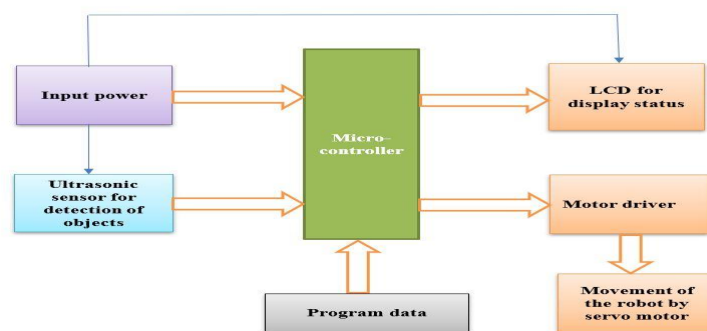
Paper /Project	System Architecture	Cost	Ease Of Implementation	Performance	User Experience	Limitations
Patel et al. [1]	IoT Surveillance Robot	Moderate	Complex (Video streaming)	Real time video & avoidance	Good security for	High power consumption
Sharma and Lee [2]	Multi-sensor fusion robot	Moderate	Moderate (sensor fusion)	Robust navigation	Highly reliable	Complex calibration needed



Paper /Project	System Architecture	Cost	Ease Of Implementation	Performance	User Experience	Limitations
Kumar et al. [4]	Smart wheel chair	High	Complex (voice integration)	(Safe semi-autonomous navigation	Empowering for users	High cost, complex design
Chen [3]	Bluetooth Arm+ car	Low	Moderate (arm control)	(Precise	Interactive	Limited to arm reach
Tanaka et al. [8]	Interactive toy car	Low	Easy	Fun and interactive	Great for children	Very basic functionality
Zhang [13]	Dual-mode (Wi-Fi) robot	Moderate	Moderate (Wi-Fi setup)	Versatile mode switching	Flexible control	Dependent on Wi-Fi network
Ali et al. [14]	Fire-fighting robot	Moderate	Complex (fire sensor mechanism)	Effective at targeted task	For specific missions	Single purpose application

III. PROPOSED METHODOLOGY

The development and implementation of the Obstacle Avoidance and Bluetooth Control Car follow a structured methodology that integrates a microcontroller, sensors, a communication module, and motor control elements to create a versatile and intelligent robotic system.



The proposed robotic vehicle is a versatile system designed for both autonomous operation and user-directed steering. It functions with a lithium-ion battery pack, providing a reliable and portable DC power supply for all components, including the microcontroller, sensors, and motors.

The system's central processing unit is the Arduino Uno microcontroller, which acts as its primary intelligence. It continuously collects data from two key sources: the HC-SR04 ultrasonic sensor and the HC-05 Bluetooth module. The HC-SR04 sensor is mounted on a servo motor, allowing it to scan the environment by rotating up to 180 degrees. It



emits ultrasonic waves and measures the time taken for the echo to return, calculating distances to obstacles ranging from 2cm to 400cm. In autonomous mode, this data is used to make navigation decisions.

The HC-05 Bluetooth module facilitates wireless communication between the vehicle and a smartphone. A custom mobile application, created using platforms like MIT App Inventor or a similar Android IDE, provides a user-friendly interface with buttons for controlling movement (Forward, Backward, Left, Right, Stop). Commands sent from the app are received by the HC-05 and relayed to the Arduino, which executes them in manual mode.

The decision-making logic within the Arduino determines the operational mode and controls the actuators. It evaluates sensor data and user inputs, comparing distance readings against a predefined safety threshold (e.g., 15 cm). When an obstacle is detected within this range in autonomous mode, the Arduino triggers an avoidance maneuver, such as turning left or right. For motor control, the Arduino sends signals to the L298N motor driver module, providing the necessary current and voltage to operate the two DC gear motors attached to the wheels, ensuring precise movement control. The system's software employs a state machine architecture, allowing for seamless transitions between "Autonomous" and "Manual" modes based on commands from the user. allowing for seamless transitions between "Autonomous" and "Manual" modes based on commands from the user.

IV. CONCLUSION

The Obstacle Avoiding robot car project effectively demonstrates the integration of fundamental embedded systems concepts within a practical and versatile robotic platform. The vehicle serves as a valuable and educational tool for understanding robotics by offering both autonomous and manual control options.

It adeptly maneuvers around obstacles in its environment, reducing the risk of damage and enabling independent operation. The Bluetooth control feature allows for seamless and rapid user engagement, making the project engaging and applicable to real-world remote control scenarios.

In summary, this project provides an economical and comprehensive introduction to robotics, suitable for both learners and hobbyists. Its modular design also supports future enhancements, such as the incorporation of additional sensors, advanced navigation algorithms, or IoT connectivity.

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