D. Y. PATIL COLLEGE OF ENGINEERING AND TECHNOLOGY

(An Autonomous Institute)

KASABA BAWADA, KOLHAPUR

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Department of Computer Science and Engineering

(Artificial Intelligence and Machine Learning)

A PROJECT REPORT

ON

"Autonomous Obstacle Detection and Braking System for Smart Vehicles"

Submitted By

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3	Swapnil Alange	60
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Under the Guidance of
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Experiment No 16

Project Title: Autonomous Obstacle Detection and Braking System for Smart Vehicles

ABSTRACT

The Autonomous Obstacle Detection and Braking System for Smart Vehicles is designed to enhance safety by preventing collisions through real-time obstacle detection and automatic braking. Utilizing an ultrasonic sensor connected to a Raspberry Pi, the system continuously measures distance to detect objects within a threshold of 20 cm. When an obstacle is detected, the system activates a relay to stop the vehicle's motor and triggers both an LED and a buzzer as visual and audio alerts.

This rapid-response mechanism ensures effective braking in close proximity to obstacles, minimizing collision risks. The system's components, including the Raspberry Pi, relay module, ultrasonic sensor, LED, and buzzer, offer a scalable, low-cost approach to intelligent vehicle control. Through successful testing, the system has proven reliable and responsive, halting the vehicle as intended within the defined threshold. This project not only provides a foundation for basic autonomous braking systems but also serves as a prototype for more advanced safety applications in smart vehicles.

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INTRODUCTION

The Autonomous Obstacle Detection and Braking System is a pioneering project aimed at enhancing safety in autonomous vehicles by incorporating basic yet effective collision avoidance mechanisms. With the rise in autonomous and smart vehicle technologies, ensuring reliable detection of obstacles and immediate braking actions has become essential to reduce accidents and build user trust. This project serves as a scaled-down version of real-world automotive safety systems, using an RC car equipped with an ultrasonic sensor, relay switch, and a Raspberry Pi controller to mimic autonomous braking capabilities.

The core of the system lies in the ultrasonic sensor, which measures distances by emitting sound waves and receiving them upon reflection from obstacles. By analyzing the time interval for the sound waves to return, the Raspberry Pi computes the precise distance of nearby objects. When an obstacle is detected within a set threshold of 20 cm, the Raspberry Pi instantly activates a relay connected to the motor.

This relay, functioning as an electronic switch, cuts power to the motor, stopping the car and simulating a braking action. In addition, an LED and buzzer are triggered to provide visual and auditory alerts, signaling the detection of an obstacle and the immediate halting of the car.

This project is designed to simulate and explore the concept of autonomous braking, a crucial feature in today's vehicle safety systems. By using widely available, low-cost components, it provides an accessible and adaptable model for exploring automated safety mechanisms in transportation.

The applications of this system extend beyond personal projects; similar technology can be adapted for industrial robotics to prevent machinery collisions, or scaled for use in larger autonomous vehicles, enhancing real-time obstacle avoidance and safety protocols. This project serves as a foundation for understanding and developing automated vehicle safety systems, aligning with the advancements in smart mobility and autonomous vehicle technology.

PROBLEM STATEMENT

The Autonomous Obstacle Detection and Braking System for Smart Vehicles project addresses the critical need for automated collision prevention in autonomous and semi-autonomous vehicles. With an increasing focus on road safety, this project aims to design a system that can accurately detect obstacles within a specified range and respond by stopping the vehicle. Using an ultrasonic sensor, Raspberry Pi, relay module, and additional alert components like an LED and buzzer, the system detects obstacles within a 20 cm threshold and halts the RC vehicle, simulating emergency braking. This project serves as a proof-of-concept for implementing effective obstacle detection and braking solutions in smart vehicles, enhancing both safety and reliability in autonomous navigation.

MATERIALS AND COMPONENTS

For the Autonomous Obstacle Detection and Braking System for Smart Vehicles, the following materials and components are used:

- **Raspberry Pi 4B** : The main controller for the system, responsible for processing sensor data and managing outputs like the relay and buzzer.
- **Ultrasonic Sensor (HC-SR04)**: Used for obstacle detection, measuring the distance to an object by sending out an ultrasonic pulse and calculating the time it takes to return.
- **SPST Relay Module**: This relay controls the motor of the RC car, enabling it to turn off when an obstacle is detected.
- **DC Motor (connected to RC car):** Simulates the vehicle's movement, powered by an external battery, and controlled via the relay for start/stop operations.
- **Buzzer:** Acts as an audible alert when an obstacle is detected, signaling the system to halt the motor.
- **LED:** Provides a visual indication when an obstacle is detected, indicating that the braking system has activated.
- **Jumper Wires:** Used to connect various components to the Raspberry Pi GPIO pins.
- **Power Supply (5V Power Bank):** Powers the Raspberry Pi and other low-power components like the ultrasonic sensor and buzzer.
- **Breadboard** : Facilitates easier wiring and organization of the circuit connections.

Each of these components plays a role in the detection, alert, and braking functionalities of the obstacle detection and braking system. Together, they provide a practical prototype of an autonomous braking system, enhancing the project's real-world applicability for vehicle safety.

METHODOLOGY

The methodology for the Autonomous Obstacle Detection and Braking System for Smart Vehicles consists of several steps involving sensor data collection, decision-making, and motor control.

System Initialization:

The Raspberry Pi is configured to use the BCM GPIO numbering system, setting up each required pin to control the components. GPIO pins are assigned to specific components, including the ultrasonic sensor (trigger and echo), LED, buzzer, and relay module, which controls the DC motor.

Distance Measurement Using Ultrasonic Sensor:

The system continuously measures distance using an ultrasonic sensor (HC-SR04). When an object is within a certain range, the sensor sends an ultrasonic pulse that reflects off the object.

The Raspberry Pi calculates the distance to the obstacle by measuring the time it takes for the pulse to return. This distance is then compared against a predefined threshold value (e.g., 20 cm) to decide if braking is required.

Obstacle Detection and Signal Activation:

If the measured distance falls below the threshold value, the system identifies an imminent collision risk. Upon detection, the system triggers both the LED and buzzer to indicate an obstacle within close range, alerting of a braking event.

Automatic Motor Control:

In addition to alerting, the Raspberry Pi changes the relay's state to stop the motor connected to the RC car. Specifically, it switches the relay from output mode to input mode, cutting power to the motor. If the distance is greater than the threshold, the relay switches back to output mode, allowing the motor to resume normal operation.

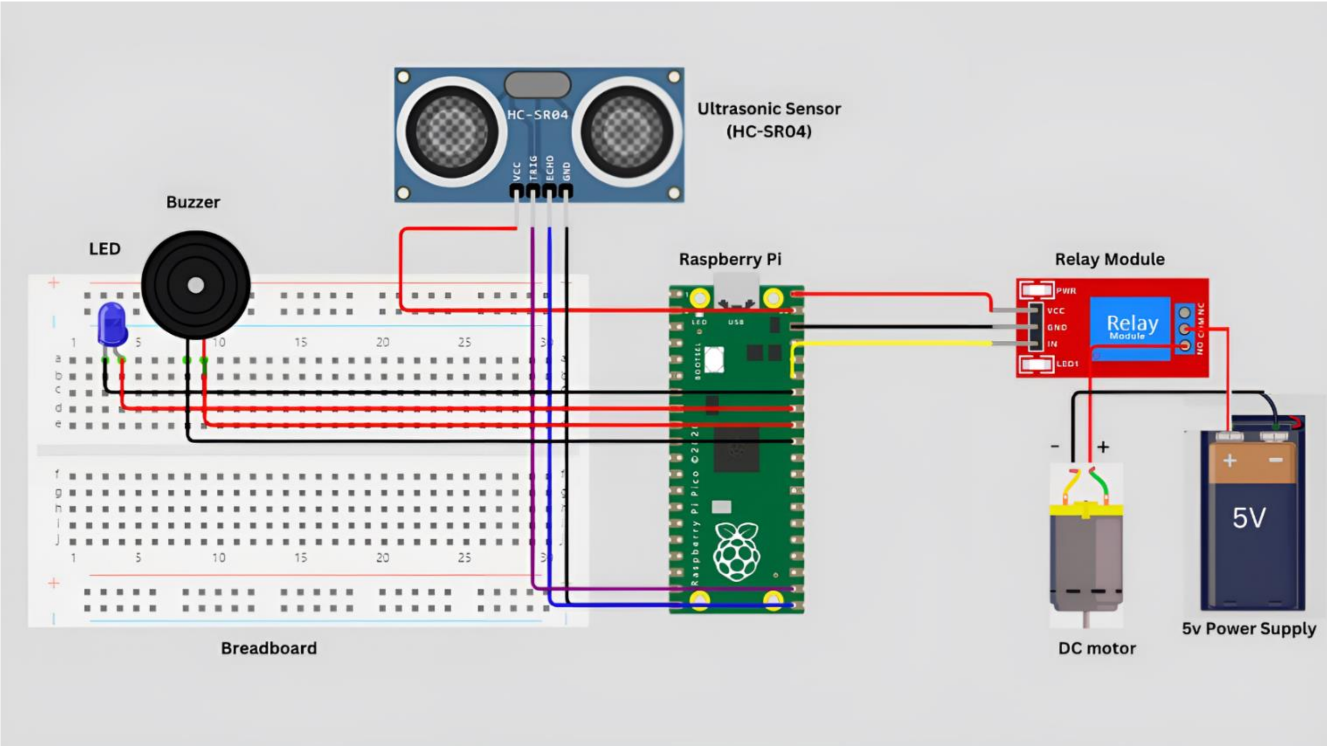
Continuous Monitoring:

The system continuously loops through the detection process, allowing real-time response to changing obstacle distances. The code includes a small delay to avoid excessive CPU usage, optimizing the system’s power and response times.

System Shutdown and Cleanup:

When the system is halted manually, the Raspberry Pi runs a cleanup process to ensure all GPIO pins are reset to a safe state, preventing potential short circuits or hardware conflicts on the next use. This methodology ensures an efficient, real-time obstacle detection and braking system that autonomously stops the motor upon detecting an obstacle, thus providing a practical, safety-enhanced driving simulation for smart vehicles.

CIRCUIT DIAGRAM



Components connections

Component	Pin on Raspberry Pi	Pin on Component
Ultrasonic Trigger	GPIO 20 (Pin 38)	Trigger (HC-SR04)
Ultrasonic Echo	GPIO 21 (Pin 40)	Echo (HC-SR04)
Ultrasonic VCC	5V (Pin 2 or Pin 4)	VCC (HC-SR04)
Ultrasonic GND	GND (Pin 6)	GND (HC-SR04)
LED Positive	GPIO 23 (Pin 16)	Anode (+)
LED Negative	GND (Pin 14)	Cathode (-)
Buzzer Positive	GPIO 24 (Pin 18)	Positive (+)
Buzzer Negative	GND (Pin 20)	Negative (-)
Relay IN	GPIO 18 (Pin 12)	IN (Relay)
Relay VCC	5V (Pin 2 or Pin 4)	VCC (Relay)
Relay GND	GND (Pin 6)	GND (Relay)
Motor Positive	Relay NO	Positive (Motor)
Motor Negative	Ground of Power Supply	Negative (Motor)

TESTING AND RESULTS

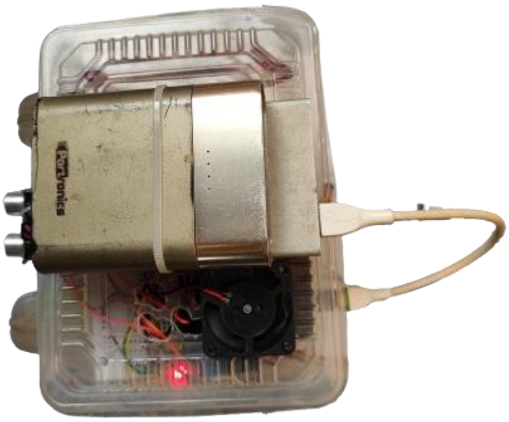
Testing: The obstacle detection and braking system was tested by placing objects at various distances in front of the RC car. The threshold distance was set at 20 cm to ensure timely response. The system was observed under different conditions to verify the following:

- **Distance Measurement**: The ultrasonic sensor reliably measured distances, and the readings were consistent with manual measurements.
- **Obstacle Detection**: When an object was within 20 cm, the LED and buzzer activated, and the relay stopped the motor, demonstrating the system's ability to detect and respond to obstacles effectively.
- **Motor Control:** The relay successfully cut power to the motor when an obstacle was detected, and resumed operation when the obstacle was removed.

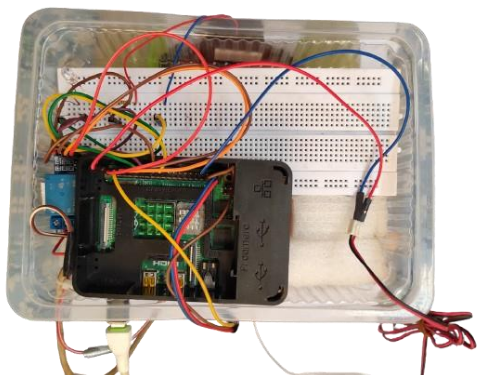
Results: The system achieved accurate, real-time obstacle detection, with a quick and reliable response. The LED and buzzer alerted users effectively, while the relay control stopped the motor as intended. These results validate the system's functionality, demonstrating its suitability for autonomous braking in real-world scenarios.

FRONT VIEW

SIDE VIEW



TOP VIEW



CIRCUIT VIEW

CONCLUSION

The Autonomous Obstacle Detection and Braking System for Smart Vehicles effectively demonstrates the potential of ultrasonic sensors and GPIO-controlled relays in enhancing vehicle safety. Through real-time distance measurement, this system can detect obstacles within a pre-set threshold and promptly halt the RC car, thus preventing potential collisions. The integration of visual and audio indicators (LED and buzzer) further enhances user awareness, making it a practical and intuitive system.

Testing revealed consistent and accurate performance, with the system responding swiftly to obstacles within the 20 cm range. The use of Raspberry Pi for control and data processing showcases the power of microcontroller-based solutions in IoT applications, offering a scalable model for advanced autonomous systems. This project highlights the simplicity and cost-effectiveness of using readily available components for implementing basic autonomous functions, paving the way for further advancements in intelligent vehicle safety features. This prototype provides a solid foundation for developing autonomous braking systems, particularly suited for smart vehicles and robotic applications where safety and responsiveness are critical.

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