REPORT ON

# Obstacle Detection and Avoidance in Autonomous Robots Using Ultrasonic Sensors and Arduino Controllers

SUBMITTED BY

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# ABSTRACT

This study presents the design of an obstacle-avoiding robot using ultrasonic sensors and an Arduino microcontroller. The robot autonomously detects and avoids obstacles in real time, achieving an accuracy rate of 84 percent age .By processing data from a front-mounted ultrasonic sensor, the system adjusts its direction to prevent collisions. This approach integrates robotics, sensor technologies, and basic AI techniques to enhance navigation safety and offers potential applications in various domains.

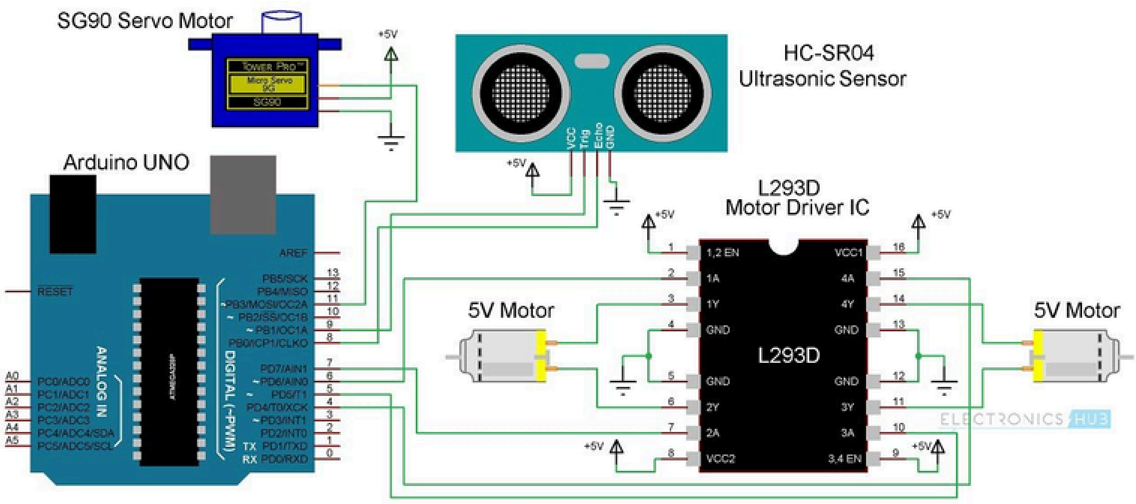
# Chapter 1

## 1.1 INTRODUCTION

Obstacle detection and avoidance are fundamental capabilities for autonomous robotic systems, especially as their deployment in dynamic and unpredictable environments continues to grow. Whether in industrial automation, au tonomous vehicles, or service robotics, the ability to sense, interpret, and respond to obstacles in real time is critical for ensuring both operational effi ciency and safety. This study focuses on developing a mobile robot equipped with ultrasonic sensors and an Arduino microcontroller, designed to detect and avoid obstacles autonomously. Ultrasonic sensors are widely recognized for their accuracy, reliability, and cost-effectiveness, making them a preferred choice for obstacle detec tion. These sensors operate by emitting ultrasonic waves and measuring the time taken for the echoes to return after hitting an obstacle, enabling the robot to calculate distances with precision. Their effectiveness across varying distances and environments makes them particularly suitable for real-time robotic navigation. The Arduino microcontroller serves as the central processing unit of the system, integrating sensor data and executing control algorithms to guide the robot's movements. By continuously analyzing data from the ultrasonic sensors, the microcontroller makes real-time decisions to adjust the robot's trajectory, ensuring safe and efficient navigation. This research combines hardware and software components to achieve a practical and efficient obstacle-avoidance solution. The system demonstrates the integration of robotics principles, sensor technologies, and algorithmic control to address the challenges of autonomous navigation. By presenting this implementation, the study aims to contribute to the growing field of intelligent robotic systems and their applications in safety-critical domains

## 1.2 BACKGROUND

Obstacle avoidance is a fundamental capability for autonomous vehicles, re quiring accurate and timely detection of obstacles. Traditional methods often involve complex algorithms or expensive hardware, which can be limiting in cost-sensitive applications.

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## 1.3 PROBLEM STATEMENT

Robots operating in dynamic or cluttered environments must be capable of detecting and avoiding obstacles in real-time. Standard sensor setups can have limited field of view, which can lead to undetected obstacles and potential collisions. A system that can dynamically adjust sensor angles while navigating is required to address this issue.

## 1.4 OBJECTIVE

- The main objectives of this project are:
- To design a robot capable of detecting obstacles in real time using ultrasonic sensors mounted on servo motors.
- To implement an obstacle-avoidance algorithm that adjusts the direction of ultrasonic sensors using servo motors.
- To ensure autonomous navigation with adaptive obstacle detection in
  both open and cluttered environments
- To evaluate the performance of the robot in various real-world scenar ios.

# Chapter 2

## LITERATURE SURVEY

Autonomous robots with obstacle-avoidance capabilities have been a key area of research in robotics. Different sensor technologies such as infrared, LIDAR, and ultrasonic sensors have been explored for obstacle detection.

**Venkata Sai Surya et al. (2017)**

An Arduino Uno-based line follower and obstacle avoidance bot. It is an autonomous robot that detects obstacles in its path using infrared and ultrasonic sensors and navigates based on user-specified actions. As a result, this system complements the current system by substituting skilled employees with automated systems that can do more work in less time, with greater accuracy and at a lower average cost.

**Roy et al. (2016)**

A Bluetooth-controlled Arduino uno robot. They proposed the formation of a robot that can be monitored by smart phones via an Android app. They used Bluetooth based technology to connect the Arduino UNO and the Android application. Their proposed method makes use of a Smartphone, which is inexpensive and widely available. Several commands, such as move reverse, forward, move left, and move right, can be performed via the Android smartphone or tablet.

### 2.1 Previous Work

The key components include:

• Ultrasonic Sensors:Ultrasonic sensors have long been used for distance measurement due to their reliability. Their limitations, however, include a fixed sensing range and field of view.

• Servo Motor Integration: Recent systems have employed servo motors to rotate sensors, effectively increasing the sensor's field of view. This approach enhances obstacle detection, especially in environments with obstacles at varying angles.

• Real-Time Control Algorithms: The use of control algorithms with adaptive sensor positioning enables robots to react to obstacles dynamically, improving their navigation in complex environments.

# Chapter 3

## METHODOLOGY

Autonomous robots with obstacle-avoidance capabilities have been a key area of research in robotics. Different sensor technologies such as infrared, LIDAR, and ultrasonic sensors have been explored for obstacle detection.

**Obstacle Avoidance Algorithm**

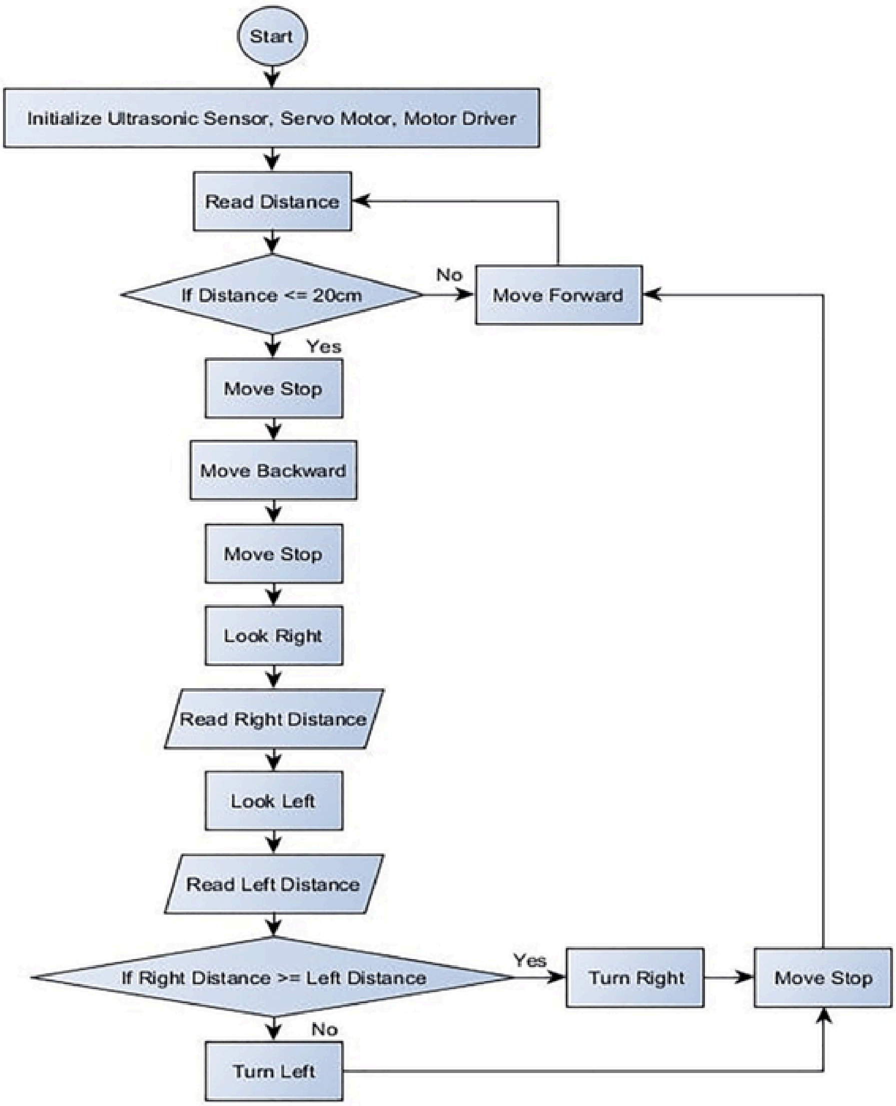
• Initialization: The Arduino initializes the sensors and servo motors.

• Distance Measurement: Ultrasonic sensors continuously measure distances to detect obstacles.

• Servo Motor Rotation: Servo motors rotate the ultrasonic sensors to scan for obstacles in different directions.

• Decision Making: If an obstacle is detected within a critical distance, the robot adjusts its direction to avoid it.

• Movement Control: Based on sensor input, the robot’s wheels are controlled by the motor driver, allowing the robot to navigate autonomously while avoiding obstacles.






Algorithm flowchart

## 3.1 COMPONENT SPECIFICATION

### HARDWARE:-

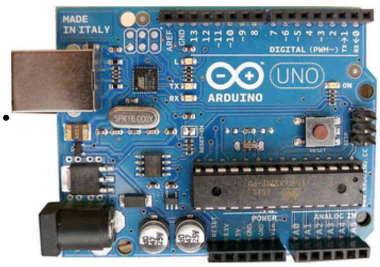
**1.**


- Ultrasonic Sensors (HC-SR04):Used for measuring distances to nearby obstacles.

**2.**

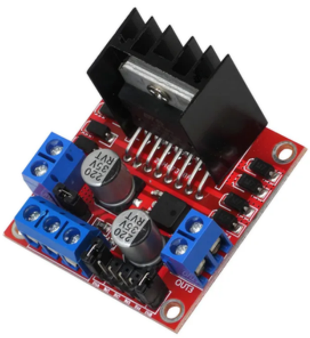
- Servo Motor: Used to dynamically adjust the orientation of the ultrasonic sensors to widen the detection range.

**3.**




Arduino Uno: The microcontroller responsible for processing sensor data, controlling the servo motors, and handling robot navigation.

**4.**



DC Motors and Motor Driver (L298N): These control the movement of the robot based on feedback from the sensors and the control
algorithm.

**5.** 

- Chassis and Wheels: The physical structure that supports all components and enables movement.

**6.** 


• Battery Pack: Powers the robot and its components.

## SOFTWARE:-

**1.** 


Arduino IDE: For programming the Arduino microcontroller and implementing control logic.

**2.** Obstacle Detection and Avoidance Algorithm: The algorithm continuously reads the distance data from the ultrasonic sensors and adjusts the robot's direction and speed accordingly.

**3.** Servo Motor Control: The servo motors adjust the ultrasonic sensors angles between predefined positions to extend the detection range.

## 3.2 CIRCUIT AND PROGRESS

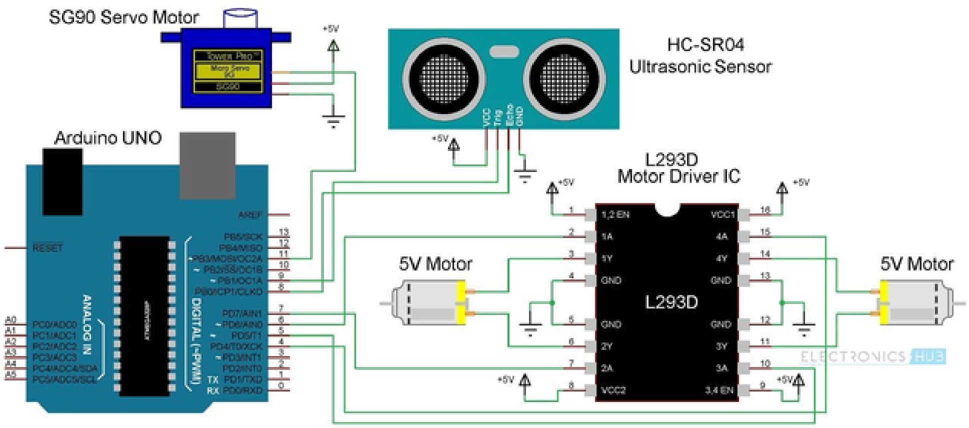



fig 3.1 : The circuit connection autonomous robot used in obstacle detection experiments.

### 3.3.1 Prototype Design

The prototype robot includes an ultrasonic sensors mounted on servo motors, controlled by an Arduino Uno. The sensors scan for obstacles at various angles by rotating the servo motors. The robot's movement is controlled by DC motors, ensuring smooth navigation

### 3.3.2 Simulation and Testing

The robot was tested in multiple environments, including:

• Indoor Testing: In a room filled with obstacles, the robot used its rotating sensors to detect obstacles at different angles, successfully avoiding collisions.

• Outdoor Testing: The robot's performance was also tested outdoors on uneven terrain. The servo motor's ability to rotate sensors allowed the robot to detect obstacles that would otherwise be missed by a fixed sensor.

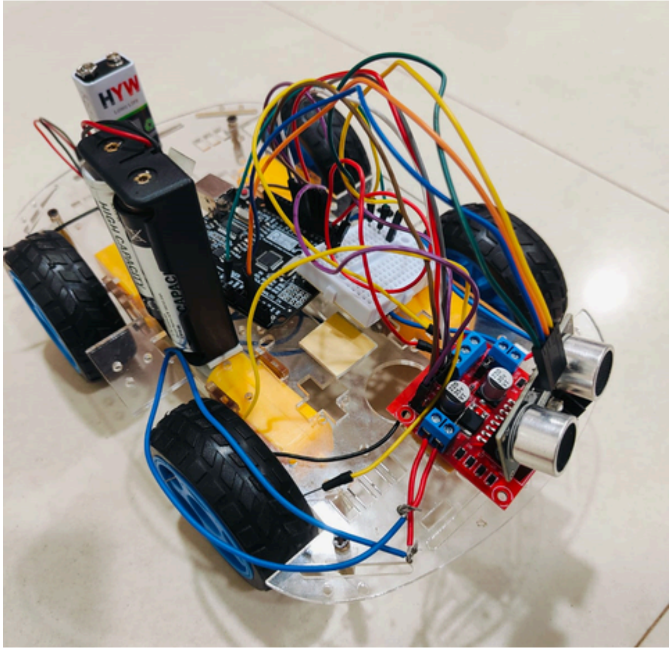



fig 3.2: Prototype

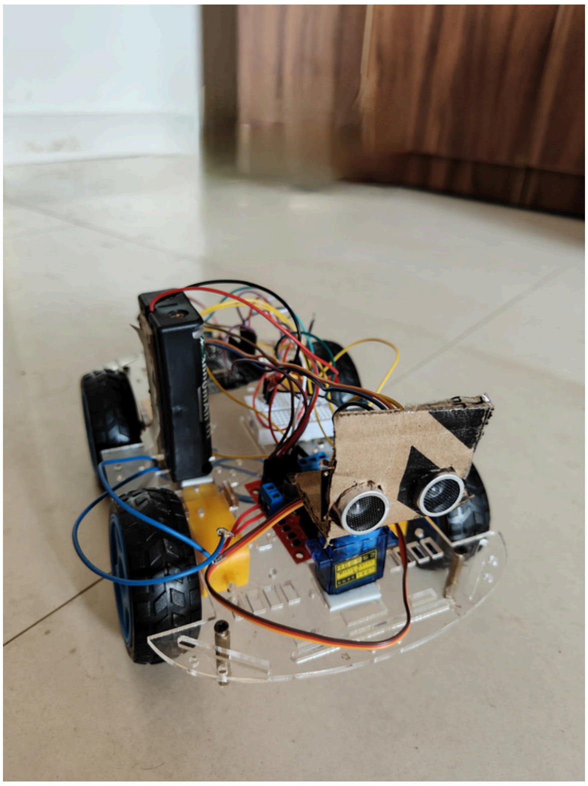


fig 3.3: Final design

# Chapter 4

## RESULTS OBTAINED

The robot was able to detect obstacles with high accuracy and adjust its path dynamically. The servo motors provided a wider detection range, significantly improving the robot’s performance compared to fixed sensor setups. The response time of the system was sufficient for real-time obstacle avoidance, even in cluttered environments

# Chapter 5

## CONCLUSION

The integration of servo motors with ultrasonic sensors has significantly enhanced the obstacle-avoidance capabilities of the robot. By dynamically adjusting the sensor orientation, the robot was able to detect and avoid obstacles more effectively. The proposed system is well-suited for real-time applications in autonomous navigation, particularly in environments where obstacles may not always be directly in front of the robot.

# Chapter 6

## FUTURE SCOPE

Future enhancements to the obstacle-avoiding robot could include:

• Sensor Fusion: Integrating other types of sensors such as infrared or LIDAR to improve detection in different environmental conditions (e.g., fog or bright light).

• Improved Control Algorithms: Implementing more sophisticated path-planning algorithms, such as A* or Dijkstra, to enable more efficient navigation in complex environments.

• Wireless Communication: Adding wireless communication for remote control and monitoring.

• Machine Learning: Incorporating machine learning to allow the robot to learn from its environment and improve obstacle avoidance over time.

# Chapter 7

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