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4WD Obstacle Avoidance Robot using Arduino Uno

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Abstract: This paper describes the development of a four-wheel-drive autonomous obstacle avoidance robot designed using the Arduino Uno platform. The system utilizes an ultrasonic distance sensor mounted on a servo motor to actively scan the surrounding environment and identify obstacles in multiple directions. Based on the measured distances, the robot selects a safe path and navigates autonomously without human intervention. A micro-step motion technique is implemented to achieve slow and controlled movement without employing PWM-based speed control. A regulated power supply using a buck converter ensures stable operation of the controller and sensors. Experimental evaluation in indoor environments demonstrates reliable obstacle detection and effective navigation performance, making the system suitable for educational and research applications.
Keywords: Arduino Uno, Obstacle Avoidance Robot, Ultrasonic Sensor, 4WD Mobile Robot, Embedded Systems.

I. INTRODUCTION

Autonomous mobile robots have gained significant attention in recent years due to their wide range of applications in automation, service robotics, and intelligent systems. One of the essential capabilities of such robots is the ability to sense their surroundings and avoid obstacles in real time. Obstacle avoidance enables safe navigation in unknown or dynamic environments and forms the foundation for advanced robotic behaviors. This project focuses on the design of a low-cost and reliable obstacle avoidance robot using commonly available electronic components. The Arduino Uno microcontroller is selected as the control unit due to its simplicity, flexibility, and ease of programming, making it ideal for academic and prototyping purposes.

II. LITERATURE REVIEW

Several researchers have explored obstacle avoidance techniques using different sensing technologies such as ultrasonic sensors, infrared sensors, and camera-based vision systems. Ultrasonic sensors are widely used in mobile robots because of their low cost, simple interfacing, and acceptable accuracy for short-range detection. Previous studies indicate that robots equipped with fixed ultrasonic sensors often suffer from limited directional awareness. To overcome this limitation, servo-mounted ultrasonic scanning mechanisms have been proposed to increase the sensing field of view while keeping hardware requirements minimal. The reviewed literature suggests that servo-based scanning provides an effective balance between system complexity and navigation performance, which motivates its adoption in this project.

III. PROPOSED SYSTEM

The proposed obstacle avoidance robot consists of three main subsystems: sensing, control, and actuation. The sensing subsystem includes an HC-SR04 ultrasonic sensor mounted on an SG90 servo motor to perform directional scanning of the environment. The control subsystem is built around the Arduino Uno, which processes sensor data and executes navigation decisions. The actuation subsystem comprises an L298N motor driver and four DC geared motors arranged in a four-wheel-drive configuration. The modular design of the system allows easy modification and future expansion.

IV. HARDWARE DESIGN

The hardware architecture is designed to ensure stable electrical operation and mechanical reliability. A three-cell lithium-ion battery pack supplies power to the system, while a buck converter regulates the voltage to provide a steady 5 V supply for the Arduino and sensors. The L298N dual H-bridge motor driver interfaces between the Arduino and the DC motors, enabling bidirectional motor control. The four-wheel-drive chassis improves traction and stability, allowing the robot to navigate smoothly over indoor surfaces.

V. SOFTWARE ALGORITHM

The software algorithm is implemented using the Arduino programming environment. The control logic initializes the sensor and motor interfaces and continuously monitors distance measurements obtained from the ultrasonic sensor. The servo motor rotates the sensor to scan left, center, and right directions. If an obstacle is detected within a predefined safety threshold, the robot halts and selects an alternate direction based on the maximum available clearance. A micro-step movement strategy is employed to limit the forward displacement during each motion cycle, thereby ensuring slow and safe navigation without using PWM speed control.

VI. EXPERIMENTAL RESULTS

The developed robot was tested in various indoor environments containing static obstacles such as walls, chairs, and furniture. The system demonstrated consistent obstacle detection and avoidance behavior during multiple test runs. The effective detection range of the ultrasonic sensor was observed to be between 2 cm and 300 cm, with an average response time of less than 200 milliseconds. The robot achieved an obstacle avoidance accuracy of approximately 95 percent under controlled conditions. Minor limitations were observed in narrow corner scenarios due to the use of a single ultrasonic sensor.

VII. APPLICATIONS

The proposed obstacle avoidance robot can be applied in educational robotics laboratories for teaching embedded systems and control concepts. It can also serve as a basic navigation platform for indoor service robots, surveillance systems, and research prototypes. The system provides a foundation for further development toward more advanced autonomous robotic applications.

VIII. CONCLUSION AND FUTURE SCOPE

This paper presented the design and implementation of a low-cost 4WD obstacle avoidance robot using Arduino Uno and ultrasonic sensing. The system successfully demonstrates autonomous navigation using simple hardware and an efficient control algorithm. Future enhancements may include the addition of side-mounted sensors for improved obstacle detection, wireless communication for remote monitoring, and intelligent decision-making algorithms to support complex navigation tasks.

REFERENCES

[1] Arduino. Arduino Uno Board Documentation
[2] HC-SR04 Ultrasonic Sensor Datasheet.
[3] L298N Dual H-Bridge Motor Driver Datasheet.
[4] TowerPro SG90 Servo Motor Datasheet.
[5] R. Siegwart and I. R. Nourbakhsh, Introduction to Autonomous Mobile Robots, MIT Press.

Experimental Setup and Hardware Prototype

The following figures illustrate the developed 4WD obstacle avoidance robot prototype, including the complete hardware assembly, sensor placement, and power supply arrangement.

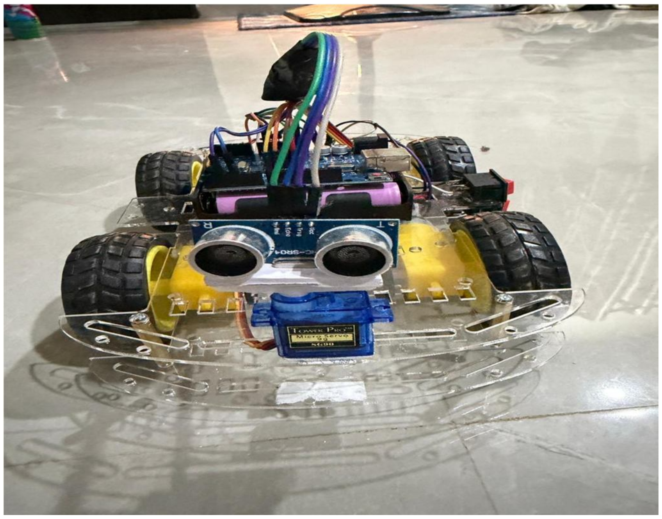

Figure 1: Front view of the 4WD obstacle avoidance robot with ultrasonic sensor

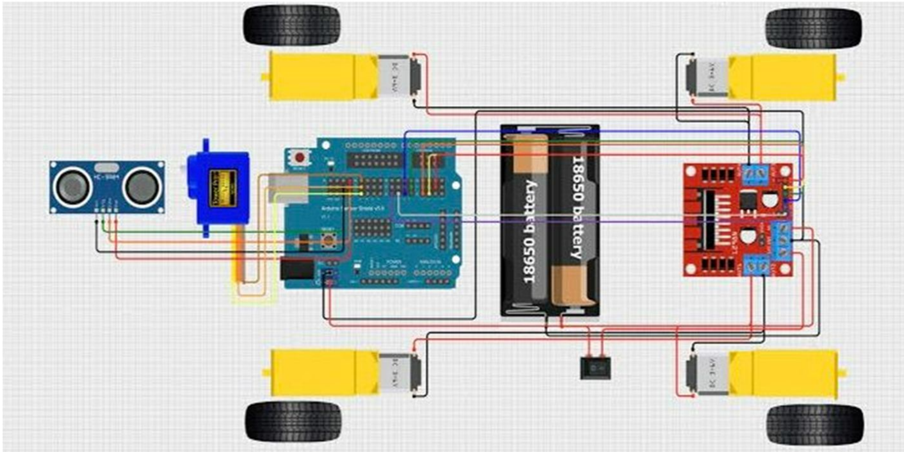

Figure 2: Top view showing Arduino Uno, buck converter, and battery arrangement

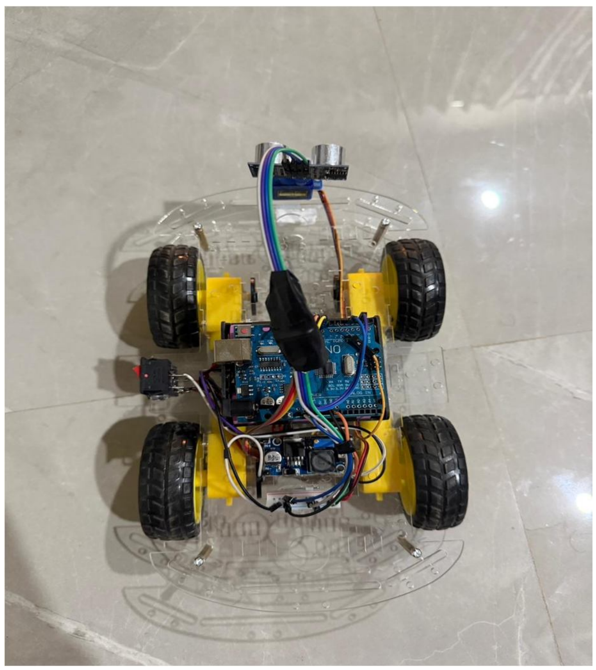
Figure 3: Side view illustrating chassis structure and wheel configuration

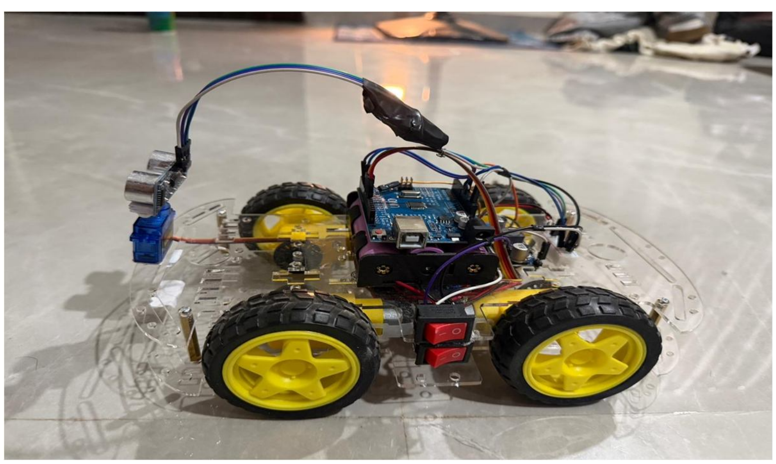
Figure 4: Fully assembled hardware prototype of the obstacle avoidance robot

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Software Control Algorithm (Detailed)

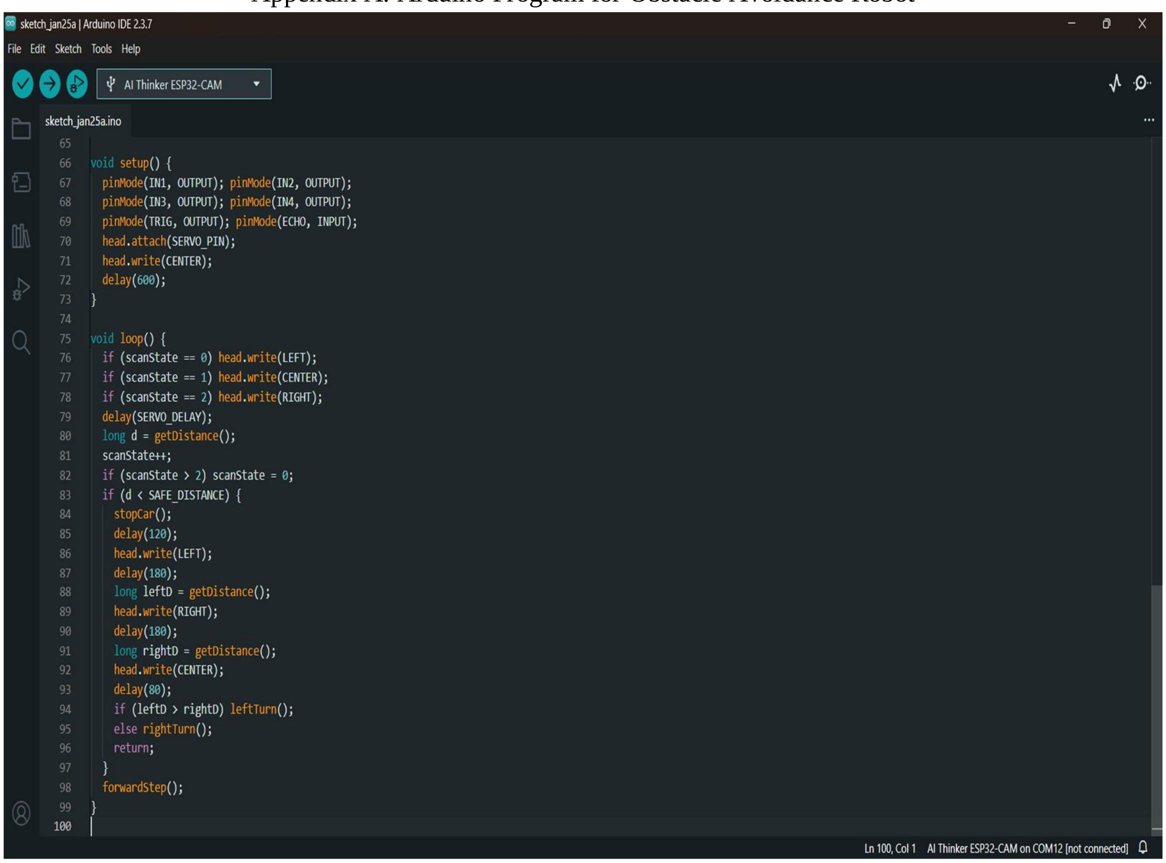
The control algorithm is implemented on the Arduino Uno microcontroller using embedded C. The robot follows a continuous scanning and micro-step motion strategy to achieve slow, safe, and reliable obstacle avoidance without the use of PWM-based speed control. The ultrasonic sensor is mounted on a servo motor that continuously scans the environment in left, center, and right directions. During each scan cycle, distance measurements are obtained and compared with a predefined safety threshold.

If no obstacle is detected, the robot performs a short forward movement using a micro-step technique, where the motors are activated for a brief duration and then stopped. This method effectively reduces the robot's speed while maintaining smooth motion. When an obstacle is detected within the safety distance, the robot immediately stops, scans both left and right directions, and turns toward the direction with greater free space. This process repeats continuously, allowing autonomous navigation in indoor environments.

Algorithm for Obstacle Avoidance

Step 1: Initialize Arduino Uno, ultrasonic sensor, servo motor, and motor driver pins.
Step 2: Rotate the servo motor to scan left, center, and right directions sequentially.
Step 3: Measure the distance to obstacles using the ultrasonic sensor.
Step 4: Compare the measured distance with a predefined safety threshold.
Step 5: If no obstacle is detected, move the robot forward using micro-step motion.
Step 6: If an obstacle is detected, stop the robot immediately.
Step 7: Scan left and right directions to determine a safer path.
Step 8: Turn the robot toward the direction with maximum clearance.
Step 9: Repeat the above steps continuously.

Appendix A: Arduino Program for Obstacle Avoidance Robot



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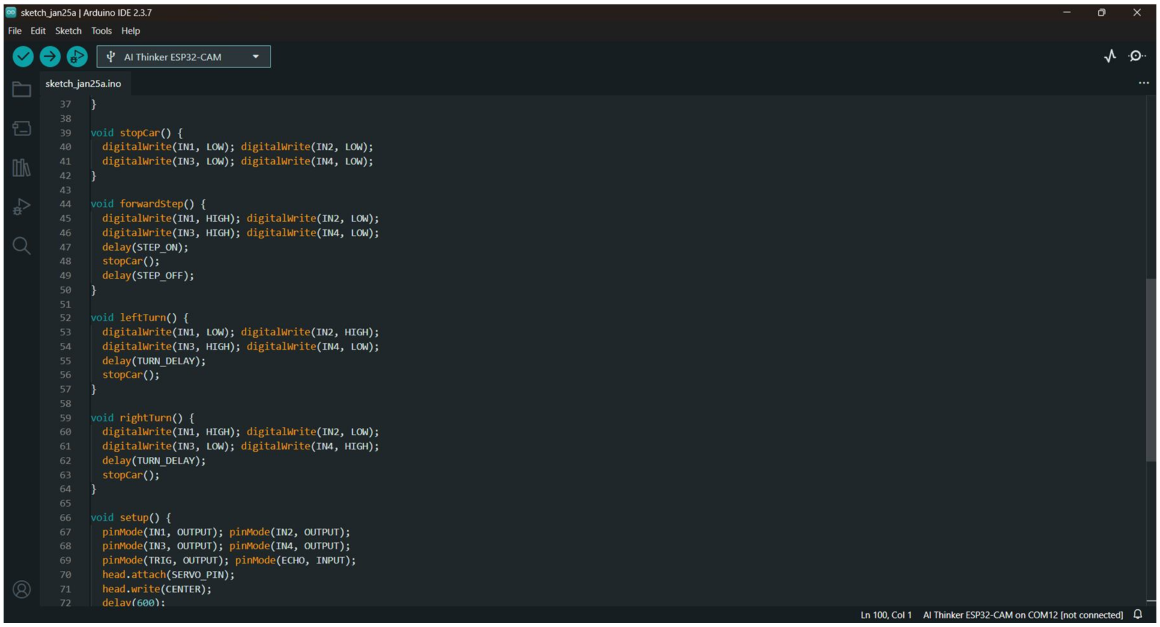

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