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Obstacle Avoidance Robotic Car by Using Single Ultrasonic sensor

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ABSTRACT

Our project centers around creating and practically testing a pathfinding algorithm using a single ultrasonic sensor on a test RC car. The algorithm consists of two phases: normal and intensive detection. This algorithm provides a reliable method for determining an obstacle-free path. The intensive detection method uses a servo motor for a broader field of view, thus creating an omnidirectional composite sensor with just one monodirectional sensor. It reduces the number of potential false positives for the ideal path by a mean-based approach.

Keywords: Arduino UNO, DC Motors, H-W 130 Motor Shield, Servo Motor, Ultrasonic Sensor, Chassis, Jumper wires, Glue gun, Electronic buzzer.

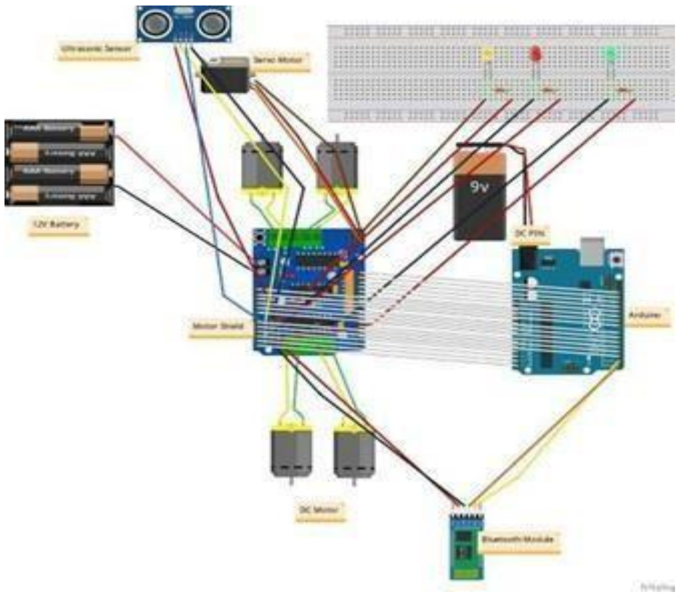
I. INTRODUCTION

In the modern world, pathfinding algorithms have become essential tools in robotics and automation. A significant limitation of commonly used pathfinding algorithms that utilize ultrasonic sensors is their monodirectional nature. These algorithms often rely on simple binary directional decisions, such as left or right, which can be inaccurate. This project aims to enhance these existing algorithms to improve the ability of robots to find paths and avoid obstacles.

The importance of effective pathfinding algorithms is highlighted by their diverse applications, including military operations in inaccessible or dangerous areas and obstacle avoidance systems on extraterrestrial surfaces with an atmosphere.

The primary motivation for this project is to address the limitations of the monodirectional nature of ultrasonic sensors. This limitation can result in false positives, hindering the accurate identification of an ideal path.

While wide-angle methods exist, they often introduce greater expense and complexity. To mitigate these issues, this project introduces a composite sensor design that integrates an ultrasonic sensor with a servo motor.



This innovative sensor is paired with an algorithm designed for omnidirectional pathfinding and obstacle detection.

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Fig. 1. Circuit Diagram

II. EXISTING METHOD

- In recent years, object detection for perception tasks in autonomous vehicles has significantly progressed thanks to immense amount of research using camera sensor datasets.

- Current robotic navigation systems use multiple sensors (ultrasonic, infrared, LiDAR, cameras) for environment mapping and pathfinding, requiring complex data fusion and high computational power.

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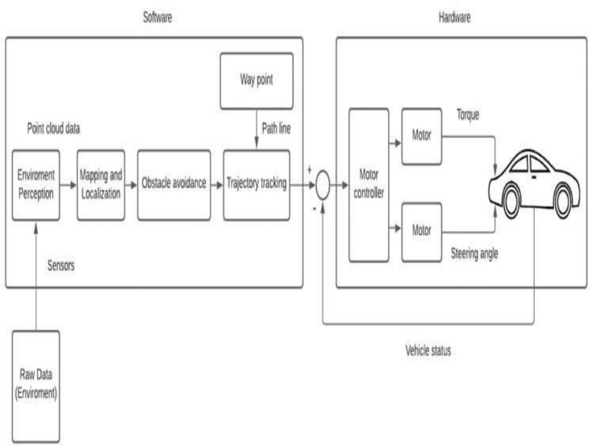
- LiDAR is precise but costly, while camera- based systems need advanced processing.

- Many systems lack adaptability to dynamic environments and are inflexible for low-cost applications, leading to inefficient power use and redundant data collection.

- There is a need for a cost-effective, sensor- efficient, and computationally lightweight pathfinding solution.



(a) Block diagram of control system.

LIMITATIONS OF EXISTING MODEL

1. ***Limited Range and Accuracy:*** Single ultrasonic sensors have limited range and accuracy.

2. ***Multipath Interference:*** Single ultrasonic sensors are susceptible to multipath interference.

3. ***Noise Sensitivity:*** Single ultrasonic sensors can be sensitive to noise.

4. ***Limited Adaptability:*** Existing models lack adaptability to dynamic environments.

5. ***High Computational Complexity:*** Existing models require significant computational power.

6. ***Inflexibility:*** Existing models are inflexible in low- cost robotic applications.

7. ***Power Consumption:*** Existing models consume excess power due to inefficient path correction algorithms.

8. ***Difficulty in Navigation:*** Existing models can have difficulty navigating through complex environments.

III. PROPOSED METHOD

- The proposed system aims to develop a novel omnidirectional pathfinding algorithm for a robotic car using a single ultrasonic sensor.

- This approach effectively addresses the challenge of obstacle detection and navigation while minimizing the need for additional hardware, making it cost-efficient and easy to implement.

- The system is built around an Arduino UNO, which serves as the central controller for the robotic car.

- The car's movement is powered by DC motors, managed through a H-W 130 Motor Shield, while a servo motor is used to rotate the ultrasonic sensor to expand its field of view, enhancing the robot's ability to detect obstacles in multiple directions.

- The system provides omnidirectional movement, real-time obstacle avoidance, and user feedback through an LCD and buzzer, making it suitable for various indoor and outdoor applications.

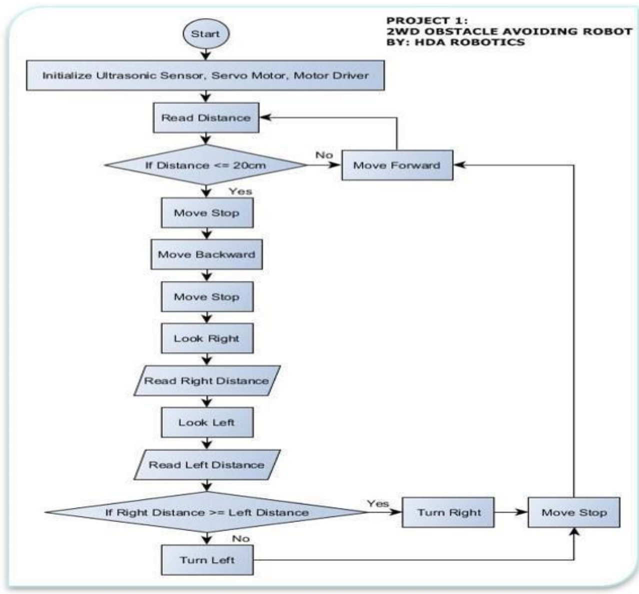


Fig. 3. Proposed Method

WORKING MODEL

- The working model involves connecting the ultrasonic sensor to the Arduino board, which then controls the servo motor, LCD display, and buzzer. The four gear motors with wheels are connected to the Arduino board to control the movement of the robot.

- When an object is detected within the threshold distance, the servo motor rotates to 90 degrees, the LCD display shows "Object is too close!", and the buzzer beeps. Otherwise, the servo motor rotates to 0 degrees, the LCD display shows "Object is at safe distance.", and the buzzer stops.

- This working model demonstrates a basic path-finding algorithm using a single ultrasonic sensor with a servo motor, LCD display, buzzer, and four gear motors with wheels

IV. RESULTS AND DISCUSSION

The implementation of the mean-based omnidirectional pathfinding algorithm demonstrated a functional approach to navigating a robotic car through dynamic environments using a single ultrasonic sensor. The system successfully acquired distance data across 360 degrees by rotating the sensor, enabling the robot to perceive its surroundings in multiple directions. The mean distance calculations for defined sectors, such as forward, left, and right, effectively identified the areas with the most free space. This allowed the robot to prioritize movement towards those sectors, achieving a basic form of obstacle avoidance. The 16x2 LCD display provided real-time feedback, showing sensor readings and the robot's decisions, which proved invaluable for debugging and visualizing the algorithm's behaviour.

The algorithm's performance was notably influenced by the sensor's accuracy and the sector definition. In open environments with minimal obstacles, the robot navigated smoothly, consistently choosing the path with the largest mean distance. However, in cluttered environments with narrow passages, the algorithm exhibited limitations. The single sensor's field of view occasionally resulted in blind spots, leading to delayed reactions or incorrect path selections. Furthermore, the fixed sector sizes sometimes failed to accurately represent the available space, particularly when obstacles were located at sector boundaries.

The mean-based approach, while simple to implement, showed a degree of robustness against sensor noise due to the averaging process. This reduced the impact of occasional erroneous readings, improving the robot's overall stability. However, the algorithm's reliance on mean values also limited its ability to react to sudden changes in the environment.

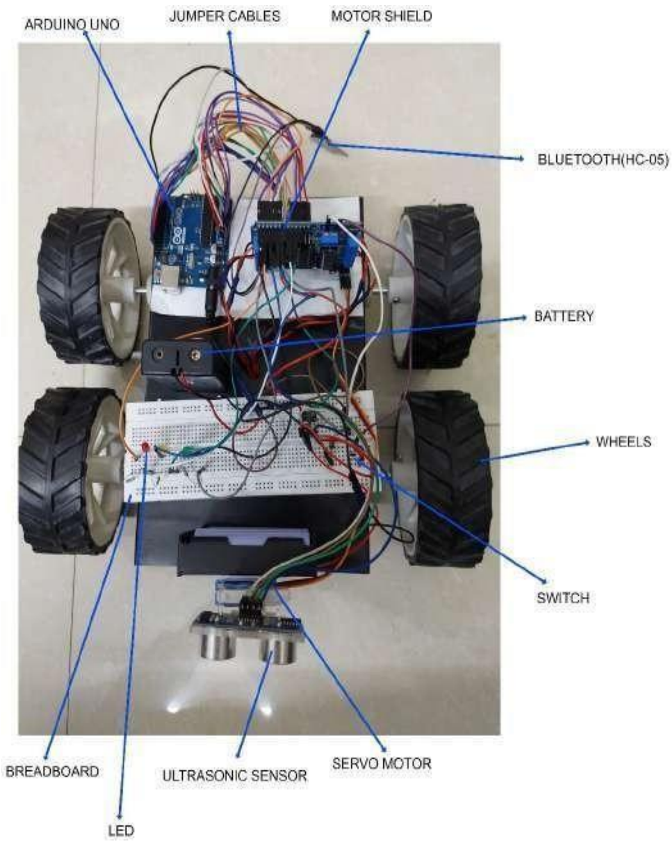


Fig. 4. Final Model

V. CONCLUSION

Considering all the aforementioned points, we have practically tested and demonstrated better pathfinding and obstacle- avoiding algorithms on a test model car. This algorithm can detect and find its path with a higher level of precision, as tested practically. The dual-phase nature of the algorithm allows for a low power consumption implementation while still providing an accurate and reliable ideal path. It can be used in military applications, research endeavors, and places where human interference may be dangerous.

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