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Design and Implementation of a Non-Blocking Line Following and Obstacle Avoiding Robot Using Arduino

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Abstract: This paper presents the design and implementation of an autonomous robot capable of performing both line following and obstacle avoidance using an Arduino microcontroller. The system integrates infrared (IR) sensors for path detection and an ultrasonic sensor for obstacle detection. A non-blocking control strategy based on time tracking is employed to ensure continuous sensing and real-time responsiveness. Additionally, sensor noise is minimized using filtering techniques, improving operational stability. The robot prioritizes obstacle avoidance over line tracking, enabling safe navigation in dynamic environments. Experimental results demonstrate improved responsiveness and reliability compared to conventional delay-based systems.
Keywords: Arduino, Line Following Robot, Obstacle Avoidance, Non-blocking Control, Sensor Filtering, Embedded Systems.

I. INTRODUCTION

Autonomous mobile robots are widely used in industrial automation, logistics, and smart transportation systems. Line-following robots serve as a fundamental platform for studying navigation and control in embedded systems. However, basic line-following robots lack the capability to handle unexpected obstacles, limiting their real-world applicability. To overcome this limitation, obstacle avoidance mechanisms must be integrated into the system. Traditional implementations often rely on blocking delay functions, which reduce responsiveness and prevent continuous sensor monitoring. This paper proposes an improved system that combines line following and obstacle avoidance using a non-blocking control mechanism. A state-based approach is used to manage robot behavior efficiently, while sensor filtering techniques enhance accuracy and stability. The proposed system provides a reliable and responsive solution for autonomous navigation in structured environments.

II. MATERIALS AND METHODS

A. Hardware Components

Arduino UNO microcontroller
L298N motor driver module
Two IR sensors for line detection
HC-SR04 ultrasonic sensor for obstacle detection
DC motors with robotic chassis
Power supply unit

B. Software Tools

Arduino IDE, Embedded C/C++ programming

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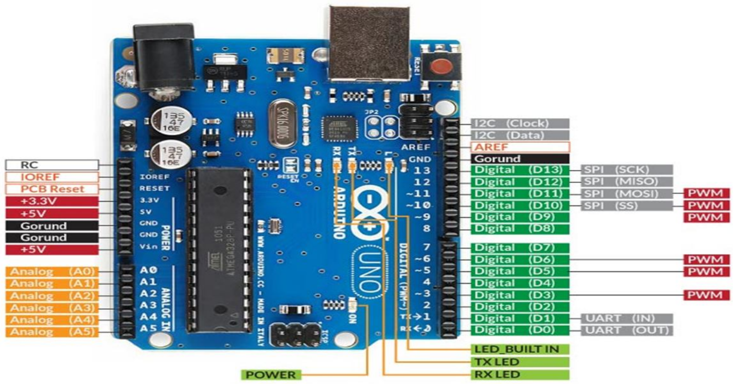

Fig.1.Arduino UNO

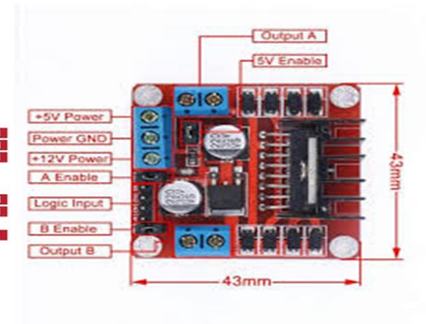

Fig.2. Motor Drive

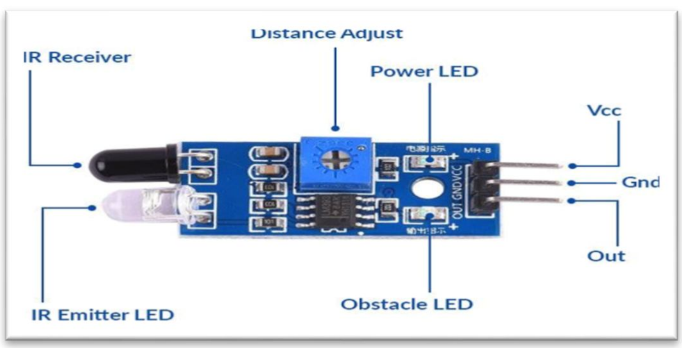

Fig.3. IR Sensor

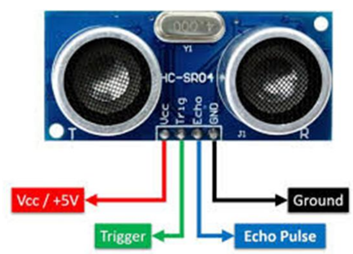

Fig.4. Ultra Sonic Sensor

C. System Methodology

The robot operates using a state-machine approach that enables dynamic switching between line-following and obstacle-avoidance modes. Initially, the system continuously measures the distance using an ultrasonic sensor. The measured values are filtered by averaging multiple readings to reduce noise and improve accuracy.

When an obstacle is detected within a predefined threshold distance of 20 cm, the robot temporarily halts its line-following operation and transitions into obstacle avoidance mode. In this mode, the robot stops, moves backward for a short duration, and then turns right to avoid collision. These actions are executed using a non-blocking timing mechanism based on time difference calculations, allowing the robot to continue sensing during execution.

In the absence of obstacles, the robot operates in line-following mode. The IR sensors detect the presence of a line, and the robot adjusts its movement accordingly. A majority-based filtering method is used to stabilize sensor readings and minimize false detections. Based on sensor inputs, the robot moves forward, turns left or right, or stops if no line is detected.

The system is implemented using modular programming, where separate functions are defined for sensing, decision-making, and motor control. This structure improves code readability and scalability.

D. Sensor Processing

1) Ultrasonic Sensor Filtering

To improve accuracy, multiple readings are averaged:

```
for (int i = 0; i < samples; i++) {
  total += getDistanceRaw();
}
```

Additionally: Timeout is added to avoid hanging.

Invalid readings are handled safely

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2) IR Sensor Noise Handling

A majority-voting method is used:

if (count >= 3) return LOW; This reduces: Signal noise False detections Erratic movement

III. ALGORITHM

Initialize system components
Continuously measure distance using ultrasonic sensor
Apply filtering to distance readings
If distance < 20 cm : Stop robot Move backward for a fixed duration Turn right **Else :** Read IR sensor values Apply noise filtering Move according to line-following logic Repeat the process continuously

TABLE 1: Algorithm

IV. RESULTS AND DISCUSSION

A. Observations

The robot successfully follows a predefined path while detecting and avoiding obstacles in real time. The use of non-blocking timing ensures continuous sensor monitoring, resulting in improved responsiveness. Sensor filtering reduces noise, leading to smoother and more stable movement.

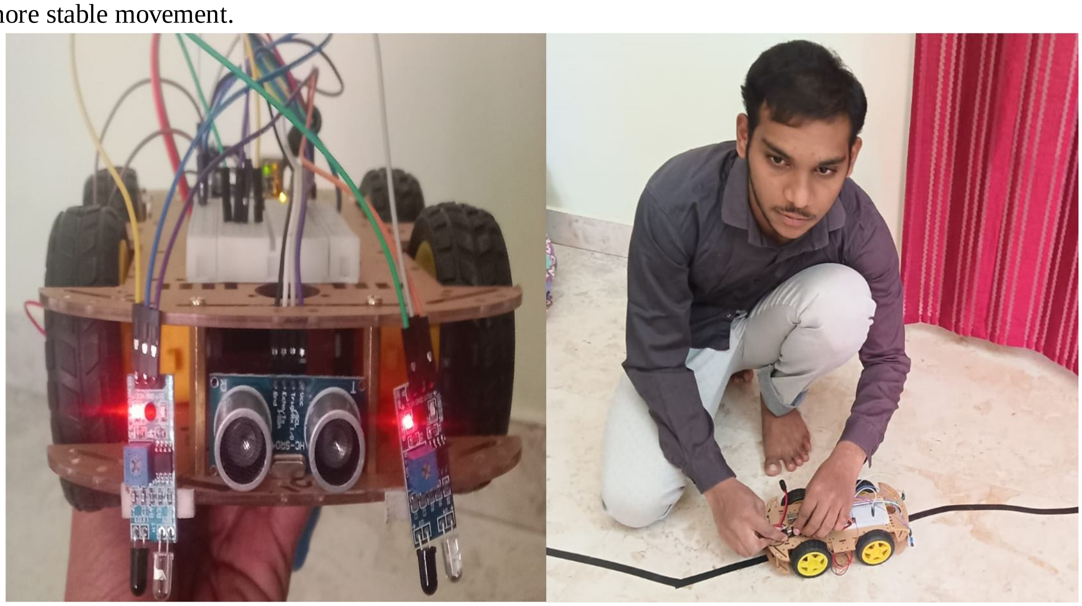

Fig. 5. Robot front view

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B. Performance Analysis

Parameter	Proposed System	Control Method
Control Method	Delay-based	Non-blocking
Responsiveness	Moderate	High
High Sensor Stability	Low	Improved
Real-time Operation	Limited	Efficient

TABLE 2: Performance Analysis

C. Discussion

The proposed system demonstrates significant improvement over traditional implementations. The non-blocking control mechanism allows the robot to remain responsive during all operations, while filtering techniques enhance sensor reliability. However, the system still uses fixed timing for turning, which may limit adaptability in complex environments.

V. CONCLUSION

This paper presents an efficient and reliable implementation of a line-following and obstacle-avoiding robot using Arduino. The integration of non-blocking control, state-based logic, and sensor filtering significantly improves system performance. The robot demonstrates stable operation and real-time responsiveness, making it suitable for educational and practical applications. Future enhancements can future improve adaptability and intelligence.

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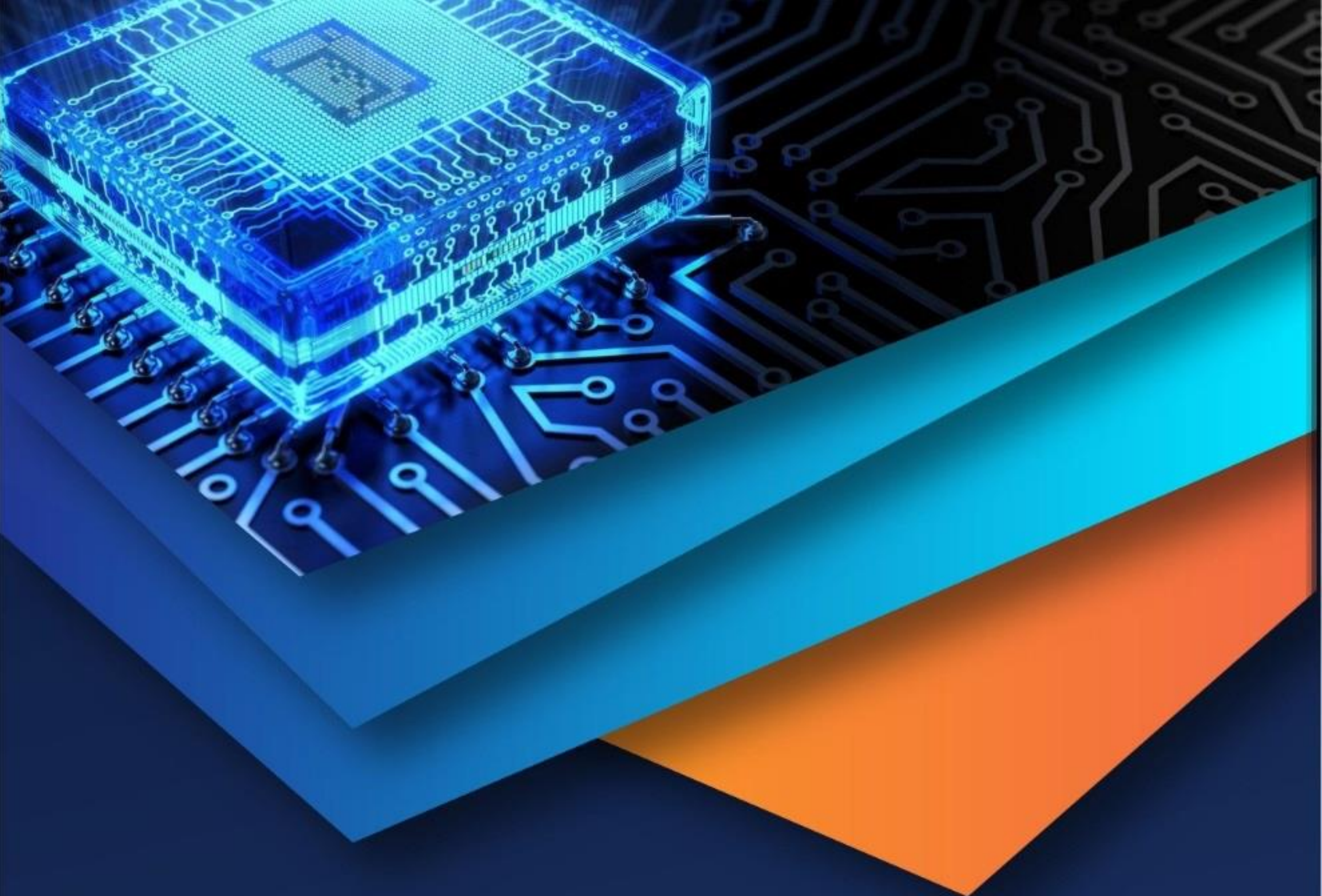

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