VEHICLE -TO-VEHICLE COMMUNICATION COLLISION AVOIDANCE

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Abstract. Road accidents remain a major concern, largely due to delayed driver reactions, poor visibility, and the absence of real-time awareness about nearby vehicles. To address this issue, this paper proposes a simple and cost-effective Vehicle-to-Vehicle (V2V) collision avoidance system using Arduino, ultrasonic sensors, and RF communication modules. The system continuously monitors the distance between vehicles and compares it with a predefined safety threshold to detect potentially dangerous situations. When vehicles come too close, a warning signal is wirelessly transmitted to nearby vehicles, and immediate alerts are generated through a buzzer and LED to notify the driver. The system operates in real time without relying on external infrastructure, making it suitable for low-cost and prototype-level applications. Experimental results indicate that it performs reliably in short-range conditions, although limitations such as restricted communication range and lack of predictive capability are observed.

Keywords: V2V Communication, Collision Avoidance, Arduino, Ultrasonic Sensor, Embedded Systems, Road Safety.

1 Introduction

Road safety has become a growing concern as the number of vehicles on the road continues to increase, leading to a higher risk of accidents. Many of these accidents occur not because of mechanical failure, but due to human factors such as delayed reaction, distraction, or poor visibility in conditions like fog or heavy traffic. Traditional safety measures mainly depend on the driver's ability to notice and respond to danger, which is not always reliable in critical situations. To improve this, there is a need for systems that can assist drivers by providing timely information and warnings. Vehicle-to-Vehicle (V2V) communication is one such approach, where vehicles can share important data with each other in real time to enhance awareness and reduce collision risks. In this context, the proposed system focuses on developing a simple and low-cost solution that combines distance sensing and wireless communication to help drivers react faster and avoid potential accidents.

2 Literature Survey

Existing research on collision avoidance systems shows that different approaches have been explored to improve vehicle safety, but each comes with its own limitations. Early systems mainly relied on sensors such as ultrasonic and infrared to detect nearby obstacles, which are simple and cost-effective but only work for short-range detection and do not support communication between vehicles. More advanced solutions use technologies like radar, LiDAR, and Advanced Driver Assistance Systems (ADAS), offering better accuracy and automation, but they are expensive and complex. Communication-based approaches, including DSRC and IoT-based systems, enable real-time data sharing between vehicles, but they often depend on network infrastructure and may introduce delays. Some recent studies also explore machine learning for predicting collisions, but these require high computational power and large datasets. Overall, most existing systems either focus on sensing or communication rather than combining both in a simple and affordable way, highlighting the need for a balanced solution that is low-cost, reliable, and capable of real-time operation.

3 Proposed System

Conventional vehicle safety systems mainly depend on the driver's awareness and reaction, which can often be delayed due to factors such as distraction, fatigue, or poor visibility. This limitation increases the risk of accidents, especially in dynamic traffic conditions where quick decision-making is critical. To address these challenges, the proposed system introduces a Vehicle-to-Vehicle (V2V) collision avoidance solution that enables real-time communication between vehicles using a low-cost embedded platform. The system integrates ultrasonic sensors for distance measurement and RF communication modules for wireless data exchange, allowing vehicles to share proximity information instantly. When a potential collision is detected, warning signals are transmitted to nearby vehicles and immediate alerts are generated through audio and visual indicators. The system operates continuously and does not rely on external infrastructure, making it suitable for cost-effective deployment and prototype applications. By providing timely warnings and enhancing driver awareness, the system helps reduce reaction time and improve overall road safety.

V2V Collision Avoidance Algorithm (Sensor, Communication & Alert System)

1. **Step 1**: The system is powered ON, and the Arduino initializes all components (ultrasonic sensor, HC-12 module, buzzer, and LED).
2. **Step 2**: The ultrasonic sensor continuously sends trigger pulses and receives echo signals to measure the distance between vehicles.
3. **Step 3:** The Arduino calculates the distance using the time delay between transmitted and received signals.

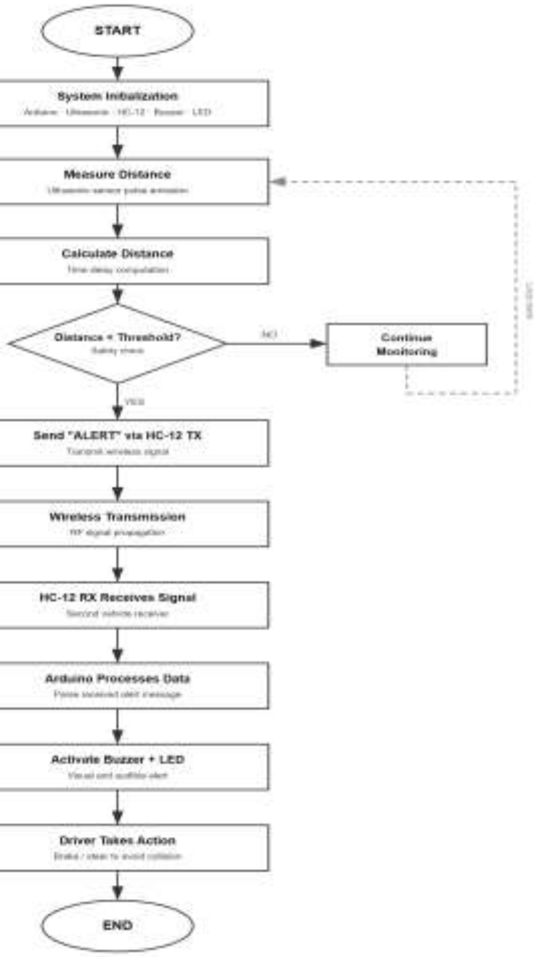

Fig. 1. *System Flowchart*

4.Step 4: The calculated distance is compared with a predefined safety threshold.

5.Step 5: If the distance is greater than the threshold, the system considers the situation safe and continues monitoring.

6.Step 6: If the distance is less than or equal to the threshold, the system identifies a potential collision risk.

7.Step 7: A warning message (e.g., "ALERT") is transmitted wirelessly using the HC-12 module.

8.Step 8: The receiving vehicle's HC-12 module captures the signal and forwards it to the Arduino.

9.Step 9: The Arduino processes the received data and activates alerts:

1. Buzzer produces an audible warning
2. LED provides a visual indication

10.Step 10: The driver receives the alert and takes necessary action (slow down, brake, or change direction).

11.Step 11: The system continues operating in a loop, ensuring real-time monitoring and communication.

4 System Methodology

The proposed system follows a real-time, embedded approach to enable Vehicle-to-Vehicle (V2V) collision avoidance by combining distance sensing, decision-making, and wireless communication. Unlike traditional systems that rely solely on driver awareness, this system continuously monitors the distance between vehicles and automatically generates warnings when unsafe conditions are detected. The methodology focuses on integrating sensing, processing, communication, and alert mechanisms into a unified workflow.

The system operates in multiple stages, including distance measurement, data processing, condition evaluation, wireless communication, and alert generation. Each stage works in coordination to ensure timely detection of potential collisions and immediate response. The architecture is designed to function continuously in a loop, allowing real-time monitoring and rapid decision-making without external infrastructure.

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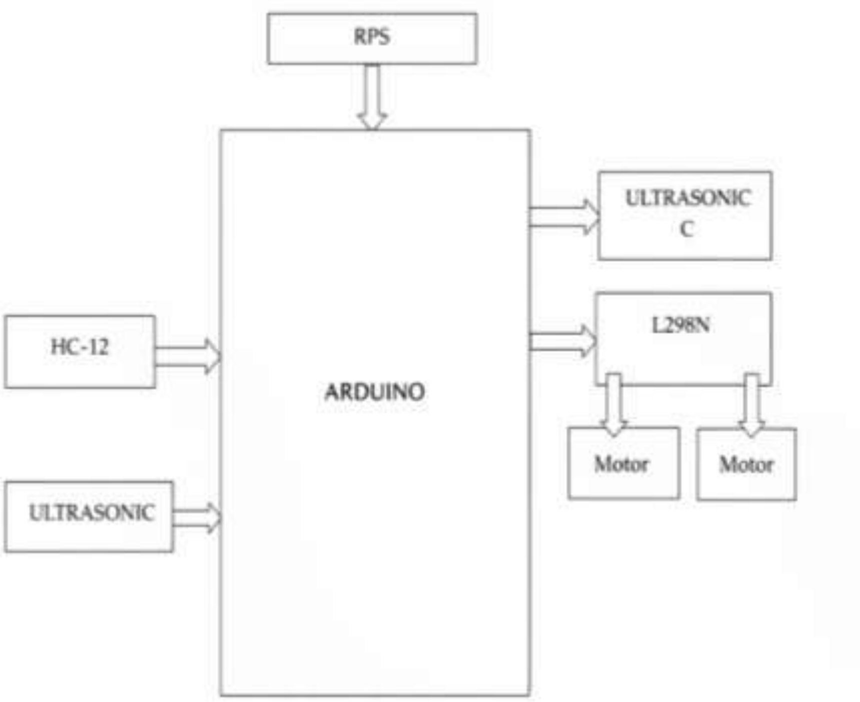

Fig.2. *System Architecture*

4.1 Input Layers (Sensing Unit)

Ultrasonic sensors measure the distance between vehicles using echo-based detection and provide continuous real-time data to the system.

4.2 Data Processing and Decision Making

The Arduino processes sensor data and compares it with a safety threshold to determine whether the situation is safe or requires action.

4.3 Communication Module

The HC-12 module enables wireless communication by transmitting and receiving warning signals between vehicles.

4.4 Output and Alert System

The Alerts are generated using a buzzer and LED to notify the driver. The motor driver is used in the prototype to simulate vehicle movement.

4.5 Architectural Strength

The system is low-cost, simple, and operates in real time, making it suitable for prototype and educational applications.

5 Results and Discussions

The experimental results demonstrate that the proposed Vehicle-to-Vehicle (V2V) collision avoidance system performs effectively in terms of distance detection, communication response, and alert generation. The system was tested under different distance conditions using two prototype vehicles equipped with ultrasonic sensors, Arduino controllers, and HC-12 communication modules. It was observed that the system continuously monitors the distance between vehicles and accurately identifies safe and unsafe conditions based on a predefined threshold.

The ultrasonic sensor provided stable and reliable distance measurements within the range of short-distance operation. The system showed consistent performance when vehicles were aligned properly, with slight variations observed at different angles or surface conditions. The integration of sensing, processing, and communication ensures smooth operation and timely detection of potential collision scenarios.

Table 1. *Distance Detection and Alert Response*

Distance Range	**Example Condition**	**Alert Status**
> 100 cm	Safe distance	No alert
50 – 100 cm	Moderate range	Monitoring
20 – 50 cm	Close proximity	LED ON
< 20 cm	Critical zone	LED + Buzzer ON
Distance Range	Example Condition	Alert Status
> 100 cm	Safe distance	No alert

This table shows how the system responds based on the distance between vehicles. When the distance is greater than 100 cm, the situation is considered safe and no alert is generated. As the distance reduces to the range of 50–100 cm, the system continues monitoring without triggering any warning. When the distance falls between 20–50 cm, it indicates close proximity, and a visual alert (LED) is activated. If the distance becomes less than 20 cm, the situation is critical, and both LED and buzzer are triggered to provide immediate warning to the driver.

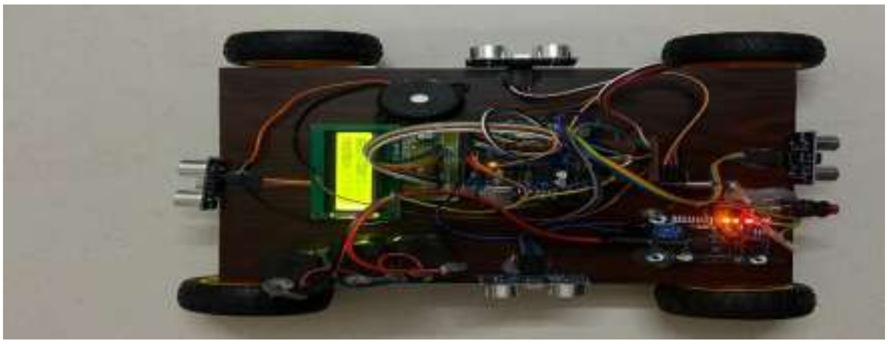

Fig.3 *Distance Measurement Display for Red Vehicle*

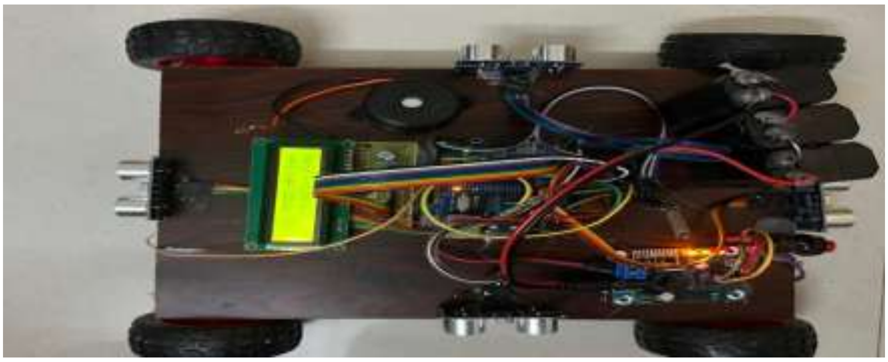

Fig.4 *Distance Measurement Display for Yellow Vehicle*

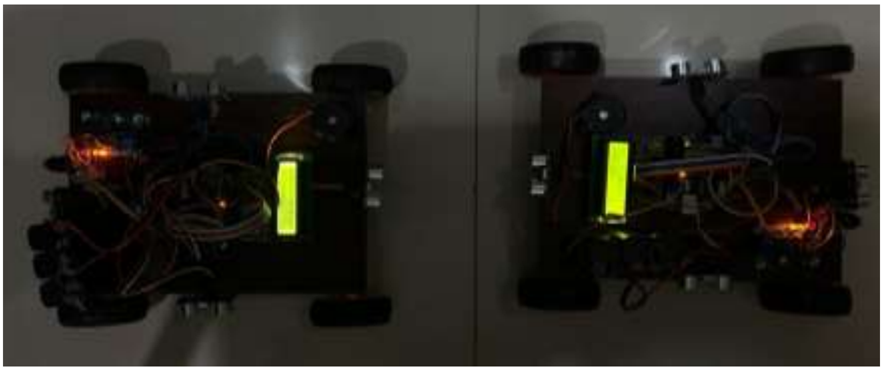

Fig.5 *Collision Warning During Vehicle-to-Vehicle Approach*

The overall results indicate that the proposed Vehicle-to-Vehicle (V2V) collision avoidance system performs reliably in detecting short-range obstacles and generating timely warnings. The ultrasonic sensors provided consistent distance measurements, and the Arduino processed this data efficiently to identify safe and unsafe conditions. The HC-12 communication module successfully transmitted alert signals between vehicles with minimal delay, ensuring that both vehicles received warnings in near real time. The alert system, including the buzzer and LED, responded instantly when critical conditions were detected, improving driver awareness.

However, the system has certain limitations. Its performance is best in short-range and low-speed conditions, and accuracy may decrease with angled surfaces or environmental factors. The communication range is limited in indoor testing, and the system does not consider parameters such as vehicle speed or predictive analysis. Despite these constraints, the system effectively demonstrates the core concept of V2V communication and provides a simple, low-cost solution for enhancing collision awareness in prototype-level applications.

5 Conclusion

This project presents a simple and cost-effective Vehicle-to-Vehicle (V2V) collision avoidance system that helps improve road safety by reducing complete dependence on driver awareness. The system continuously measures the distance between vehicles using ultrasonic sensors and processes this data through an Arduino microcontroller to detect unsafe conditions. When vehicles come too close, a warning signal is transmitted using the HC-12 module, and alerts are generated through a buzzer and LED to notify the driver in real time. The results show that the system works reliably in short-range conditions, providing consistent distance detection, quick communication between vehicles, and immediate alert response without requiring any external infrastructure. Although the system has some limitations, such as limited communication range and lack of predictive capabilities, it effectively demonstrates the concept of V2V communication using a low-cost embedded approach and provides a strong foundation for future improvements in intelligent transportation systems.

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