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Advanced Collision Prevention and Iot- Based Vehicle Safety System

Assistant Professor Rajani Veluvolu, Shaik Shareef, Nidamanuri Prasad, Upputuri Phanindra Kumar, Uppala Hemanth, Shaik Jony Basha
B.Tech Student Department of ECE KKR&KSR Institute of Technology and Sciences
Guntur, Andhra Pradesh, India

Abstract- This project introduces an Accident-Avoidance System based on Arduino Uno, utilizing Ultrasonic Sensors and Long-Range Distance Measurement Sensors for collision prevention. When the long-range sensor identifies an obstacle within a set distance, the system reduces the engine speed via PWM control using an L298N motor driver and triggers a buzzer alert. If an obstacle is detected within a critical range by the ultrasonic sensor, the system halts the engine completely and activates a continuous buzzer warning. Moreover, real-time system status updates, including obstacle detection and motor control actions, are displayed on a 16x2 LCD module and transmitted to the ThingSpeak IoT cloud through a NodeMCU ESP8266 for remote monitoring. This system can be effectively implemented in autonomous vehicles, industrial automation, and safety-critical transportation applications.

Index Terms- Real-Time Monitoring, Vehicle Safety System, Collision Prevention,PWM Control.

I. INTRODUCTION

Road accidents remain one of the most pressing global public health challenges, accounting for approximately 1.35 million deaths annually, according to the World Health Organization (WHO), with an additional 20–50 million people sustaining non-fatal injuries. These incidents disproportionately affect low- and middle- income countries, where inadequate infrastructure, lax safety regulations, and limited access to advanced vehicular technologies exacerbate the risks.

While traditional safety mechanisms—such as airbags, crumple zones, and seatbelts—have significantly reduced fatalities post-collision, they do little to address the root cause: preventing accidents before they occur.

Human error—including distracted driving (e.g., smartphone use), fatigue, or impaired judgment— contributes to over 90% of accidents. This underscores the urgent need for systems that augment or override human decision-making in critical scenarios.

Advanced Driver-Assistance Systems (ADAS), sensor-based obstacle detection, and IoT-enabled real-time monitoring have emerged as effective solutions to improve road safety. By leveraging ultrasonic sensors, long-range distance sensors, and IoT-based communication, vehicles can detect obstacles, control their speed, and take preventive actions in real time.

This project aims to design and implement an advanced collision prevention and IoT-based vehicle safety system that enhances road safety through automated braking, real- time monitoring, and cloud-based data analysis.

II. LITERATURE REVIEW

Smith et al. (2021) conducted a study on real- time vehicle safety monitoring using IoT. They observed that traditional vehicle security systems such as alarms and immobilizers are insufficient against modern theft techniques. To address this, their work proposed the use of IoT devices like GPS, accelerometers, and gyroscopes for continuous monitoring and anomaly detection. The methodology involved integrating various sensors with communication protocols like GSM, LTE, and Wi-Fi to transmit real-time data. Their system enabled proactive theft prevention and offered additional benefits like preventive maintenance and insurance telematics. However, the authors also noted challenges including privacy concerns, data security, and high system integration complexity.

Johnson and Lee (2020) proposed an integrated approach to vehicle collision avoidance using ultrasonic and radar sensors. They found that while ultrasonic sensors are suitable for close-range detection, radar sensors perform better at longer distances and in adverse weather conditions. By combining these sensors, their system achieved improved accuracy and obstacle detection reliability. Their methodology involved placing sensors around the vehicle and using data fusion

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algorithms like Kalman filters for enhanced performance. Although effective, the system posed challenges such as increased cost and complexity in sensor integration.

Garcia and Patel (2022) further supported Johnson and Lee's findings, emphasizing the usefulness of ultrasonic sensors in low-speed applications like parking and radar sensors for detecting distant threats. Their observations confirmed that sensor fusion significantly reduces false positives and improves overall system robustness. The methodology included simulation-based testing in various real-world scenarios. Despite the benefits, they also highlighted challenges including system calibration and environmental sensitivity.

Smith et al. (2020) studied the role of LiDAR in autonomous vehicle collision avoidance systems. They observed that LiDAR provides high-resolution 3D maps of the surroundings, allowing better object detection and classification than traditional sensors. Their system processed point cloud data in real-time to determine distances, shapes, and potential obstacles. However, the researchers noted that the high cost and sensitivity to environmental conditions were major limitations of LiDAR.

Chen et al. (2023) explored the integration of IoT technologies with autonomous vehicles to improve safety. Their study demonstrated that IoT connectivity enhances the vehicle's ability to process external data like traffic and weather conditions. The methodology involved integrating IoT-based communication modules (V2X) and cloud platforms to allow real-time decision-making. They concluded that such integration improves responsiveness and safety but also introduces issues related to data reliability, security, and infrastructure dependency.

Nguyen et al. (2020) focused on Vehicle-to- Vehicle (V2V) communication systems and their impact on collision avoidance. They observed that real-time sharing of vehicle status information greatly improves situational awareness and reduces the risk of collisions. Their methodology involved simulating traffic scenarios to test communication latency and system reliability. Despite their positive findings, concerns regarding data integrity and system delays were also highlighted.

Choudhury et al. (2021) investigated the use of computer vision in obstacle and pedestrian detection. They found that image processing techniques could identify objects in real time, making them a valuable supplement to traditional sensors. Their experiments showed promising results, but also revealed performance degradation under poor lighting and high computational demands.

Lee et al. (2021) analyzed the combination of IoT and artificial intelligence (AI) for intelligent collision prevention. Their system used real-time sensor data with AI algorithms to predict and respond to potential hazards. While the system improved decision-making speed and accuracy, it required continuous data input and significant effort to train the AI models effectively.

Sinha et al. (2020) reviewed hybrid sensor systems for collision avoidance. They concluded that combining radar, ultrasonic, and vision-based sensors leads to more reliable obstacle detection across different driving environments. Their proposed architecture showed improved detection rates but increased cost and design complexity.

Brown et al. (2020) evaluated driver assistance systems such as adaptive cruise control and lane-keeping assist. Their analysis found that such systems significantly enhance driver awareness and reduce accidents caused by human error. However, the effectiveness heavily depends on driver engagement and system reliability.

Verma et al. (2021) incorporated real-time traffic and weather data into vehicle safety systems. They demonstrated that contextual awareness improved the vehicle's ability to avoid hazards by adapting behavior based on external conditions. Nevertheless, they identified challenges in collecting accurate data and integrating it into real-time operations.

III. METHODOLOGY

The Advanced Collision Prevention and IoT-Based Vehicle Safety System is illustrated in Figure 1, and its working procedure is outlined in Algorithm 1.

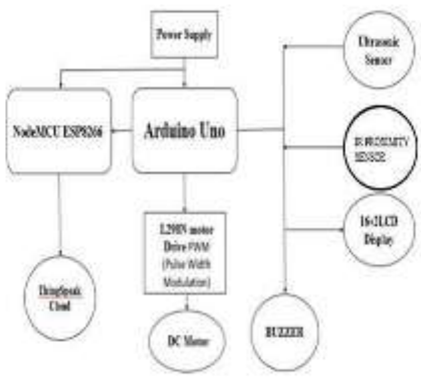

Fig.1 Block Diagram of Advanced Collision Prevention and IOT-Basedvehiclesafety System

Hardware Components
Ultrasonic Sensor (HC-SR04): Detects obstacles by emitting ultrasonic waves and calculating echo time; used for accurate distance measurement.

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Fig.2. Ultrasonic Sensor

IR Proximity Sensor: Senses nearby objects using reflected infrared light; enhances close-range obstacle detection.

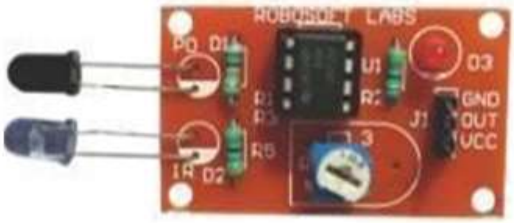


Fig.3. IR proximity Sensor

Arduino UNO: Serves as the central processing unit; reads sensor inputs and controls outputs like motor, buzzer, and display.

Fig.4. Arduino UNO

L298N Motor Driver: Controls motor speed and direction using PWM signals; receives commands from the microcontroller.


Fig.5. L298N Motor Driver

DC Motor: Simulates vehicle movement based on control signals; adjusts speed or stops depending on detected obstacles.


Fig.6. DC Motor

16x2 LCD Display: Displays real-time data such as obstacle distance and system alerts; keeps the driver visually informed.

Fig.7. 16x2 LCD Display

Buzzer: Produces an audible alert when an obstacle is detected; warns the driver of potential hazards.

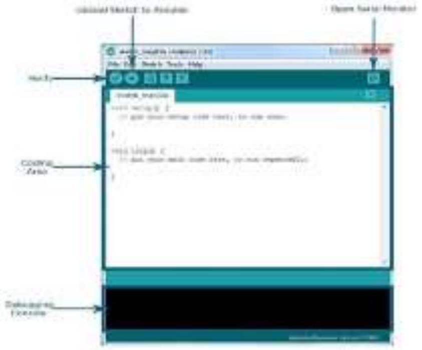

Fig.8. Buzzer

NodeMCU ESP8266: Enables Wi-Fi-based IoT connectivity; transmits data to the ThingSpeak cloud for remote monitoring.


Fig.9.NodeMCU ESP8266

Software Components
Arduino IDE: Used to write, compile, and upload embedded code to microcontrollers; provides a simple interface for system development and debugging.

Embedded C/C++: Programming language used for logic implementation; handles sensor data processing, control actions, and communication.
Thing Speak IOT Platform: Cloud-based platform for IOT data visualization; receives real-time system data for monitoring and analysis.
Wi-Fi Communication Protocols: Enable wireless data transmission between the system and the cloud; ensure seamless remote connectivity and updates.
Serial Monitor (Arduino IDE Tool): Displays real-time sensor readings and debugging info; helps in verifying system behavior during development.



Algorithm 1
Step-1: Start the system and initialize all modules.
Step-2: Continuously monitor the area around the vehicle.
Step-3: Measure the distance to the nearest obstacle.
Step-4: If the path is clear, allow the vehicle to move normally.
Step-5: If an obstacle is detected within a warning range, reduce the vehicle's speed and alert the driver.
Step-6: If an obstacle is too close, stop the vehicle immediately and activate a continuous alert.
Step-7: Display the system status and obstacle distance.
Step-8: Send system data to the cloud for remote monitoring.
Step-9: Repeat Steps 2 to 8 continuously during system operation.

Implementing an advanced collision prevention and IoT-based vehicle safety system is a sophisticated task that involves precise design, real-time data handling, and continuous monitoring. However, when effectively executed, it can greatly improve road safety and significantly reduce the risk of vehicle-related accidents

IV. RESULTS AND DISCUSSION

The Advanced Collision Prevention and IoT-Based Vehicle Safety System was successfully implemented and tested under various conditions to evaluate its real- world performance. The primary objectives were accurate obstacle detection, real-time response, and effective data transmission to a cloud platform. During testing, the system reliably detected obstacles at different distance thresholds. When the path was clear (over 50 cm), the vehicle moved at full speed. If an object was detected within 30–50 cm, the system slowed the vehicle and issued a short buzzer warning. At distances under 30 cm, the system stopped the vehicle immediately and triggered a continuous buzzer alert to prevent collisions.

The 16x2 LCD displayed real-time updates such as distance measurements and systemresponses like —CLEAR, ‖ —SLOWING, ‖ or —STOP, ‖ ensuring the driver remained aware of the vehicle's surroundings. Simultaneously, the system transmitted real-time data, including obstacle distance and system actions, to the ThingSpeak IoT cloud platform via Wi-Fi. This data was visualized through live graphs, enabling remote monitoring and performance analysis.

Overall, the system was accurate, responsive within 0.5 seconds, and stable during long-term operation. The combination of ultrasonic and IR sensors enhanced detection reliability, while cloud connectivity supported effective data visualization and potential for future scalability.

(a)

(b) (c)

Fig.8.Working of the proposed System

V. CONCLUSION

The development and implementation of the Advanced Collision Prevention and IoT-Based Vehicle Safety System have demonstrated a practical and effective approach to enhancing road safety. By integrating real-time obstacle detection, automated speed control, and cloud-based data monitoring, the system successfully addresses the limitations of traditional safety measures, which often focus only on post-collision protection.

Through testing, the system proved capable of detecting objects accurately, responding within milliseconds to varying threat levels, and communicating relevant information both to the driver and to an IoT platform for remote tracking. The use of sensor-based automation and real-time feedback mechanisms ensures a more proactive form of safety, potentially reducing the number of accidents caused by delayed human response or lack of situational awareness.
This project not only contributes to vehicle safety but also lays a foundation for future innovations in intelligent transportation systems. It serves as a scalable and affordable prototype for real-world applications, particularly in areas where access to high-end vehicle automation remains limited

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