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Iot Revolution In Road Safety: Preventing Accidents And Saving Lives

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ABSTRACT

This research presents an IoT-based safety and alert system utilizing the ESP32 microcontroller to enhance vehicular safety and real-time monitoring. The system integrates various sensors to detect environmental and driver-related conditions. An alcohol sensor detects intoxication, while a DHT11 sensor monitors temperature and humidity. Ultrasonic and IR sensors enable obstacle and proximity detection, and a flame sensor alerts for fire hazards. Mobility is handled via BO wheels and DC motors controlled by a motor driver, with a buzzer providing instant audio alerts. A vision-based module detects driver drowsiness, triggering a Telegram chatbot alert with an audio message: "You are in drowsiness." In case of accidents, the system notifies emergency services through the chatbot. Critically, when any unsafe condition—such as alcohol consumption, drowsiness, or accident—is detected, the vehicle stops automatically to prevent further risk. This system demonstrates a robust combination of embedded systems, automation, and wireless communication for improved road safety and driver assistance.

Key words: ESP 32 microcontroller, Road Safety, Accident Prevention, Drowsiness Detection, Alcohol Detection, Automatic Braking System, Emergency Alert System

INTRODUCTION

Road safety has become a global concern due to the increasing number of accidents caused by human errors such as drunk driving, drowsiness, and delayed emergency response. Traditional safety mechanisms in vehicles often rely on manual intervention or post-incident action, which limits their effectiveness in critical moments. With the advancement of IoT, sensor technology, and embedded systems, there is an opportunity to design proactive safety solutions that monitor both driver behaviour and environmental conditions in real-time. The ESP32 microcontroller, with its powerful processing and wireless communication capabilities, serves as an ideal platform for such intelligent systems. Combining real-time sensing, automation, and alert mechanisms, the proposed system seeks to actively prevent accidents rather than merely respond to them. By integrating intelligent decision-making, automated vehicle control, and instant communication through a Telegram chatbot, this work aims to bridge the gap between conventional safety systems and the emerging need for smarter, responsive driving technologies.

PROBLEM STATEMENT

Despite significant advancements in vehicle safety technologies, road accidents remain a leading cause of death and injury worldwide, often due to human errors such as alcohol consumption, driver fatigue, and delayed emergency response. Conventional safety systems typically operate reactively, responding only after an incident has occurred. These systems fail to monitor driver behaviour and environmental factors continuously or take proactive actions to prevent accidents. There is also a lack of integration between multiple safety measures that can address various hazards simultaneously. Furthermore, emergency response is often delayed due to the absence of real-time communication and alerts to relevant authorities. The need for an integrated, proactive solution that can detect critical conditions—such as alcohol influence, drowsiness, or accidents—and automatically respond by halting the vehicle and notifying emergency services is paramount. Such a system would significantly improve road safety, reduce accident-related fatalities, and enhance real-time driver monitoring and intervention capabilities.

MOTIVATION

The motivation for developing an IoT-based road safety and accident prevention system stems from the urgent need to reduce road accidents, enhance driver monitoring, and enable faster emergency response. Key features that support this motivation include:

Key Features:

1.Reduce Human Error in Driving: Implement real-time monitoring of driver behaviour through alcohol and drowsiness detection to prevent accidents caused by impairment or fatigue.

2.Enhance Collision Prevention: Utilize ultrasonic sensors for object detection and automatic braking to avoid obstacles and minimize collision risk.

3. Enable Timely Emergency Response: Transmit critical data to nearby emergency services immediately after an accident to ensure rapid assistance and potentially save lives.

4.Promote Autonomous Safety Measures: Automate actions such as speed adjustment and hazard notifications based on real-time environmental and driver data.

LITERATURE REVIEW

1.Bhandari, S., Singh, R., & Patel, A. (2020). IoT-based intelligent accident prevention system.[1]
Bhandari et al. (2020) developed an IoT-enabled system focused on accident prevention through alcohol detection, speed control, and emergency alerting. Using MQ-3 sensors and GSM modules, the system detects alcohol levels and restricts vehicle access accordingly. It also communicates real-time accident data to emergency services, helping reduce response time. This research emphasizes the importance of real-time monitoring and automation in enhancing road safety.

2.Kumar, N., & Sharma, P. (2019). Real-time accident detection and alert system using IoT.[2]
Kumar and Sharma (2019) proposed a real-time accident detection system using accelerometer and GPS modules integrated with IoT. The system sends immediate alerts to nearby emergency services along with GPS coordinates, reducing response time and potentially saving lives. This study highlights the impact of IoT in critical situations where every second counts.

3.Rani, S., Gupta, A., & Verma, M. (2021). Driver fatigue detection system using computer vision techniques.[3]
Rani et al. (2021) presented a drowsiness detection model utilizing camera sensors and computer vision algorithms to monitor eye-blink rates. The system accurately detects signs of driver fatigue and issues alerts, reducing the risk of accidents due to drowsiness. This research demonstrates the potential of vision-based IoT solutions in improving driver safety.

4.Mehta, V., & Joshi, K. (2018). Automatic braking system using ultrasonic sensors.[4] Mehta and Joshi (2018) designed a vehicle system equipped with ultrasonic sensors for real-time obstacle detection. When a nearby object is detected, the system automatically applies brakes to prevent collision. Their work confirms the effectiveness of sensor-based automation in accident prevention.

5.Patil, R., & Kulkarni, D. (2022). Edge computing for IoT-based vehicle safety systems.[5] Patil and Kulkarni (2022) discussed the implementation of edge computing in IoT safety systems to minimize latency and improve local data processing. Their study shows that edge-based architecture enhances system responsiveness and protects user data by reducing dependence on cloud infrastructure.

6.Sharma, T., & Verma, S. (2021). Multi-sensor integration for intelligent vehicle safety.[6] Sharma and Verma (2021) proposed a comprehensive safety framework integrating alcohol detection, drowsiness monitoring, speed control, and emergency alerts. Their research illustrates the benefits of combining multiple IoT sensors into a single platform to improve road safety through automation and real-time intervention.

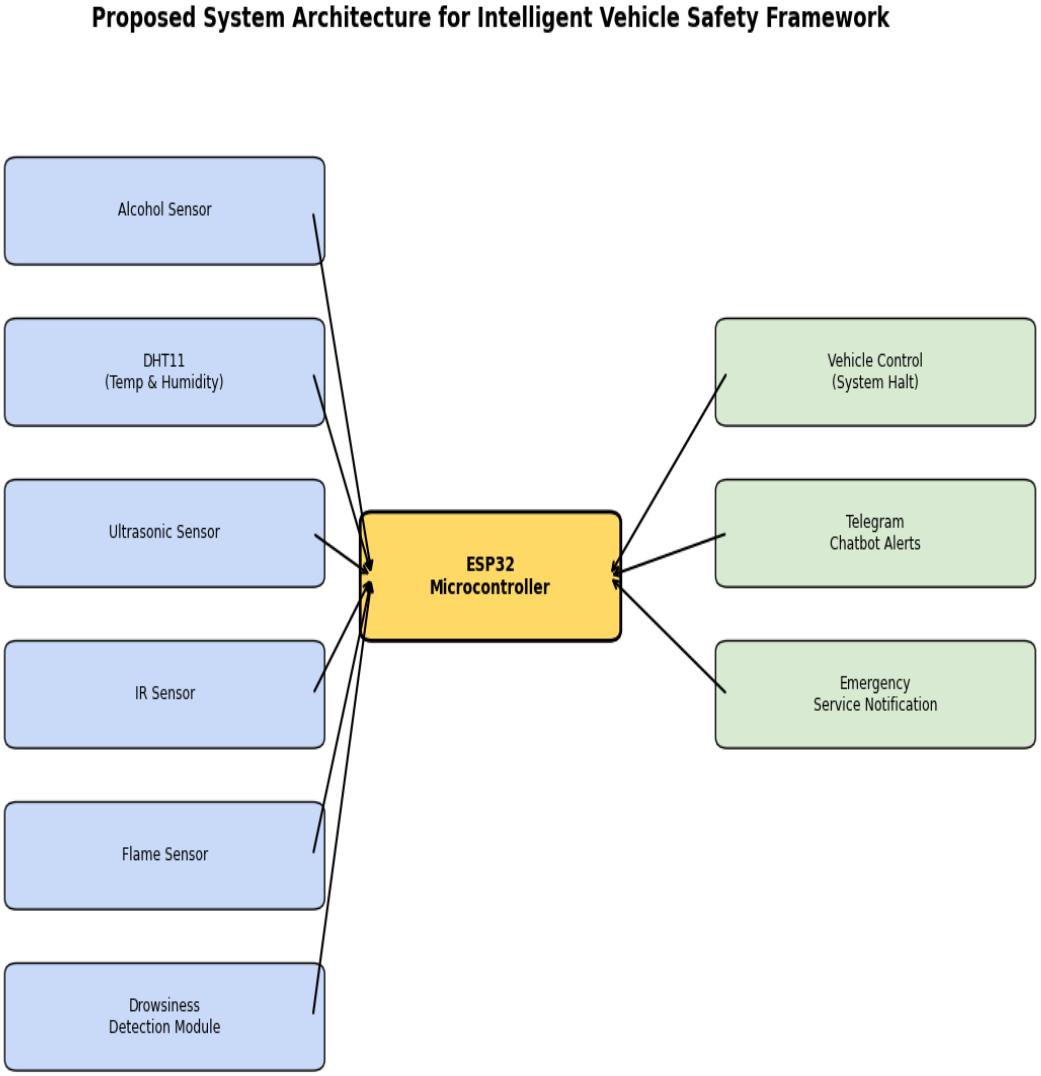
7.Ahmed, M., & Farooq, F. (2020). Smart vehicle accident detection and alert system using IoT and GPS.[7]
Ahmed and Farooq (2020) designed a smart accident detection system that combines IoT sensors with GPS modules to detect crashes and immediately notify emergency services. The system uses threshold-based motion detection to identify collisions and sends real-time location data through GSM communication. This study demonstrates how IoT can improve accident reporting and reduce emergency response time.

8.Chakraborty, D., & Saha, S. (2021). Drowsiness detection using deep learning and embedded vision systems.[8]
Chakraborty and Saha (2021) proposed a deep learning-based approach to detect driver drowsiness using embedded camera modules. The model analyzes facial features and eye movement in real-time to identify fatigue and trigger alerts. Their work illustrates the growing role of AI-integrated IoT systems in enhancing road safety by preventing fatigue-related accidents.

PROPOSED SYSTEM

The proposed system aims to create an intelligent, multi-sensor framework that enhances road safety by continuously monitoring driver behaviour and environmental conditions. At its core, the ESP32 microcontroller manages data from several sensors, including an alcohol sensor to detect impaired driving, a DHT11 sensor for temperature and humidity, and ultrasonic and IR sensors for collision detection. The system also includes a flame sensor for fire detection. A critical component is the drowsiness detection module, which assesses driver alertness and triggers immediate warnings via a Telegram chatbot if fatigue is detected. In addition, the system automatically halts vehicle movement when unsafe conditions such as alcohol consumption or drowsiness are identified. Emergency services are notified in real-time through the chatbot, ensuring rapid intervention during accidents. By combining sensors, automated vehicle control, and communication technologies, this system offers an integrated approach to significantly improve vehicular safety and reduce accident risks.

PROPOSED SYSTEM ARCHITECTURE



METHODOLOGY

1. Sensor Integration

- Ultrasonic sensors are used to detect obstacles in the vehicle's path in real-time.
- MQ-3 alcohol sensors measure the driver’s breath before ignition, ensuring sober driving.
- Camera modules capture facial expressions and eye movements to monitor signs of drowsiness.

2. Data Acquisition

- Sensor data is continuously gathered from the environment and driver conditions.
- Collected data includes distance from obstacles, alcohol levels, and visual driver cues.
- Real-time acquisition ensures the system operates responsively and accurately..

3. Edge-Level Data Processing

- All sensor data is processed locally using microcontrollers (e.g., Arduino or Raspberry Pi).
- Local image processing detects drowsiness using tools like OpenCV or TensorFlow Lite.
- Edge processing eliminates latency and ensures faster decision-making.

4. Decision Making

- Based on thresholds (e.g., distance, alcohol level, drowsiness), decisions are made in real-time.
- Safety actions like braking, slowing down, or triggering alerts are executed.
- The system prioritizes critical threats and automates responses accordingly..

5. Driver Feedback and Alerts

- **Buzzers** and **LCD displays** are used to warn the driver of detected risks.
- Visual or sound alerts signal drowsiness, intoxication, or nearby obstacles.
- The interface is designed to be intuitive and non-distracting.

6. Emergency Detection and Response

- If an accident or dangerous condition is detected, the system initiates emergency protocols.
- Vehicle crash or prolonged inaction triggers the emergency sequence.
- This ensures immediate recognition of life-threatening events.

7. Telegram Chatbot AI Integration

- A Telegram bot is connected via API to send automated messages to emergency contacts.
- The bot shares live GPS coordinates, driver condition, and sensor status.
- It provides a lightweight, secure, and fast alternative to traditional messaging systems.

8. Local Execution and Data Privacy

- All processing and communication occur without cloud dependence, reducing network risks.
- Data is processed locally, preventing third-party access to sensitive information.
- Ensures the system is usable even in low-connectivity or rural areas.

9. Logging, Feedback, and Scalability

- Event data is logged for later analysis (e.g., near-miss incidents or ignored alerts).
- The system is modular, supporting future upgrades like heart-rate monitoring or vehicle diagnostics.
- Scalable architecture allows deployment in two-wheelers, cars, and transport fleets.

RESULTS AND ANALYSIS

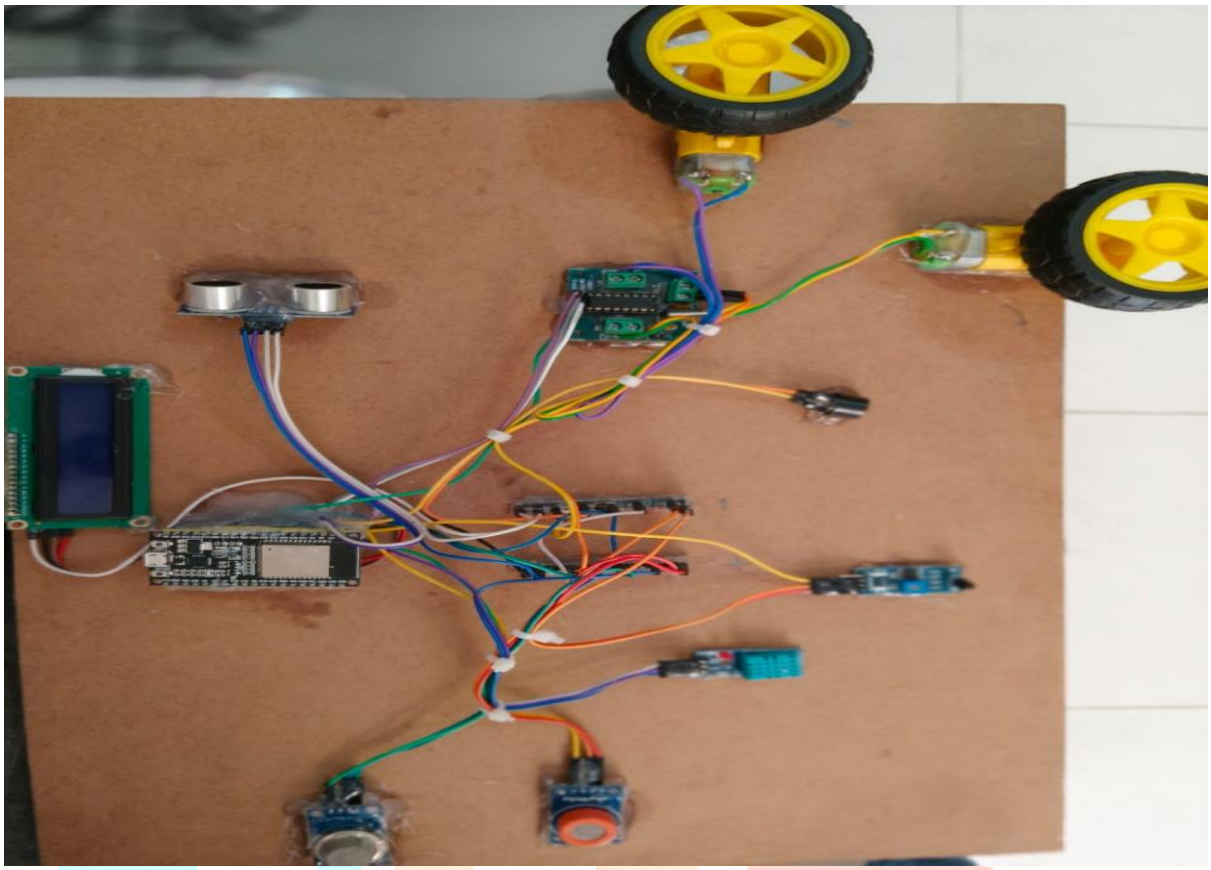


Figure1 :BEFORE CONNECTING TO THE SYSTEM

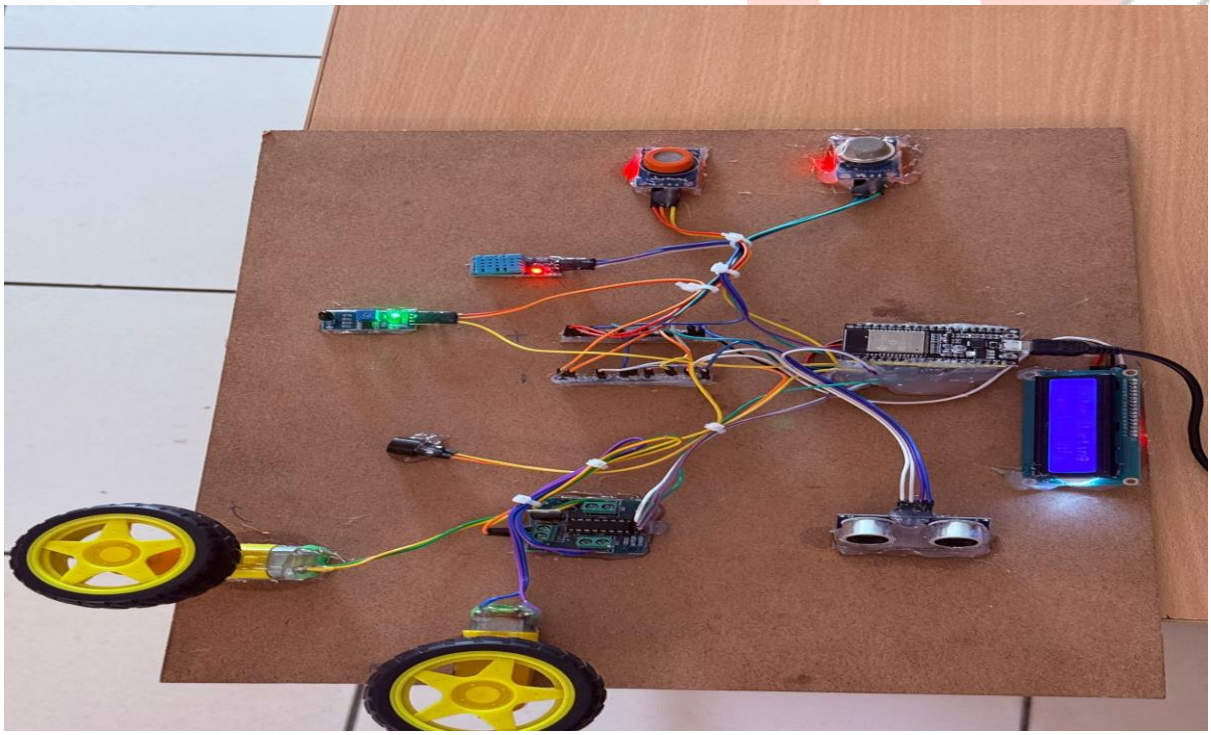


Figure2: AFTER CONNECTING TO THE SYSTEM

Figure3:PROVIDING ALERTS THROUGH CHATBOT

CONCLUSION

In conclusion, the proposed IoT-based safety and alert system demonstrates a comprehensive and proactive approach to enhancing vehicular safety through real-time monitoring and automation. By leveraging the ESP32 microcontroller and an array of sensors, the system effectively detects critical conditions such as alcohol consumption, drowsiness, obstacles, and fire hazards. Automated vehicle control, instant alerts via a Telegram chatbot, and emergency notifications ensure timely intervention and risk mitigation. This integration of embedded systems, mobility control, and wireless communication presents a scalable solution for intelligent transportation, paving the way for safer driving environments and reduced accident rates through advanced driver assistance technology.

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