Design and Implementation of Vehicle Accident Detection and Real-Time Alert System Using GPS, GSM, and Alcohol Sensor

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***ABSTRACT*—**Road accidents lead to a significant number of injuries and deaths each year. Immediate medical assistance after an accident is extremely important to save lives. This paper introduces an ESP32 based vehicle accident detection and alert system that utilizes GPS, GSM, and an alcohol sensor. The ESP32 controller observes vehicle conditions using sensors and detects sudden impacts that signal an accident. When an accident happens, the GPS module determines the location of the vehicle, and the GSM module sends an emergency message with the location to predefined contacts. The MQ-3 alcohol sensor measures the alcohol level of the driver and gives a warning if it crosses the safe limit. The proposed system supports faster emergency response and encourages safer driving.

KEYWORD: ESP32 Microcontroller, Vehicle Accident Detection, GSM Module, GPS Module, Vibration/Impact Sensor, Alcohol Sensor (MQ-3), Real-Time Alert System, Road Safety System, Intelligent Transportation System.

I. INTRODUCTION

Traffic accidents result in thousands of injuries every year, and fast emergency response is essential to save human lives. In many cases, delays in providing medical help increase the severity of injuries caused by accidents. Therefore, there is a need for a system that can automatically identify accidents and quickly notify emergency contacts.

The proposed system is designed using the ESP32 microcontroller, which serves as the main controller of the system. Various sensors are connected to observing the vehicle condition and driver behavior. The MPU6050 sensor identifies sudden impacts, abnormal tilt, or rapid motion changes that may signal an accident. When such a condition occurs, the system triggers a buzzer to alert nearby people.

At the same time, the GPS module gathers the real-time location of the vehicle, and the GSM module sends an SMS alert containing the location link to emergency contacts. In addition, the MQ-3 alcohol sensor measures the alcohol level of the driver and provides a warning when the level exceeds the allowed limit. This system enhances road safety by enabling quick accident notification and discouraging drunk driving.

The system is powered by a rechargeable Li-Ion battery and controlled using an LM2596S DC-DC Buck Converter, ensuring a stable voltage supply to all components. Overall, this smart vehicle safety system improves road safety by offering automatic accident detection, real-time location tracking, and preventive measures against drunk driving. It is a cost-effective and efficient solution suitable for personal vehicles, commercial transport, and fleet management.

II. Literature Review and History of Technology

Many researchers have designed intelligent vehicle safety systems using IoT technology. Several studies have concentrated on detecting alcohol consumption by drivers and preventing vehicles from operating in unsafe conditions. Systems using sensors such as MQ-3 and microcontrollers like Arduino or ESP32 have been suggested to monitor driver behavior and vehicle movement.

Some research works have also combined GPS and GSM technologies to automatically send accident alerts along with location details to emergency contacts. Recent developments include cloud-based monitoring, mobile applications, and advanced sensor integration for improving vehicle safety and emergency response systems. These studies indicate that combining sensors with communication technologies can greatly improve road safety and reduce accident response time. The recent research in the area of vehicle safety systems is dominated by IoT-based technologies for accident prevention, with a particular focus on alcohol detection and automatic intervention.

Vitiello et al. (2025) introduced smart card technology for ignition control using advanced materials for impairment and drug detection with regulatory compliance. Sapthami et al. (2024), Hebsur et al. (2024), Prabu et al. (2024), and Heamesh et al. (2024) introduced Arduino and MQ-3 sensor technologies for alcohol detection, engine lock, and GPS/GSM messages for accident prevention, resulting in a reduction of up to 40-50%. Sathish et al. (2024) and Sindhuja (2024) also introduced advanced technologies for multiple sensor integration for real-time vehicle monitoring and accident detection with cloud analytics, with a specific focus on Kurundkar et al. (2024) for fuel theft prevention.

III. Proposed System Architecture

The proposed ESP32-based vehicle safety system is designed using a detailed hardware architecture that integrates sensing, processing, communication, and alerting components for real-time accident detection and driver impairment monitoring. At the core of the system is the ESP32 microcontroller, a dual-core 240 MHz system-on-chip with built-in Wi-Fi and Bluetooth capabilities. It serves as the central processing unit and manages all operations using GPIO, I2C, UART, and ADC interfaces.

A. Sensing Components

The system includes multiple sensors for monitoring vehicle conditions and driver behavior. The MQ-3 alcohol sensor is used to detect ethanol concentration in the driver’s breath. It produces an analog voltage proportional to alcohol levels, which is calibrated based on the legal BAC limit of 0.4 mg/L.

Additionally, the MPU6050 6-axis accelerometer and gyroscope continuously observe motion along the X, Y, and Z axes with a range of ±16g. It identifies sudden impacts exceeding 4g and detects abnormal orientation changes using filtering techniques to avoid false detection caused by road disturbances.

B. Positioning and Communication

The NEO-6M GPS module provides precise real-time latitude and longitude coordinates with an accuracy of approximately 2.5 meters using NMEA data parsing. The SIM800L GSM module is used for communication, allowing the system to send emergency alerts in the form of SMS messages. These messages include Google Maps links, timestamps, and accident details, and are sent to predefined emergency contacts using AT command protocols.

C. Alerting Mechanism

The system uses a high-decibel active buzzer for local alert generation. It produces different signal patterns, such as continuous sound for alcohol detection and pulsating sound for accident detection, to attract nearby attention.

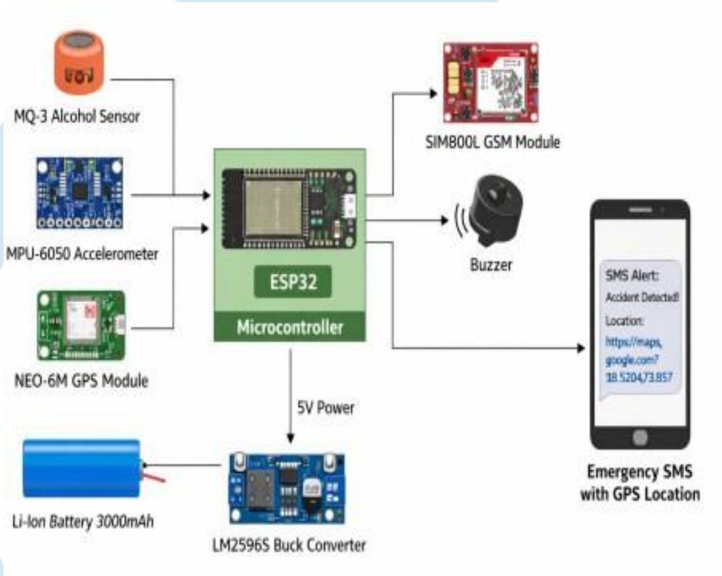
D. Power Management

The system is powered by a 3000 mAh rechargeable Li-ion battery. An LM2596 DC-DC buck converter is used to regulate the voltage and provide stable 5V and 3.3V outputs required by the ESP32 and other modules. This ensures reliable operation even under fluctuating automotive power conditions, with a backup duration of 24–48 hours.

E. System Overview

The overall architecture is represented using a block diagram, which illustrates the flow of data from sensors to the ESP32, and further to the GPS, GSM, and buzzer modules. The system is cost-effective (less than $25) and scalable for various IoT-based vehicle safety applications.

IV. SYSTEM ARCHITECTURE BLOCK DIAGRAM



V. METHODOLOGY

The proposed ESP32-based vehicle safety system is designed to detect accidents and impaired driving conditions using integrated sensors and communication modules such as GPS, GSM, MQ-3 alcohol sensor, and MPU6050 accelerometer + gyroscope.

A. System Initialization

When the system is powered on, the ESP32 microcontroller starts and establishes communication with all connected modules. This includes the MPU6050 sensor, MQ-3 alcohol sensor, GPS module, and GSM module. This step ensures proper operation and continuous monitoring.

B. Alcohol Detection

The MQ-3 alcohol sensor continuously checks the alcohol concentration in the driver's breath. The measured value is compared with a predefined threshold (0.4 mg/L BAC). If the detected value exceeds this limit, the system triggers a buzzer to alert.

C. Motion Monitoring

The MPU6050 sensor tracks acceleration and orientation along X, Y, and Z axes in real time. This helps in identifying normal driving conditions as well as unusual movements.

D. Accident Confirmation

If a sudden change in acceleration or abnormal orientation is detected beyond a predefined threshold, the system recognizes it as an accident event.

E. Location Acquisition

The GPS module obtains the real-time latitude and longitude coordinates from satellites. These coordinates are converted into a Google Maps link for easy access.

F. Emergency Alert

The GSM module sends an SMS alert to predefined emergency contacts. The message includes location coordinates, date, and type of emergency, enabling a quick response.

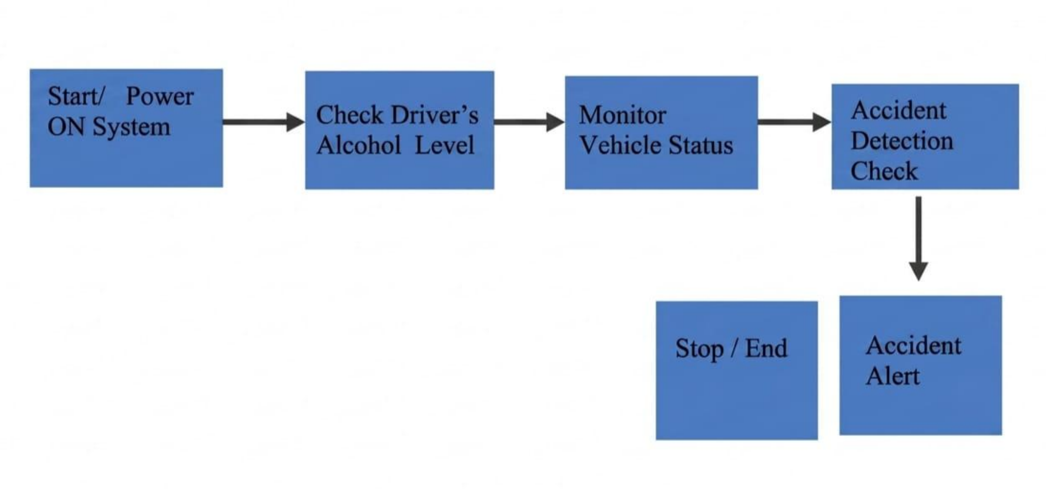
G. Local Alert Activation

At the same time, a buzzer is triggered to alert nearby people about the accident or unsafe condition.

H. Overall Operation

The system performs real-time monitoring, fast detection, and instant communication. This reduces response time during emergencies and improves overall road safety.

VI. WORKING PRINCIPLE



Working of Arduino Based Vehicle Accident & Alcohol Alert System Using GPS, GSM, Alcohol Sensor.

The working of the ESP32-based vehicle accident detection and real-time alert system is based on the integration of multiple sensors and communication modules that continuously monitor the condition of the vehicle and the driver. The system is designed to detect abnormal situations such as accidents or drunk driving and immediately respond by sending alerts along with the vehicle's real-time location. The ESP32 microcontroller acts as the central processing unit that collects data from all connected sensors, processes the information, and triggers appropriate actions.

In normal operation, the system remains active and continuously monitors the inputs from the alcohol sensor, vibration or accelerometer sensor, and GPS module. The alcohol sensor, typically an MQ-3 sensor, is responsible for detecting the presence of alcohol in the driver's breath. It operates by measuring the concentration of alcohol vapors in the surrounding air. When the driver exhales near the sensor, the sensor produces an analog voltage proportional to the alcohol concentration. This signal is read by the ESP32 through its analog input pins.

If the alcohol level exceeds a predefined threshold value, the ESP32 interprets this as a case of drunk driving. In such a situation, the system activates a buzzer to alert the driver. Additionally, depending on the system design, it can also prevent the vehicle from starting by disabling the ignition system using a relay module. This ensures that the driver cannot operate the vehicle under the influence of alcohol, thereby enhancing road safety. Simultaneously, the system monitors the motion and stability of the vehicle using a vibration sensor or an accelerometer such as the ADXL335. This sensor detects sudden shocks, impacts, or abnormal /tilting of the vehicle. During normal driving conditions, the sensor outputs remain within a stable range.

However, in the event of a collision or accident, the sensor experiences a sudden spike in acceleration values, which is detected by the ESP32.When the ESP32 detects a sudden change in acceleration beyond a predefined threshold, it interprets this as an accident. To avoid false positives, the system may include a delay mechanism or confirmation logic. For example, after detecting a potential accident, the system may wait for a few seconds and check if the condition persists. If the abnormal condition continues, the system confirms that an accident has occurred. Once an accident is confirmed, the ESP32 initiates the emergency alert process. The first step in this process is to obtain the current location of the vehicle using the GPS module, such as the NEO-6M. The GPS module communicates with satellites to determine the exact latitude and longitude of the vehicle.

These coordinates are then sent to the ESP32 via serial communication. After acquiring the location data, the ESP32 formats the information into a message that includes the coordinates and a Google Maps link. This link allows the recipient to easily view the accident location on a map. The message typically contains text such as "Accident detected! Please respond immediately. Location:https://maps.google.com/?q=latitude,longitude".Next, the ESP32 uses the GSM module, such as SIM800L, to send the alert message. The GSM module operates using a SIM card and communicates over the cellular network. The ESP32 sends AT commands to the GSM module to initiate the sending of an SMS message. The message is sent to predefined emergency contact numbers, such as family members, friends, or emergency services. In addition to sending SMS alerts, the system may also activate a buzzer to provide an audible alert at the accident site. This can help nearby people become aware of the incident and provide immediate assistance.

The entire process, from accident detection to alert transmission, occurs within a few seconds, ensuring rapid response and minimizing the delay in providing medical assistance. The use of the ESP32 microcontroller enhances the system's efficiency due to its high processing speed, built-in Wi-Fi and Bluetooth capabilities, and multiple input/output pins. The system operates continuously as long as it is powered, making it suitable for real-time monitoring in vehicles. It can be powered using the vehicle's battery or an external power supply. The compact design and low power consumption make it easy to install in different types of vehicles. to generate calibration curves. The MPU6050 is fine-tuned for accurate motion detection. The GSM module is tested for reliable communication, and the GPS is validated for fast signal acquisition. System testing ensures high accuracy (above 95%), low false alarm rates (below 1%), and battery backup of 24–48 hours.

1. Accident Response and Location Broadcasting

Upon accident confirmation, the GPS module retrieves real- time latitude, longitude, speed, and timestamp data using NMEA parsing. The ESP32 converts this data into a Google Maps link. The GSM module then sends an SMS alert containing this information to predefined emergency contacts. Simultaneously, a buzzer is activated for 30–60 seconds to alert nearby individuals.

2. Pre-Deployment Calibration and Validation

Before deployment, all system components are calibrated. The MQ-3 sensor is tested under controlled alcohol levels

3. Overall System Operation

The system performs continuous monitoring, accurate detection, and rapid communication. This ensures timely emergency response and enhances road safety by reducing accident impact and preventing drunk driving.

VII. RESULT

This system has a wide range of applications in modern transportation and safety systems. It can be implemented in both personal and commercial vehicles to enhance road safety and reduce accident- related fatalities. The proposed system for Vehicle Accident and Alcohol Detection System implementation was successfully accomplished and tested under different conditions. The MPU-6050 sensor successfully detected the sudden impact and abnormal acceleration beyond the specified threshold value. This helped in identifying the vehicle accident. The alcohol sensor based on the MQ-3 alcohol sensor successfully measured the alcohol concentration value and sent an alert signal when the value exceeded the specified limit.

When the vehicle is involved in an accident, the GPS module successfully sent the real-time latitude and longitude values. The GSM module successfully sent SMS alert messages containing the link to the contacts. The buzzer also successfully sent an immediate local alarm signal for the emergency situation. The system also exhibited good response time and effective utilization of hardware modules. However, some differences in sensor values due to environmental factors were noted. This can be reduced by calibrating the system properly. Overall, the proposed system is an effective solution for vehicle safety.

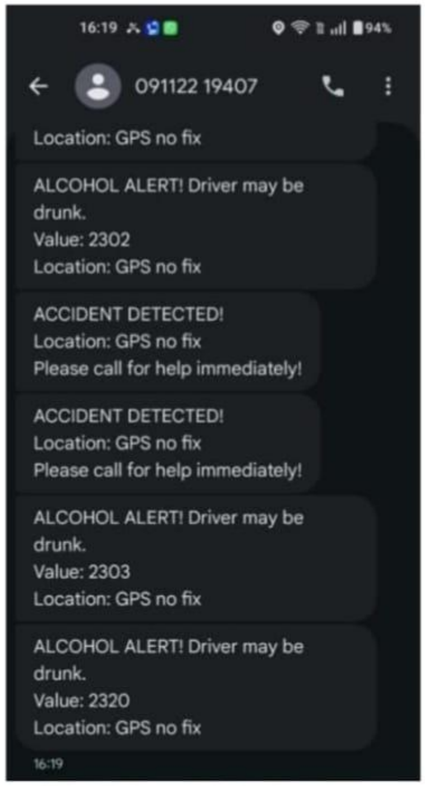


Fig. Result SMS:- Alcohol & Accident

VIII. CONCLUSION

The proposed vehicle accident detection and alcohol monitoring system provides an effective solution for improving road safety. By combining ESP32, GPS, GSM, and sensor technologies, the system is capable of detecting accidents and sending real-time alerts to emergency contacts. The alcohol detection feature also helps in preventing unsafe driving conditions. The system reduces the delay in emergency response and ensures faster assistance during accidents. Overall, the proposed solution is cost-effective, reliable, and suitable for various vehicle safety applications.

IX. FUTURE SCOPE

The final output of the system can be understood in terms of both hardware response and communication output.

- When alcohol is detected:
  - Buzzer turns ON
  - Warning indication is activated
- When accident occurs:
  - Buzzer alerts immediately
  - System processes data
  - SMS Output Example:
  - Accident Detected!
  - Location: https://maps.google.com/?q=21.1458,79.0882
  - Driver Condition: Critical
  - This message is sent to predefined contacts such as:
- Family members
- Emergency services
- Vehicle owner
  - Visual Output (Optional Enhancements):
- LCD Display showing:
  - GPS coordinates

  - System status
- Mobile App showing:
  - Real-time location
  - Alert notifications Overall System Behavior:
- Fully automatic operation
- Immediate response to critical situations
- Continuous monitoring without manual intervention

X. References

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