Vehicle Accident Detection and Alert System

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Abstract: This project presents a smart and efficient Vehicle Accident Detection and Alert System designed to enhance road safety and reduce the response time during accidents. The system uses an ESP32 microcontroller, which supports both Wi-Fi and Bluetooth communication, to detect abnormal vehicle conditions and send immediate alerts. A gyroscope sensor is employed to detect tilt or sudden motion, which may indicate a crash or rollover. An MQ3 gas sensor is integrated to sense the presence of alcohol or gas leakage inside the vehicle, which ensures early detection of dangerous situations such as drunk driving or fuel leaks. Additionally, an ultrasonic sensor is used to detect nearby obstacles or impacts, further contributing to accident detection. Once a potential accident or hazard is identified, the system activates a buzzer and LED indicator to alert passengers or nearby people. A 16x2 LCD display is used to show the system status in real-time. At the same time, an alert message, including location data if GPS is used, is sent wirelessly to emergency contacts or authorities using Wi-Fi or Bluetooth. The system is powered by a battery, ensuring functionality even when the vehicle's main power fails during a collision. This real-time monitoring and alert mechanism provides a cost-effective and practical solution for improving vehicle safety, especially in areas with limited access to immediate medical support or rescue services. The modularity of the system allows for future upgrades such as GPS integration, GSM for SMS alerts, and mobile app connectivity for live tracking. It is particularly beneficial for private vehicles, public transportation, and fleet management. Overall, the system contributes to minimizing accident severity, saving lives, and providing valuable data for post-accident analysis. This innovative approach demonstrates the effective use of embedded systems and sensors in building safer and smarter transportation systems.

Keywords: Vehicle safety, Accident detection, ESP32, IoT, Gyroscope sensor, MQ3 Alcohol sensor, Ultrasonic sensor, Alert system, Real-time monitoring, Embedded system, Wireless communication, Alcohol detection, Tilt sensor, Buzzer alert, LCD display.

I. Introduction

In recent years, road accidents have become one of the major causes of death and serious injury across the globe. Despite advancements in vehicle technology and infrastructure, the lack of real-time accident detection and delayed emergency responses continue to contribute to the loss of lives. To address this growing concern, the Vehicle Accident Detection and Alert System project aims to provide a smart, affordable, and efficient solution that can automatically detect accidents and send alerts to concerned authorities or emergency contacts. The system is built using an ESP32 microcontroller, which comes with built-in Wi-Fi and Bluetooth capabilities, making it ideal for wireless communication and IoT applications. A gyroscope sensor is used to detect sudden tilts, rollovers, or impact movements, which are common indicators of accidents. An MQ3 alcohol sensor is integrated into the system to detect the presence of alcohol in the vehicle environment, helping to identify if the driver may be intoxicated. It also helps in detecting gas leakages that could be hazardous in case of an accident. The ultrasonic sensor is responsible for identifying nearby obstacles or collisions, further enhancing the system’s ability to recognize crash scenarios. When an accident or irregular condition is detected, the system activates a buzzer and LED indicator to provide immediate warning to passengers or bystanders. A 16x2 LCD display is used to show system status and alerts in real-time. Furthermore, through Wi-Fi or Bluetooth, the system can send alert messages, potentially including GPS location if integrated, to pre-defined emergency contacts. The use of a rechargeable battery ensures the system remains functional even in the event of a power cut during a collision. This project not only enhances vehicle safety by enabling quick response in critical situations but also acts as a preventive system by monitoring alcohol presence and sudden movements. Its low cost, portability, and scalability make it a suitable choice for both private and public transport vehicles. By combining embedded systems, sensor networks, and wireless communication, this project contributes to the development of smarter and safer transportation technologies..

II. Literature Review

With the increasing rate of road accidents worldwide, researchers and developers have been actively working on intelligent systems that can detect accidents and provide timely alerts to reduce fatalities. Previous studies have utilized various microcontrollers like Arduino and Raspberry Pi for building accident detection systems; however, the ESP32 microcontroller has gained attention due to its built-in Wi-Fi and Bluetooth capabilities, allowing seamless integration with IoT-based alert systems. Gyroscope sensors have been widely used in detecting sudden tilts or rollovers that typically occur during vehicle collisions. Alcohol detection through gas sensors like MQ5 and MQ3 has also been explored in many projects to prevent drunk driving, as these sensors can detect the presence of alcohol vapors in the vehicle cabin. Ultrasonic sensors are commonly used to detect obstacles and measure proximity, which helps in recognizing sudden impacts or potential crashes. Several systems have incorporated GSM and GPS modules to send location-based alerts via SMS; however, they often face limitations such as high cost and dependency on mobile networks. The use of ESP32 overcomes these issues by enabling real-time communication through Wi-Fi or Bluetooth. Furthermore, components like buzzers, LEDs, and LCD displays have been used in existing systems to give immediate alerts to drivers and passengers. Based on this literature, it is evident that a combination of sensors—gyroscope, gas, ultrasonic—and wireless communication modules in a compact embedded system can enhance vehicle safety. The proposed Vehicle Accident Detection and Alert System builds on this foundation by integrating all these technologies into a single, low-cost solution that not only detects accidents but also addresses alcohol-related driving and gas leakage hazards, providing a comprehensive approach to vehicular safety and emergency response.

III. Methodology

a) Operation of The System

The Vehicle Accident Detection and Alert System operates by continuously monitoring various parameters using multiple sensors integrated with the ESP32 microcontroller. The gyroscope sensor detects sudden tilts, flips, or abrupt movements, which may indicate an accident or rollover. Simultaneously, the ultrasonic sensor monitors the proximity of nearby objects to detect possible collisions. The MQ3 alcohol sensor is used to detect the presence of alcohol or gas leakage within the vehicle, which can help in identifying drunk driving or hazardous leaks. When any of these abnormal conditions are detected, the system immediately activates a buzzer and LED indicator to provide a local warning. At the same time, the status is displayed on a 16x2 LCD screen for easy visibility. The ESP32, using its Wi-Fi or Bluetooth capabilities, sends an alert message to predefined emergency contacts or monitoring systems. The system is powered by a battery, ensuring uninterrupted operation even if the vehicle's main power supply is cut off during an accident. This real-time monitoring and alert mechanism ensures quick detection and response, potentially saving lives and minimizing post-accident damage.

b) System Block Diagram and Flowchart

Figure 1 is a block diagram of the system, and Figure 2 is an illustration of the flowchart of the system. An accelerometer MPU6050 sensor is utilized in order to detect the occurrence of the accident with the assistance of a three-axis gyroscope and a three-axis accelerometer. It is the GPS module of the Global Positioning System that is responsible for determining the position of the vehicle. These sensors provide the Esp32 Microcontroller with the data that details the angle and location of the object. The GSM SIM900A module should be utilized in order to deliver an alert message to a mobile phone that has been predetermined. For the purpose of displaying the position, the LCD is also connected to the Arduino.

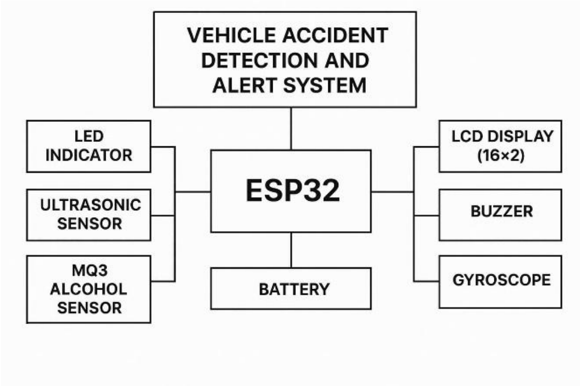

Figure 1: Block Diagram of Proposed System

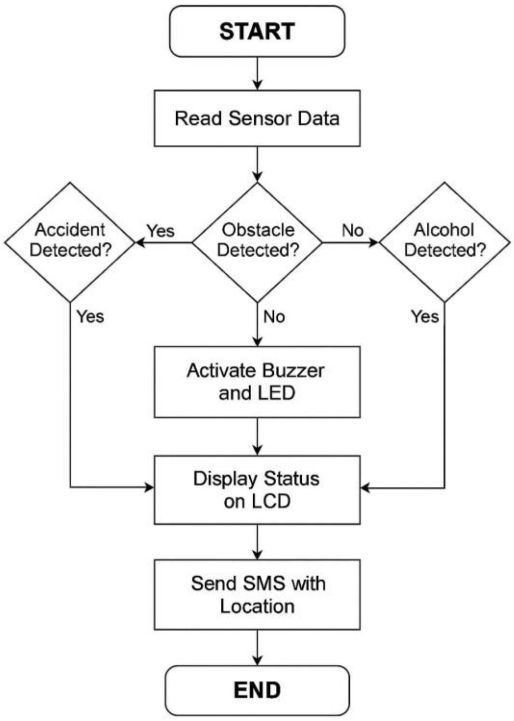

Figure 2: System Flowchart

IV. Result and discussion

Vehicle Accident Detection and Alert System was successfully developed and tested using the ESP32 microcontroller in combination with key sensors and communication modules. The system efficiently detects accidents, monitors alcohol presence, and immediately alerts emergency contacts with both SMS and location details. The gyroscope sensor played a vital role in identifying abnormal tilts, jerks, or rollovers that typically occur during a crash. When sudden motion was detected, the system recognized it as a potential accident. The ultrasonic sensor was employed to detect close-range collisions by identifying objects or sudden stops in the vehicle's path. The MQ3 alcohol sensor accurately sensed alcohol vapors inside the vehicle cabin, helping to flag potential drunk driving scenarios. Upon detection of any critical situation—such as a crash or alcohol presence—the system activated a buzzer and LED indicator to alert passengers and nearby individuals, while also displaying status information on a 16x2 LCD screen.

One of the key features of the system was its ability to send an SMS alert along with the real-time GPS location of the accident to pre-saved emergency contacts. This functionality ensures a quick response from family members or rescue services, especially in remote or less populated areas. The use of ESP32 allowed seamless integration with Wi-Fi, Bluetooth, and GPS modules, enabling wireless communication and accurate location tracking. The system was powered by a rechargeable battery, ensuring continued operation even if the vehicle's main power source failed during a crash. During multiple test runs, the system responded quickly and accurately, confirming its practical application for real-world use. Overall, the project demonstrated a low-cost, reliable solution for accident detection and emergency alerting. Future improvements could include mobile app integration, data logging, and voice-based alerts to enhance usability and user interaction.

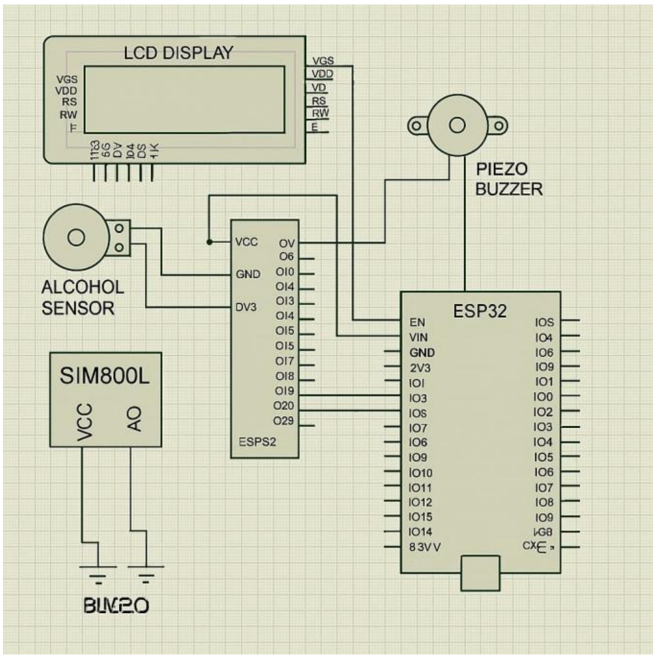

Figure 3: Connection of Proposed System

a) Displaying on LCD

Displaying on LCD is depicted in Figure 4, which illustrates the connection. In addition, the LCD and the Esp32 interface were put through their paces. For the purpose of controlling the 16 x 2 LCD display, the four-bit mode is utilized. This project's switch is connected to both the ground and the voltage-controlled circuit (VCC). All of the components are included in this supply. The term "GSM and GPS module Init" will be displayed on the LCD screen when the switch is turned on, and the word "GSM and GPS signal ready" will be displayed on the LCD screen after the GSM and GPS receive the signal. The word "Collision detect" will be shown on the LCD screen once the MPU 6050 has determined that there has been an accident.

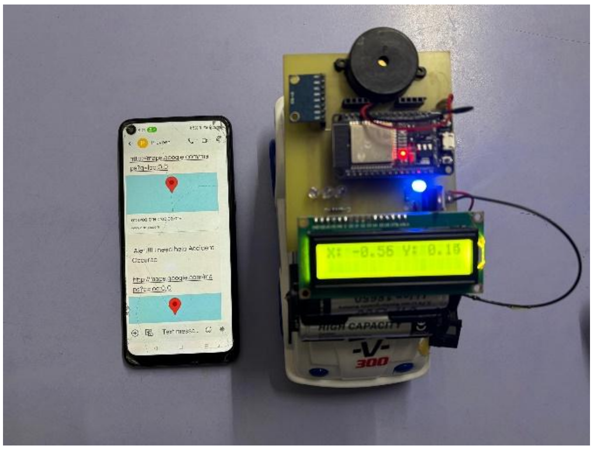

Figure 4: LCD Test

This is the final connection that the system has, as seen in Figure 6. The devices are meticulously linked together, and the entire application is then posted to the Esp32 platform once each test has been successfully completed. The maximum limit acceleration is determined in order to facilitate the detection of accidents. At the moment when the MPU 6050, with the assistance of a three-axis gyroscope and a three-axis accelerometer, determines that an accident has taken place, the piezo buzzer will begin to play, and the LED will begin to illuminate. In the event that the MPU6050 does not detect, the buzzer and LED will be turned off .

Figure 5: All Component Test

b) The notification messages

GSM 900a was the communication method that was utilized, and the GPS module transmitted the data in NMEA format. This format can be utilized to locate the precise position of the tragedy. GSM allows for the transmission of text messages to specific individuals. The designated individual will be able to take the necessary actions in the event of an accident because they will be aware of the location of the motorcycle and will receive a notification that states, "Collision sensor has been activated at Position https://www.google.com/maps/place." The user's mobile device displays the notification message, as shown in Figure

6.

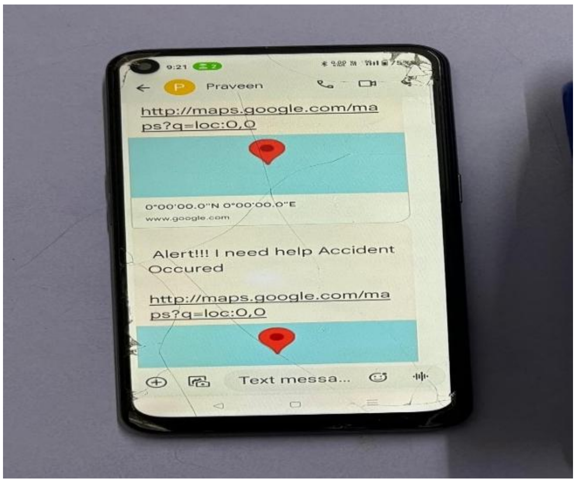

Figure 6: Notification

V. Conclusion

With the help of the ESP32 microcontroller and the MPU6050 sensor, this article shows an Internet of Things-based accident detection system that is both efficient and inexpensive. The system ensures that emergency contacts are instantly contacted with the location of the accident due to the incorporation of a mobile application that is capable of sending text message notifications. This technology has the potential to become an indispensable instrument in accident response systems if further advancements are made to reduce the number of false positives and increase power efficiency.

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