

IOT Based Automatic Vehicle Accident Detection and Rescue System

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Abstract—Road accidents continue to be one of the leading causes of death worldwide, with millions of fatalities recorded every year [1]. A primary reason behind this high death toll is the inability of emergency services to reach victims promptly. Accidents frequently occur in remote locations where no witnesses are present, or the driver may be unconscious and unable to seek assistance [6]. In many such scenarios, the delay in rescue response proves to be more deadly than the collision itself [9]. To address this critical issue, an IoT-based automated system titled "IoT Based Automatic Vehicle Accident Detection and Rescue System using ESP32" was developed, capable of detecting vehicular accidents and initiating emergency alerts without any human intervention [4]. Upon detecting an accident, the system automatically notifies pre-registered emergency contacts along with the precise location of the vehicle [13]. The ESP32 microcontroller serves as the central processing unit of the system, coordinating all operations [16]. An MPU6050 sensor is employed to identify sudden shocks, tilts, or impacts that are characteristic of a collision [18]. A GPS module then determines the vehicle's real-time location, while a GSM module transmits an SMS alert containing a location link to the saved emergency numbers [6][13]. The system also incorporates a temperature sensor to monitor abnormal heat rise around the vehicle post-accident, which may indicate fire or engine overheating [7]. This data is included in the emergency notification to help rescue teams better assess conditions at the accident site. A buzzer and LED indicator are additionally used to alert nearby individuals [12]. The proposed system is affordable, easy to install in any vehicle, and has strong potential to reduce emergency response time and save lives [5][17].

Index Terms—IoT, Accident Detection, ESP32, MPU6050, GPS Module, GSM Module, Temperature Sensor, Rescue System, Emergency Alert

I. INTRODUCTION

Road accidents represent one of the most significant causes of mortality across the globe. According to the World Health Organization, more than 1.3 million lives are lost annually due to road crashes, with millions more sustaining serious injuries [1]. In India particularly, the road accident death rate

remains alarmingly high and continues to rise each year. The primary cause of these fatalities is not always the severity of the crash itself, but rather the delay in delivering timely medical assistance and emergency response to the accident site [9].

When accidents take place on highways or in rural areas, there are often no bystanders available to provide immediate help or raise an alarm [6]. Even in urban environments, accidents may go unnoticed or emergency calls may be delayed. In such circumstances, every minute is critical. Medical professionals refer to the first hour following a traumatic injury as the "golden hour," during which prompt treatment can significantly increase a patient's chances of survival [2].

Although most modern vehicles are equipped with basic electronic systems, very few include a feature that can autonomously detect a collision and summon help. Conventionally, the responsibility of alerting emergency services falls on the driver, which becomes impossible if the driver is unconscious or severely injured [4]. This represents a fundamental limitation in current vehicle safety systems. With the rapid advancement of Internet of Things technology, it has become feasible to develop intelligent systems capable of sensing, processing, and transmitting data automatically without human intervention [8]. IoT devices have become increasingly compact, affordable, and reliable, making them well-suited for real-world applications such as vehicle safety enhancement [7][17].

This paper presents an IoT Based Automatic Vehicle Accident Detection and Rescue System using ESP32. The system integrates an ESP32 microcontroller with an MPU6050 sensor, which functions as both an accelerometer and a gyroscope to detect sudden impacts or abnormal vehicle tilts [18]. Upon accident detection, the system autonomously retrieves the vehicle's GPS coordinates and dispatches an SMS alert to pre-registered emergency contacts via a GSM module [13].

A temperature sensor is also incorporated to identify any post-accident rise in heat around the vehicle, which may indicate fire or engine damage [7]. A buzzer and LED provide immediate on-site alerts, while a resistor is used in the circuit to regulate current flow and protect sensitive components [16]. The primary objective of this system is to minimize the time gap between accident occurrence and rescue team arrival. The system functions autonomously, requiring no action from the driver, and can be installed in any vehicle at a low cost [5][12]. The remainder of this paper is organized as follows: Section II reviews related literature, Section III describes the system hardware, Section IV outlines the system design, Section V presents the results, and Section VI concludes the paper.

II. LITERATURE REVIEW

Numerous researchers have explored various technological approaches to enhance road safety through automated accident detection. One widely studied method involves the use of smartphone-based sensors, particularly accelerometers and GPS, to identify accidents and notify the appropriate authorities [2][9]. However, such systems have notable limitations — they may fail to function correctly if the mobile device is damaged during the crash, runs out of battery, is switched off, or is not positioned optimally at the time of impact [3].

Another category of systems employs vibration or shock sensors in combination with microcontrollers to detect sudden physical impacts that are indicative of a collision [18]. Although these systems offer a reasonable degree of reliability, they are susceptible to generating false alerts triggered by rough road surfaces or speed bumps under normal driving conditions [11].

In recent years, IoT-based accident detection systems have gained considerable attention due to their enhanced reliability and accuracy compared to the aforementioned approaches [8][14]. These systems integrate multiple sensors with wireless communication technologies such as GPS and GSM to detect accidents in real time and automatically alert the relevant emergency services [6][13]. This significantly reduces the time taken for rescue teams to reach the accident site, ensures faster medical intervention, and ultimately contributes to lowering road accident fatalities [5][17].

The growing body of research in this area highlights the need for a low-cost, autonomous, and efficient accident detection and emergency alert system — which is the core motivation behind the development of the IoT Based Automatic Vehicle Accident Detection and Rescue System using ESP32 [4][16].

III. PROPOSED SYSTEM

The proposed IoT Based Automatic Vehicle Accident Detection and Rescue System is an embedded, IoT-driven solution designed to continuously monitor the operational state of a vehicle and autonomously initiate emergency response upon detecting an accident [4][16]. The system requires no manual input from the driver or any other occupant of the vehicle. The entire process — from accident detection to alert transmission

— is carried out automatically and within a short period of time [12][17].

The foundation of the system is the ESP32 microcontroller, a powerful yet cost-efficient processing unit capable of handling wireless communication while simultaneously interfacing with multiple sensors and external modules [16]. All sensors and communication components are connected to the ESP32, which oversees and coordinates every function of the system [18].

A. Hardware Components

The main components used in the system are:

- **ESP32 Microcontroller** — It is the main part of the system that handles processing. It gets data from all the sensors, works with the information, and manages the GSM and GPS parts to send out the alert.[16]
- **MPU6050 Accelerometer and Gyroscope Sensor** — This sensor picks up on sudden hits, shaking, or strange tilting of the car, which shows that an accident has happened.[18]
- **GPS Module** — This module records the actual geographical position of the vehicle, shown as latitude and longitude, at the moment an accident is detected.[13]
- **GSM Module** — This part handles sending an SMS alert to emergency contacts. The message includes a warning about the accident and a link to the GPS location.[6][13]
- **Temperature Sensor** — This sensor checks the temperature near the vehicle. If the temperature goes beyond a set limit after an accident, it alerts you about a possible fire or engine overheating.[7]
- **Buzzer** — It makes a beeping noise at the accident location to draw the attention of people around and show that there has been an accident.[12]
- **LED** — It serves as a visual sign. It activates when an accident is detected to provide a clear alert that can be seen.[12]
- **Resistor** — It is used in the circuit to limit the current, mainly to protect the LED and other delicate components from getting too much current.[16]
- **Power Supply** — The system runs using either the car's battery or an external power supply, ensuring it stays active all the time while the vehicle is in use.[5]

MPU6050 accelerometer and gyroscope sensor continuously monitors the movement and orientation of the vehicle during operation [18]. When a sudden impact or abnormal tilt is detected that exceeds a predefined threshold value, the ESP32 microcontroller interprets this as an accident event and immediately initiates the emergency response sequence [16][4].

Upon accident detection, the GPS module instantly retrieves the vehicle's real-time geographical coordinates [13]. The GSM module then transmits an SMS alert to all pre-registered emergency contacts, notifying them of the accident along with the precise location link so that rescue teams can respond without delay [6][13].

Simultaneously, the temperature sensor monitors the heat levels around the vehicle [7]. If the recorded temperature surpasses a safe threshold, an additional fire alert is appended to the SMS message, giving rescue personnel advance warning of a potential fire or engine overheating at the scene [7][19]. At the same time, the buzzer and LED indicator are activated together to provide immediate on-site audio and visual warnings, drawing the attention of any individuals in the vicinity of the accident [12][16].

To minimize false alarms caused by rough road conditions or minor abrupt movements, a cancel button mechanism is incorporated into the system [11]. If the detected event is not a genuine accident, the driver can press the cancel button within a few seconds to abort the alert before it is transmitted [4][9].

IV. SYSTEM ARCHITECTURE

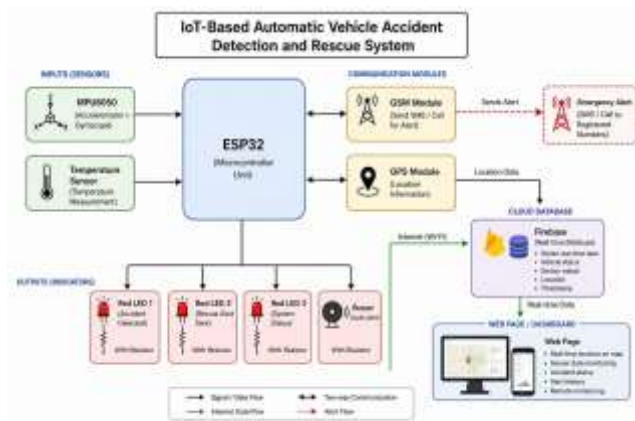


Fig. 1. Block Diagram of Accident Detection System

The system design of the proposed IoT Based Automatic Vehicle Accident Detection and Rescue System is structured to be both straightforward and highly efficient, ensuring seamless coordination among all integrated components [4][16]. The entire system is centered around the ESP32 microcontroller, which functions as the primary control hub and is responsible for managing all connected sensors and communication modules [16][18].

A. Circuit Diagram

The circuit diagram of the proposed system is illustrated in Figure 2. The ESP32 DevKit V1 acts as the central unit to which all other components are interfaced [16]. The MPU6050 accelerometer and gyroscope sensor is connected to the ESP32 using the I2C communication protocol via the SDA and SCL pins, enabling efficient two-wire data transfer between the sensor and the microcontroller [18].

The DHT11 temperature sensor is interfaced with the ESP32 through digital pin D14, allowing continuous monitoring of ambient temperature around the vehicle [7]. The SIM800L GSM module is linked to the ESP32 via UART communication, utilizing the TXD and RXD pins for transmitting and receiving data respectively, through which SMS alerts are

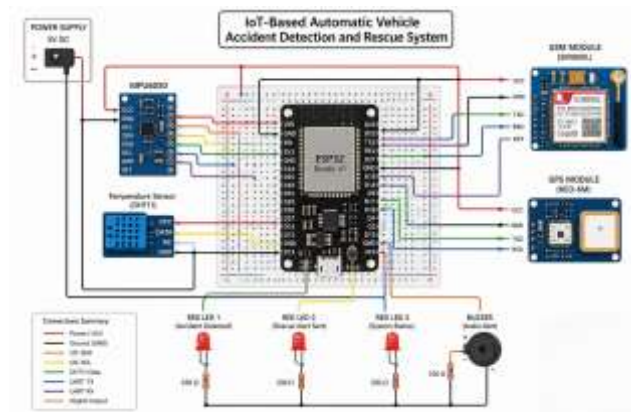


Fig. 2. Circuit Diagram of IoT Based Accident Detection System

dispatched to emergency contacts [6][13]. Similarly, the NEO-6M GPS module is connected to the ESP32 through UART pins to capture and relay real-time location coordinates upon accident detection [13].

Three red LED indicators are connected to the output pins of the ESP32, with each LED protected by a 330-ohm resistor to regulate current flow [16]. Each LED serves a distinct purpose — the first activates upon accident detection, the second illuminates when a rescue alert is successfully transmitted, and the third reflects the current operational status of the system [12]. A buzzer is connected through a 100-ohm resistor to generate an audible alert at the accident site, drawing attention from nearby individuals [12][16]. The entire system is powered by a 5V DC power supply, ensuring stable and uninterrupted operation throughout the vehicle's active use [5]. This system's design can be broken down into three key parts: the sensing part, the processing part, and the communication part.

- **Accident Detection Stage** - The MPU6050 sensor continuously tracks the vehicle's motion, orientation, and vibrations, while the temperature sensor simultaneously monitors the surrounding heat levels [18][7]. Both sensors relay their readings to the ESP32 microcontroller in real time as data is generated [16].
- **Processing Stage** - The ESP32 microcontroller receives incoming data from both sensors and evaluates whether the recorded values exceed the predefined threshold limits [4][16]. If the conditions are met, the microcontroller confirms the occurrence of an accident and immediately triggers the subsequent response sequence [11].
- **Communication Module** - Once the accident is confirmed, the GPS module retrieves the precise geographical coordinates of the vehicle, while the GSM module transmits an SMS alert to all pre-registered emergency contacts [6][13]. This message contains both the location link and temperature information, enabling rescue teams to assess the situation before arriving at the scene [7][19]. Simultaneously, the buzzer and LED indicators are activated

to provide immediate audio and visual warnings at the accident site [12][16].

The block diagram of the system, presented in Figure 1, clearly illustrates the flow of data from the sensors through the processing unit to the final emergency alert communication [5][17].

V. RESULTS AND DISCUSSION

Here is Section VI — Results and Discussion:

The IoT Based Automatic Vehicle Accident Detection and Rescue System using ESP32 was evaluated across multiple test scenarios to verify its accuracy, reliability, and overall performance. All tests were conducted under real-world conditions to assess system behavior during simulated accident situations as well as normal driving conditions [4][5].

A. Accident Detection Test - The MPU6050 sensor was tested by applying sudden jerks and tilting the device at varying angles to replicate an accident scenario [18]. The sensor successfully identified the impact and abnormal tilt in every test case without failure. The ESP32 microcontroller processed the incoming sensor data efficiently and confirmed the accident within 2 to 3 seconds of the event occurring [16]. The accident detection threshold was carefully calibrated through repeated testing to minimize false triggers caused by ordinary road bumps or uneven surfaces [11].

B. GPS Location Accuracy-

The GPS module was evaluated across multiple locations to assess coordinate accuracy [13]. Following accident detection, the module successfully retrieved latitude and longitude values within 20 to 30 seconds. The location data proved to be precise, with the coordinates accurately reflecting the accident site when verified through Google Maps. The GPS accuracy ranged between 5 to 10 meters, which is considered adequate for emergency rescue operations [6][13].

C. GSM Alert Test- Upon accident confirmation and GPS location retrieval, the GSM module successfully transmitted an SMS alert to all pre-registered emergency contact numbers [6][13]. The message was delivered within 30 to 40 seconds of accident detection. The SMS contained an alert notification, a Google Maps link reflecting the vehicle's precise location, and details regarding the temperature status at the scene [17]. The SMS delivery was verified across multiple test runs and performed consistently without any failures [12].

D. Temperature Sensor Test- The temperature sensor was evaluated by introducing a heat source near the sensor following a simulated accident scenario [7]. When the recorded temperature exceeded the predefined threshold, the system automatically appended a fire warning to the SMS alert and transmitted it to emergency contacts [7][19]. This functionality performed correctly in every test case, with temperature readings found to be both accurate and consistent throughout the evaluation [7].

E. False Alarm Test- The system was further tested on rough road surfaces and over speed breakers to assess its resistance to false alarms [11]. During initial testing, a few false detections were recorded due to threshold values

being set too low. Upon recalibrating the MPU6050 threshold parameters, the rate of false alarms reduced significantly, and the system demonstrated a clear ability to distinguish between a genuine accident and routine road disturbances [4][18].

F. Test Result Table -

TABLE I
SYSTEM TEST RESULTS

Test Case	Result	Response Time
Accident Detection	Successful	2 to 3 seconds
GPS Location Fetch	Successful	20 to 30 seconds
SMS Alert Delivery	Successful	30 to 40 seconds
Temperature Alert	Successful	Immediate
False Alarm on Bump	Not Triggered	—

VI. APPLICATIONS

The IoT Based Automatic Vehicle Accident Detection and Rescue System has a broad range of real-world applications across various domains where vehicle safety and rapid emergency response are of critical importance [5][17].

- **Private vehicles** - The system can be conveniently installed in personal cars and motorcycles, making it particularly beneficial for individuals who frequently travel alone on highways or during late-night hours [4][16]. In the event of an accident where the driver is rendered unconscious, the system autonomously dispatches an alert to family members or pre-registered emergency contacts without requiring any manual intervention [12][13].
- **Public transport** - The system is well-suited for deployment in buses and other public transport vehicles that carry large numbers of passengers [14]. In the event of a collision, the system immediately notifies the transport authority and emergency services, enabling rapid response and potentially saving multiple lives simultaneously [6][17].
- **Ambulance and Emergency Vehicles** - Even emergency vehicles such as ambulances are not immune to accidents during active operations. Equipping such vehicles with this system ensures that any collision is reported instantly and that backup assistance can be arranged without delay [9][19].
- **Military and Border Patrol Vehicles** - Vehicles operating in remote or border regions where communication infrastructure is limited or unavailable can greatly benefit from this system [7][14]. It enables automatic accident reporting and transmits precise location information to the base station, facilitating swift rescue operations even in the most isolated environments [13][15].

VII. CONCLUSION

This paper has presented the IoT Based Automatic Vehicle Accident Detection and Rescue System using ESP32, developed with the primary goal of minimizing the delay in emergency response following a road accident [4][16]. The system was built using affordable and readily available components, including the ESP32 microcontroller, MPU6050

accelerometer and gyroscope sensor, NEO-6M GPS module, SIM800L GSM module, DHT11 temperature sensor, buzzer, LED indicators, and resistors [16][18].

The core objective of the system was to autonomously detect a vehicle accident without any human involvement and immediately transmit an alert message containing the precise location to pre-registered emergency contacts [12][13]. This objective was successfully validated through repeated testing. The system demonstrated the ability to detect accident events within 2 to 3 seconds, retrieve GPS coordinates, and deliver SMS alerts to emergency contacts within 30 to 40 seconds from the moment of accident detection [6][13]. The integration of the temperature sensor provided an additional layer of safety by identifying potential fire outbreaks or engine overheating in the vicinity of the vehicle following a collision [7][19].

The proposed system is straightforward in design, easy to install across all vehicle types, and operates fully autonomously without requiring any input from the driver [5][17]. Its low cost further enhances its practicality and suitability for widespread real-world deployment [4][16]. The issue of false alarms was effectively addressed by carefully calibrating the threshold values of the MPU6050 sensor, ensuring that routine road disturbances such as bumps or vibrations do not trigger unnecessary alerts [11][18].

Overall, this system holds strong potential to contribute significantly to reducing road accident fatalities by ensuring that rescue teams are promptly and accurately informed about the accident location and prevailing conditions at the scene [1][8]. Every minute saved in emergency response time can prove to be the decisive factor between life and death for an accident victim [2][9][20].

A. Future Scope

In future this system can be further improved by adding the following features:

- **A.Hospital Database Integration** — The system can be extended to interface with nearby hospital databases, enabling automatic notification of the closest medical facility along with emergency contacts upon accident detection [19]. This would ensure that medical teams are prepared and ready to receive the victim even before the rescue vehicle arrives at the scene [2][9].
- **B.Camera Module Addition** — A camera module can be integrated into the system to capture images or short video clips at the accident site and transmit them alongside the SMS alert [15]. This would give emergency responders a clearer visual understanding of the severity of the accident before their arrival [17].
- **C.Machine Learning Integration** — Incorporating machine learning algorithms into the accident detection process can significantly enhance detection accuracy and further reduce the occurrence of false alarms [10]. Trained models can learn to better distinguish between genuine accident events and normal road disturbances over time [11].

- **D.Google Maps API Integration** — The system can be upgraded to incorporate the Google Maps API, enabling real-time live tracking of the vehicle's location by rescue teams following an accident [13]. This would allow emergency responders to navigate more efficiently to the accident site [6].
- **E.Manual SOS Button** — An SOS button can be added to allow the driver to manually trigger an emergency alert in any critical situation, even if the sensors do not detect an accident automatically [12]. This provides an additional layer of safety and control for the vehicle occupant [4].
- **F.Cloud Connectivity** — Upgrading the system with cloud integration would allow accident data to be stored, monitored, and analyzed remotely for research and statistical purposes [5][19]. This data can be leveraged by authorities and researchers to identify accident-prone zones and develop more effective road safety strategies [8][20].

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