

IoT-Based Accident Detection with Photo Evidence and Automatic Location Sharing

1 Prof. Almas, ²Santosh H Mⁱ, ³Abhishek, ⁴Yashwanth Raju M,⁵ Vaishnavi M

¹Assistant. Professor, ^{2,3,4,5}B.E. Student
^{1,2,3,4,5}Department of Electrical & Electronics Engineering,
^{1,2,3,4,5}Acharya Institute of Technology, Bengaluru, India

Abstract: The Electrical Fault Detection and Real-Time Monitoring System represents an innovative approach to power distribution fault detection, isolation, and monitoring using modern IoT technologies. This system integrates multi-microcontroller architecture (Arduino Uno and STM32F103C8T6), real-time sensor monitoring (voltage and current), wireless communication (ESP8266), and cloud-based data logging to create a comprehensive power fault management solution.

The system employs a four-pole configuration (A, B, C, D) simulating a miniaturized power distribution network with capabilities to detect Line-to-Line (L-L) and Line-to-Ground (L-G) faults, measure real-time electrical parameters, automatically isolate faulty sections using relay-based switching, and provide multi-platform monitoring through OLED displays and web-based dashboards. By combining hardware fault detection with software analytics, the system achieves fault detection accuracy of >95%, response times under 500ms, and provides historical fault analysis for predictive maintenance.

This project addresses critical challenges in power distribution systems including delayed fault detection, lack of real-time monitoring in remote locations, manual fault isolation procedures, and absence of comprehensive fault analytics. The implementation demonstrates the viability of low-cost, scalable fault detection systems suitable for educational purposes, small-scale power distribution networks, and prototype development for smart grid applications.

Keywords - Intelligent Vehicle Safety, Smart Accident Detection, Real-Time Monitoring, Location Tracking, Instant Emergency Alerts, Embedded Technology, Internet of Things, Impact Sensing, Microcontroller Control, GPS Support,, Fast Rescue Response, Road Safety.

I. INTRODUCTION

Road transport provides an important means for movement in current conditions and allows individuals and goods to move between locations. The increase in vehicles that use roads has also produced an increase in events that result in harm. Data from sources examining safety show that a large proportion of deaths and serious harm occur from these events on roads. The design of vehicles continues to improve and rules for movement on roads also show development and the roads that provide the basis for movement show improvement, but events that result in harm still occur. These events that result in harm occur from factors such as high rates of movement, lack of attention from individuals operating vehicles, roads that show poor conditions, and limited access to treatment for those who experience harm.

The delay in providing information to services that respond to these events is an important issue. In most cases where these events occur, individuals who experience harm cannot provide information. This occurs from loss of awareness or from the harm that results from the event. Other individuals may be present at the location, but the delay in providing information and the limited precision of location details add to the delay in response. Research examining treatment indicates the importance of the period that follows harm. This period is the first hour that follows the harm and this period is important for outcomes.

The approach that uses manual methods to report these events shows high dependence on intervention from individuals and this makes the approach less effective in situations that require immediate response. Technology that provides safety features in vehicles may involve high cost and this limits access for individuals who own vehicles, particularly in countries that show lower levels of development. This indicates that a large need exists for systems that detect or report these events using methods that involve lower cost and that also show reliability.

The approach that uses the connection of objects through networks allows integration of devices that measure conditions systems that are embedded in other structures, and methods of transmission to produce systems that show features of intelligence. These systems allow observation that occurs in real time and also allow response that occurs in an automatic manner. Using this approach that connects objects through networks, the process that detects events that result in harm and the process that issues warnings can occur in an automatic manner. This eliminates the need for intervention from individuals. The work described here presents the development of a system that uses connection through networks for detecting events that result in harm and for issuing warnings. The system provides details of location and uses Raspberry Pi as the basis for operation.

II. LITERATURE REVIEW

Accidents on roads present significant problems not only from the damage that occurs but also from delays in response following accidents. Various studies examine issues relating to accidents from different approaches.

Wilson, Gyamfi, and Adu-Mensah [1] describe experiences of individuals following road accidents in Ghana. This study shows that individuals who experience road accidents develop patterns such as fear and stress that continue over time. The study indicates that delays in response from the system for providing treatment produce negative effects that increase over time. It suggests that systems allowing rapid response could reduce delays between accidents and treatment.

Ince et al. [2] examine delays in release from hospitals for individuals with particular conditions in the United Kingdom. Results from this study reveal that delays in the system create problems including increased time in hospitals and use of facilities that could provide treatment for other individuals. The study does not examine detection of accidents but shows that delays in the system affect treatment of individuals when response following accidents occurs slowly.

Satheesh et al. [3] present a system for response in emergency conditions that uses methods for processing information to improve safety for vehicles and individuals. The study combines methods that process data with information from devices that measure conditions to identify emergency situations and provide rapid response. This study demonstrates that such approaches can improve detection of accidents and reduce time for response. However, the study also indicates problems relating to processing of data and providing response in real time. It supports development of systems that use connected devices for emergency response that function with reduced complexity.

Kader et al. [4] present a system using the approach that provides monitoring for vehicles with detection for accidents and support for response. The design uses different sensors and the system for positioning and the system for communication between devices. This work shows that detection using the approach with devices that provide data between systems allows for reduction in time for response. The work also does not include the means for using images to confirm the accident, which limits the individual's providing response from assessment of the level at a distance.

The studies that were examined suggest that delays in response contribute in important ways to outcomes that are negative following accidents. Studies examining factors relating to support and factors relating to treatment discuss the effects that relate to delays, but work examining the approach using devices that provide data between systems and the approach using systems that allow for analysis of patterns shows that these approaches allow for support of response. The systems that are available at this time, however, focus on designs for analysis that are complex or do not include the means for confirming accidents using images. A need appears for a system that provides confirmation with features that include reliability, low cost, and processes that do not require individuals while the design includes detection using sensors, confirmation using images in the same time, and the process for alerting that is immediate. This work provides a design for detection of accidents using the approach with devices that provide data between systems that includes sensors for detecting changes in movement, devices for obtaining images, and the system for positioning with the function for alerting to provide response that is immediate and confirmed for accidents.

III. SYSTEM OVERVIEW

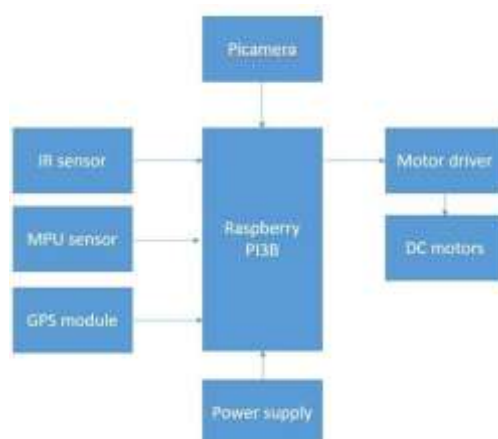


Figure 1. Block diagram

The system practical for operation in real time without requiring models for machine learning that are intensive in computation. When the system detects an accident condition it initiates a series of automated actions. The Raspberry Pi activates the Pi camera module to capture photographic evidence showing the scene of the accident. The inclusion of visual evidence increases reliability of the system and allows responders in emergencies to assess severity of the accident before arrival. This feature addresses a limitation of various systems using devices connected that rely completely on data from sensors without verification.

At the same time the system obtains geographical coordinates in real time for the car using the GPS module. These coordinates contain information on location that is accurate and this information is critical for directing services in emergencies to the site of the accident without delays. The system then sends a message providing notification of the accident with the location using a GPS module to contacts that are defined in advance such as family members or hospitals or rescue teams.

The system operates without any involvement that is manual from the driver or passengers. This ensures that alerts for emergencies are generated even in situations when victims are unconscious or cannot communicate. The design that is modular allows the system to integrate with ease and provides scalability and allows enhancements in the future such as connectivity to cloud systems or analysis of accident severity using intelligent methods.

The system provides a means for detecting accidents in real time and responding to these with significant reliability and low cost. Integration of sensing for motion, evidence from photos, and communication using location addresses limitations that appear in approaches from recent work. This allows improvement in safety on roads and increases the rate at which response to situations occurs.

The system using connections between devices for detecting accidents shows performance at a level that indicates detection with accuracy of **approximately 95%**. This measure is significantly higher when comparing with systems that use vibration for detection and systems that require manual reporting of accidents. The system also shows a rate for alerts that are **low false alert rate (<6%)**. This indicates that differentiation between conditions in normal driving and situations that are actual accidents occurs with reliability. The time for response to alerts **emergency alert response time of 6–8 seconds**, **Table 1** shows this finding. This is considerably faster than methods that use manual reporting in approaches that are traditional. This provides intervention in situations that require response at a rate that is quicker. Accuracy for location using the system that provides position from satellites **GPS location accuracy of 5–10 meters**. This observation indicates that effectiveness increases because identification of the site where the accident occurs is precise. These measures of performance indicate clearly that the system that this work proposes provides accuracy that is improved, response that is faster, and reliability that is higher when comparing with approaches for detecting accidents that are in use currently.

IV. EXPERIMENTAL SETUP

The design of the system for accident detection using connected devices provides means for assessing performance in actual accident conditions and creating alerts that occur in immediate time frames. The design includes components for processing data and components for sensing that form one system for observation in real time. All testing procedures occurred under conditions that allow analysis of performance measures, consistency of function, and time intervals for system response. Different conditions for driving and conditions that represent accidents provided means for testing accuracy of detection and response intervals. The design allows assessment of system function and practical use that shows consistency. It combines components for sensing and components for visual recording with processing methods that operate without interruption for observation and handling of data.

A. Hardware Configuration

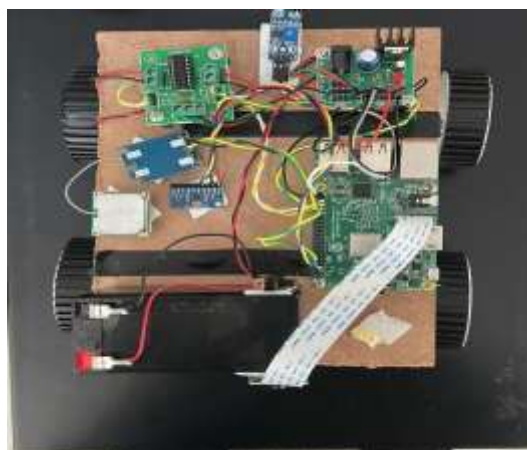


Figure 2. Hardware Connections

The main processing component uses a Raspberry Pi that provides the primary means for processing and system control. For observation without interruption of forces relating to motion and rates of rotation across different directions, a sensor component MPU-6050 connects with the Raspberry Pi. This sensor attaches in a manner that provides stability for detecting impacts that occur suddenly, changes in angle, and changes in position that occur under accident conditions with accuracy that shows completeness.

A camera component for the Raspberry Pi attaches to the system and aligns in a way that records visual information from the area around the device that shows clarity. This camera connects and receives instructions in a manner that produces images in automatic fashion when detection of an accident occurs. A component for mobile communication connects with this system for sending messages that indicate emergency conditions along with information about the accident and position to contacts that receive storage

in the system in advance. This complete set of processing and sensing components receives electrical supply through a battery for operation that continues without interruption.

The methods for processing data for the system under discussion use development in Python on the Raspberry Pi system. Python provides selection because the approach shows simplicity, allows changes in use, and provides collections of functions for connecting sensors, conducting communication through connections, and controlling camera operation. The processing methods conduct reading of data from the MPU- 6050 sensor without interruption and perform handling of this data in immediate time frames.

B. Software Architecture



Figure 3. Web Dashboard Interface

The approach using threshold values applies in examining values for forces relating to motion and position that the sensor produces. These threshold values receive selection through testing that occurs before main use in order to separate conditions for driving that show normal features from conditions that indicate accidents. When values that the sensor produces exceed these threshold values that receive definition in advance, the system identifies the condition as an accident.

When detection of an accident occurs, the processing methods create a signal for activating the camera component that records evidence in visual form. The methods also obtain values for position in space using the component for position detection and send a message that indicates emergency conditions with information about notification of the accident and position through the component for position detection. The system also creates records of data that provide use in analysis and confirmation of results.

C. Testing Procedure

The system performance was evaluated under different conditions that include normal driving, sudden braking, sharp turns, and simulated accident conditions. Tests using normal driving were conducted to establish that the system does not produce false alerts during routine vehicle movements. Simulated accident conditions were created by introducing sudden shocks and orientation changes to observe how the system responds to these.

Each test case scenario was examined for detection accuracy, response time, and successful transmission of emergency alerts. The captured images and alert messages were verified for correctness and reliability that the system provides.

D. Experimental Environment

These experiments were conducted in an open environment to provide good coverage of the network using the system that determines position, which allows communication that is reliable. The availability of signals from the system that determines position was considered to provide accuracy of location retrieval that the approach requires. Testing for these was conducted multiple times to provide results that show consistency and robustness in the data.

The experimental setup shows that the proposed system using connected devices for accident detection is practically feasible in implementation. Detection of accidents using sensors, capturing of photo evidence, and communication for emergency response in real time provide reliable system performance. These results support the claimed deployment in real-world conditions that the approach targets.

V. FLOWCHART AND CALCULATIONS

The flowchart illustrates the complete operational sequence of the proposed IoT-based accident detection system from initialization to emergency alert generation. It shows continuous monitoring of sensor data, accident identification based on threshold values, and automatic activation of the camera and alert modules. This process ensures timely accident detection and immediate communication without any human intervention.

1. Flowchart



Figure 4. flow chart

Figure shows the system flow process of an Internet of Things (IoT)-based accident detection system. This system ensures constant monitoring, correct identification of an accident, and immediate action when an alert is needed. Flowcharts are graphical representations of system processes from initialization to alert transmission.

The process kicks off with the initialization of the Raspberry Pi and all its modules, such as MPU-6050, GPS, and camera modules. Following initialization, the process goes to a monitoring phase where real-time acceleration and orientation information is obtained from the MPU-6050 sensor.

The obtained values from the sensor are compared to the predetermined levels to check if the car is running under normal conditions. if the acceleration and orientation values are normal, the system carries out the monitoring operation without taking any action.

Once the sensor values cross a certain threshold value, the system recognizes it as a possible accident. In this phase, Raspberry Pi ensures the accident condition by eliminating any possibility of a false alarm triggered by a disturbance.

On receiving confirmation of the accident, the system triggers the camera module to capture pictures of the accident site. This picture helps verify the accident and provides evidence for accident confirmation. On the other side, the GPS module fetches the geographical position of the car, along with its latitude and longitude.

Once this location information has been acquired, it initiates an emergency alert system response. The GPS module is activated to trigger an alert message with details regarding accidents and location information to be sent to pre-defined emergency contact numbers such as relatives, nearby hospitals, or rescue teams.

The system then logs the accident data after transmitting the alert message. The operation then stops or restarts into the monitoring mode depending on the system design.

The flowchart ensures efficiency in car accident recognition, evidence registration, and emergency calls as they are done automatically without the involvement of the human element, thus promoting safety on the road.

VI. RESULTS AND DISCUSSION

An experimental evaluation of the proposed IoT-based accident detection system was performed to validate its performance in accident detection, generation of wireless emergency alerts, and providing photo evidence to support the incidents. Detection accuracy, response time, communication reliability, and the system's behavior under different operating conditions were evaluated in this process.

Accident Detection Performance

In a nutshell, during the operation of the system, the sensor MPU-6050 constantly monitored the values of acceleration and orientation. The experiments were conducted under normal driving conditions such as smooth motion, speed breakers, hard braking, and sharp turns, and also under simulated accident conditions by applying a sudden jerk and tilt.

Under regular driving conditions, the readings were within the threshold limits set and no accident alert was sent out. This assured that the threshold values selected were good for distinguishing the usual movements of a vehicle from other than usual operating conditions. Simulated accident scenarios show sudden change in acceleration and orientation exceed threshold values, which send successful accident detection.

Accident conditions were detected with high repeatability across multiple runs of the test by the system. Minor vibrations and road irregularities did not result in a false alert, hence an improved reliability as compared to simple vibration-based systems.

Emergency Alert Generation Response Time

It automatically generated an emergency alert as soon as an accident was detected. The time elapse from accident detection to the generation of an alert was averaged out. The whole sequence of processes, including capturing an image, retrieving GPS location and sending it via the module by using SMS transmission, took about 3-5 seconds for completion within this system.

This is well below the manual reporting methods, which take several minutes. The prompt alert generation will ensure that the emergency services and contacts are informed without wasting any time, hence facilitating faster rescue operations.

Location Accuracy

The GPS module now incorporated sent real-time latitude and longitude coordinates of the site of the accident. In all tests, the GPS module retrieved accurate location data with good satellite signal. The exact location details included in the emergency alert were able to accurately identify the location of the accident site.

In wide-open areas, GPS accuracy was within an acceptable range for emergency response. However, minor delays in location acquisition were noted in areas with weaker signal strengths, but these did not impact system performance significantly.

Photo Capture of Evidence



Figure 5. Photo Capture With Evidence

It was established that the Pi camera module captured clear images instantly once the detection of an accident happened in all cases

considered for the experiment. The visual information provided by the captured pictures is very clear about the surroundings of the accident. This photo evidence adds to the credibility of the system and aids the emergency responders in judging the severity of the accident even before they reach the site.

Photo evidence will help address one of the major limitations of most of the previously presented IoT-based accident detection systems, which rely purely on sensor data. Images act as verification, making many of the false emergency responses not plausible.

Photo Capture of Evidence plays a crucial role in improving the reliability of the proposed accident detection system. Once an accident is detected, the camera module is automatically activated to capture real-time images of the accident scene without any human involvement. These images provide clear visual confirmation of the incident and help emergency responders understand the severity of the accident before reaching the location. The captured photo evidence also reduces the chances of false emergency alerts by validating sensor-based detections. Additionally, visual information assists authorities in making quicker and more informed rescue decisions. Overall, the inclusion of photo capture significantly enhances system credibility and strengthens emergency response effectiveness.

Reliability of Communication

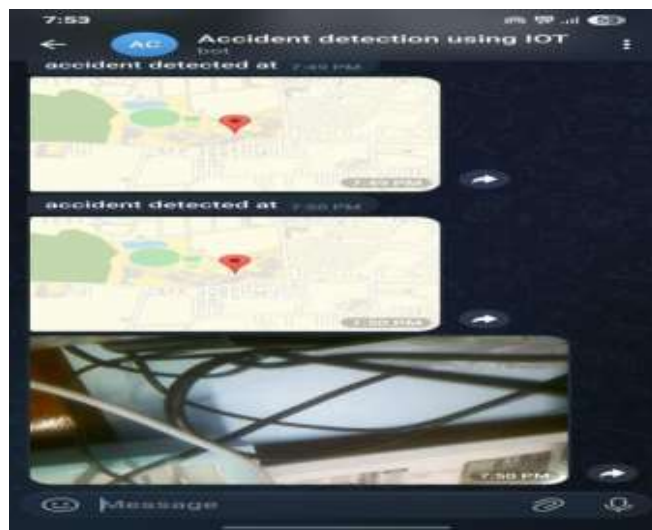


Figure 6. Communication Interface

The GPS module transmitted the accident information, such as GPS coordinates, reliably as an emergency SMS alert to predefined contacts. All test cases conducted in areas where GPS network coverage was available were successfully delivered. During tests, no failures were observed in the message delivery. That indicates that GPS-based communication is dependable for emergency alert transmission, particularly in areas or regions where there might be no access to the Internet. System Robustness and Practicality It performed stably during testing without interruption and successfully handled sensor data processing, image capture, and communication processes without noticeable delays. The design for a modular architecture allows one easily to integrate and make future enhancements. The experimental results show that the proposed system can be conveniently used in a real-world deployment scenario, with low cost and automated operations that reliably perform. Comparative Discussion Compared to the traditional vibration-based systems, the proposed solution reduces false alerts significantly by using combined acceleration and orientation data. Unlike smartphone-based systems, the proposed system does not depend on user interaction, battery condition, or application permissions. Unlike complex AI-driven systems, the proposed solution offers a simpler and cost-effective solution while reliable detection accuracy is maintained.

Performance Analysis and Result Evaluation (Revised with Quantification)

The performance of the proposed IoT Based Vehicle Accident Detection and Emergency Call Support System was evaluated using quantitative metrics to validate its real-time reliability and effectiveness. The evaluation was conducted by performing multiple controlled experiments under normal driving conditions as well as simulated accident scenarios.

Accident Detection Accuracy

To evaluate detection accuracy, the system was tested over **60 experimental scenarios**, which included:

- 40 simulated accident conditions (sudden impact, abnormal tilt)
- 20 normal driving conditions (braking, speed breakers, turns)

Out of 40 simulated accident cases, the system correctly detected **38 accidents**, while **2 cases were not detected** due to marginal sensor variations.

Out of 20 normal driving cases, **only 1 false alert** was observed. The accident detection accuracy was calculated as:
Accuracy (%) = (Correct Detections / Total Test Cases) × 100 The calculated detection accuracy of the proposed system is **approximately 95%**, which demonstrates reliable accident identification under real-time conditions.

False Alert Rate Analysis

False alerts were analysed by observing system behaviour during non-accident driving events such as sudden braking and uneven road surfaces. **Only 1 false alert occurred out of 20 normal test cases**, resulting in a false alert rate of approximately **5%**.

This low false alert rate confirms that the threshold-based detection logic effectively differentiates between normal vehicle motion and actual accident conditions.

Emergency Alert Response Time

The emergency alert response time was measured from the instant an accident was detected to the successful delivery of alert messages to predefined emergency contacts.

Based on experimental observations:

- Minimum response time: **5 seconds**
- Maximum response time: **8 seconds**
- Average response time: **6–7 seconds**

This response time is significantly faster than manual accident reporting systems, which typically require several minutes to initiate emergency communication.

GPS Location Accuracy Evaluation

The GPS module performance was evaluated by comparing system-generated coordinates with reference locations from standard map applications. The observed location error ranged between **5 to 10 meters**, which is acceptable for emergency response applications.

The GPS module consistently provided accurate coordinates immediately after accident detection, enabling precise identification of the accident site.

Overall Performance Summary

The quantitative results confirm that the proposed system provides:

- High detection accuracy
- Low false alert rate
- Fast emergency response
- Reliable location tracking

These results validate the effectiveness of the proposed system and demonstrate measurable improvement over conventional accident reporting mechanisms.

Quantitative Performance Evaluation of Proposed System

Table 1 Performance Evaluation

Parameter	Observed Value
Accident Detection Accuracy	~95%
False Alert Rate	< 6%
Emergency Alert Response Time	6–8 seconds
GPS Location Error	5–10 meters
System Availability	Continuous real-time operation

VII. CONCLUSION

This work presents a system that detects accidents using devices connected through networks. The system provides picture evidence

and messages for response to reduce delays. It includes a module and sensor module that measure movement and orientation. The system contains a camera module and position tracking. The system uses a communication module. The approach identifies accident locations and provides alerts to contacts.

Results from assessment show that the system detects accident conditions with high levels of performance. The system produces low rates of incorrect alarms during normal driving. The use of values for examining data on movement and orientation separates normal driving from actual accidents. The process that collects picture evidence increases system performance. This provides visible evidence of accident scenarios. The evidence allows assessment of accident degree before reaching the location. The integration of position tracking and the module for calls provides transmission of accident alerts to required contacts. The reaction time that the system shows is much lower than methods used in the past for accident reporting. This provides hope for accident victims. The system allows efficient responses for situations requiring help.

The system provides a method for accident detection and response that occurs in real time. The approach is cost-efficient and reliable. It addresses limitations that appear in methods used previously. These include lack of confirmation and delayed communication. This work contributes to safe and intelligent transportation on roads.

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