International Journal of Engineering and Techniques - Volume 12 Issue 2, March-April - 2026

RESEARCH ARTICLE OPEN ACCESS

Gyroscope-Based Real-Time Accident Detection and Emergency Alert System

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Abstract:

Road accidents are a major global cause of fatalities, often worsened by delayed emergency response. This paper presents a Real-Time Accident Detection and Emergency Alert System using IoT technology. The system employs gyroscope sensors with an Arduino microcontroller to continuously monitor vehicle motion and detect accidents through abnormal tilt and impact. Upon detection, it automatically triggers alerts, activates a buzzer, and sends GPS-based emergency SMS notifications via a GSM module. The solution ensures immediate response without human intervention, improving safety and reducing accident-related deaths.

***Keywords*— Internet of Things, Accident Detection, Gyroscope Sensor, Emergency Alert System, GPS Tracking, GSM Communication, Arduino, Vehicle Safety.**

I. INTRODUCTION

Road safety has become a critical concern in today's world, especially in improving accident detection and emergency response systems. Effective communication between vehicles, emergency services, and healthcare facilities plays a vital role in enhancing safety standards. Road accidents often result in serious injuries or fatalities due to delays in providing timely assistance. This problem is more severe in remote or isolated areas where immediate help is not available. In many situations, victims may be unconscious or unable to call for help after an accident. Traditional accident reporting systems rely heavily on manual communication, which is not reliable during emergencies. Additionally, CCTV surveillance systems are limited to specific monitored locations and cannot cover all accident-prone areas. The Internet of Things (IoT) offers a powerful solution by enabling devices to connect and communicate over the internet. Embedded systems equipped with sensors such as gyroscope and GPS can continuously monitor vehicle conditions. These sensors help in detecting abnormal motion, tilt, or sudden impact indicating an accident. Once an accident is detected, the system can automatically trigger emergency alerts without human intervention. The system retrieves the exact GPS location of the accident site. It then sends this information to pre-registered contacts or emergency services using communication modules like GSM. This reduces the response time and increases the

chances of saving lives. Overall, such IoT-based solutions significantly improve road safety and emergency management.

II. RELATED WORKS

Several research works have been carried out in the field of accident detection and emergency alert systems using IoT and embedded technologies. Wireless sensor-based systems have been widely used to monitor vehicle dynamics and detect abnormal conditions in real time. Many researchers have implemented IoT-based accident detection systems that automatically send alerts to emergency contacts when a collision occurs.

Arduino-based systems integrated with GPS and GSM modules are commonly used to transmit location details through SMS, ensuring faster emergency response. Some studies have focused on using accelerometers and MEMS sensors to detect sudden impact and vehicle tilt. Smartphone-based accident detection applications have also been developed using built-in sensors such as GPS and accelerometers. However, these solutions often suffer from limitations such as device damage, battery drain, and unreliable network connectivity. CCTV-based accident detection systems have been explored but are restricted to specific monitored areas and are not effective in remote locations. Recent advancements include IoT-based smart accident detection systems combined with cloud computing for real-time data processing and storage.

Some researchers have also integrated image processing techniques to enhance accident detection accuracy. In addition, systems incorporating health monitoring sensors have been proposed to track the condition of victims after accidents. Machine learning approaches are being explored to improve detection accuracy and reduce false alarms. Despite these advancements, many existing systems still rely partially on human intervention or lack continuous monitoring capabilities. Therefore, there is a need for a fully automated, reliable, and cost-effective solution. The proposed system addresses these gaps by ensuring real-time monitoring, automatic detection, and instant alert transmission without human involvement, thereby improving road safety and emergency response efficiency.

III. EXISTING SYSTEM

The existing accident detection systems primarily rely on manual reporting methods, which require victims or eyewitnesses to inform emergency services. In most cases, individuals must make phone calls and provide location details, which can lead to delays and inaccuracies. These systems are highly dependent on the victim's physical condition, making them ineffective if the person is unconscious or severely injured.

As a result, emergency response time increases, reducing the chances of survival. Smartphone-based accident detection applications have also been introduced using sensors like accelerometers and GPS. However, these applications face issues such as battery drain, accidental shutdown, and physical damage during accidents. Network connectivity problems further reduce their reliability in remote areas.

Additionally, many applications require manual activation or continuous background operation, which is not always guaranteed. CCTV-based surveillance systems are another approach used for accident detection. These systems are limited to specific monitored areas and cannot cover highways or rural regions. They also require continuous monitoring or advanced image processing, increasing cost and complexity. Overall, existing systems lack automation, reliability, and full

coverage, making them insufficient for effective accident detection and emergency response.

Therefore, there is a need for an improved system that provides real-time monitoring, remote access, cost-effectiveness, and better accuracy.

IV. PROPOSED SYSTEM

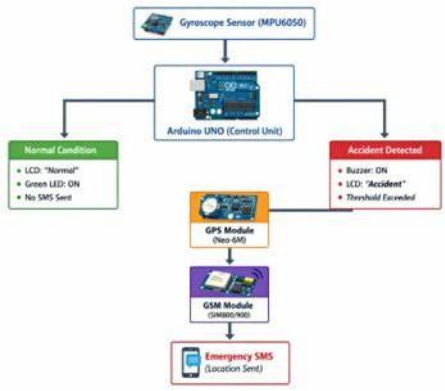
4.1 Real-Time Accident Detection and Emergency Alert System

The proposed system is a Real-Time Accident Detection and Emergency Alert System using IoT technology.It uses a gyroscope sensor (MPU6050) to continuously monitor vehicle movement and detect abnormal tilt or impact.

An Arduino microcontroller processes the sensor data in real time. When an accident is detected, the system automatically triggers an emergency response without human intervention. A buzzer is activated to provide an immediate local alert. The GPS module (Neo-6M) retrieves the exact location of the accident.The GSM module (SIM800/900) sends SMS alerts to pre-registered contacts.

An LCD display shows the system status and alert messages. The system works even if the victim is unconscious or unable to call for help. Overall, it ensures fast response, improves safety, and reduces accident-related fatalities.

4.2 System Architecture



4.3 Sensor Integration and Analysis

A. Accident Detection using Gyroscope: Accident detection is a critical component of the system, as it directly determines when emergency protocols must be activated. Any abnormal change in vehicle orientation or sudden impact indicates a possible accident. When the tilt angle exceeds predefined thresholds or sudden vibration is detected, the system identifies it as an accident condition.

The system employs an MPU6050 gyroscope sensor for real-time motion monitoring. The sensor measures angular velocity and acceleration along three axes (X, Y, Z). The tilt angle is calculated using sensor data, and abnormal variations are analyzed using threshold logic. This approach offers advantages such as high sensitivity, fast response, and accurate detection of collision events.

B. Location Tracking and Position Detection: Accurate location tracking is essential for effective emergency response and rescue operations. Immediately after accident detection, the system must determine the exact position of the vehicle to guide emergency services.

The system uses the Neo-6M GPS module to obtain real-time geographic coordinates. The GPS provides latitude and longitude values based on satellite signals. These coordinates ensure precise tracking of the accident location, even in remote areas. The

module offers high accuracy (2–3 meters) and reliable performance under open sky conditions.

C. Emergency Communication System: Quick communication plays a vital role in reducing response time during accidents. The system must instantly notify concerned authorities or contacts without delay.

The SIM800/900 GSM module is used for wireless communication. It sends SMS alerts containing accident notification and GPS location details to pre-registered phone numbers. The message transmission is done using standard AT commands over cellular networks, ensuring wide coverage and reliable communication.

D. Alert and Safety Mechanism: Immediate local alerting is important to attract nearby people who can provide quick assistance before emergency services arrive. This reduces the time gap between accident occurrence and first response.

The system includes a buzzer that activates instantly when an accident is detected. The buzzer produces a loud sound to notify nearby individuals. Additionally, a 16×2 LCD display shows real-time system status, including normal operation and accident alerts, providing clear visual feedback.

E. Control and Decision-Making Module: The control module acts as the brain of the system, managing all operations and ensuring proper coordination between components.

The Arduino UNO microcontroller processes continuous data from sensors and compares it with predefined threshold values. Based on this analysis, it determines whether the condition is normal or an accident. Upon detection, it triggers all emergency actions such as activating the buzzer, retrieving GPS data, and sending SMS alerts.

F. Automated Emergency Response: The system ensures a fully automated response mechanism, eliminating the need for human intervention during critical situations.

Once an accident is detected, all modules work together to execute emergency protocols instantly. The system continuously monitors vehicle status, ensuring rapid detection and immediate alert transmission. This automation significantly reduces rescue time and improves survival chances, making the system highly effective for real-world applications.

V. SYSTEM MODULES

Module 1: Sensor (Accident Detection) Module

Continuously monitors vehicle motion using the MPU6050 gyroscope sensor. Detects abnormal tilt angles, sudden vibrations, and impact forces. Implements threshold-based logic to identify accident conditions accurately and reduce false detections.

Module 2: Control (Processing) Module

Arduino UNO acts as the central processing unit, collecting sensor data and analyzing it in real time. Executes decision-making algorithms to differentiate between normal movement and accident scenarios, and triggers emergency protocols when required.

Module 3: Location Tracking Module

Uses Neo-6M GPS module to determine precise geographic coordinates of the vehicle. Retrieves latitude and longitude values during emergency situations to ensure accurate location tracking for rescue operations.

Module 4: Communication Module

SIM800/900 GSM module is used to transmit emergency alerts. Sends SMS notifications containing accident alerts and GPS coordinates to pre-registered contacts using cellular network communication.

Module 5: Alert & Display Module

Includes a buzzer for immediate audio alert and a 16×2 LCD display for real-time system status. Displays messages such as "System Normal" and "Accident Detected" to provide clear user feedback.

Module 6: Emergency Response Module

Automatically activates when an accident is detected, coordinating between GPS and GSM modules to send alerts instantly. Ensures quick response without human intervention, reducing delay in rescue operations and improving survival chances.

VI. FUTURE WORK

The proposed system can be further enhanced with several advanced features to improve its performance and reliability. In future, machine learning algorithms can be integrated to analyze sensor data more accurately and reduce false accident detections. The system can also be connected to a mobile application for real-time monitoring, notifications, and tracking of vehicle status. Integration with cloud platforms can enable data storage, analysis, and access to accident history for better decision-making.

Additionally, the system can be expanded to automatically notify nearby hospitals, ambulance services, and police stations based on the accident location. Incorporating additional sensors such as alcohol detection can help prevent drunk driving incidents. The inclusion of camera modules and image processing techniques can provide visual evidence of accidents. Vehicle-to-Vehicle (V2V) communication can be implemented to alert nearby vehicles and prevent further collisions. Integration with smart city infrastructure can enhance traffic management and emergency response systems. The system can also be improved with better network connectivity using 4G/5G technologies for faster communication. Overall, these future enhancements will make the system more intelligent, efficient, and widely applicable in real-world scenarios.

OUTCOME OF THE SYSTEM

The outcome of the proposed system is the successful development of a reliable and efficient Real-Time Accident Detection and Emergency Alert System. The system continuously monitors vehicle movement and accurately detects accidents based on abnormal tilt and sudden impact. Upon detection, it immediately activates a buzzer to alert nearby people and initiates emergency protocols without any human intervention. The GPS module provides precise location coordinates of the accident spot, ensuring accurate tracking. These details are instantly sent to pre-registered contacts through the GSM module as SMS alerts.

The system significantly reduces the delay in emergency response, which is critical in saving lives during accidents. It ensures that help can be dispatched even when the victim is unconscious or unable to communicate. The LCD display provides real-time status updates, improving system transparency and usability. Overall, the system enhances road safety by enabling quick detection, fast communication, and timely rescue operations, making it a practical and cost-effective solution for modern vehicular safety systems.

CONCLUSION

The proposed Real-Time Accident Detection and Emergency Alert System demonstrates an effective solution to improve road safety using IoT technology. It successfully integrates sensors, microcontroller, and communication modules to provide continuous vehicle monitoring. The system is capable of detecting accidents automatically based on abnormal tilt and sudden impact conditions. One of its key advantages is that it operates without any human intervention. This makes it highly reliable, especially in situations where victims are unconscious or unable to call for help. The

integration of GPS ensures accurate location tracking of the accident site. The GSM module enables immediate transmission of emergency alerts to predefined contacts.

The inclusion of a buzzer and LCD display enhances both local and system-level awareness. Compared to traditional systems, it significantly reduces the delay in emergency response. The system is cost-effective and can be easily implemented in various types of vehicles. It also ensures continuous monitoring, which increases overall safety. The experimental results indicate improved response time and higher chances of saving lives. This system can be further enhanced by integrating advanced technologies like machine learning for better accuracy. Overall, the system provides a reliable, efficient, and scalable solution for accident detection and emergency management.

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