# Design and Implementation of a Smart Sensor-Based Real-Time Accident Detection and Alerting System for Two-Wheelers

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**Abstract**:Road accidents involving two-wheelers constitute a significant proportion of global traffic fatalities, with delayed emergency response often resulting in severe injuries and increased mortality. This paper presents the design and implementation of a Smart Sensor-Based Real-Time Accident Detection and Alerting System for two-wheelers. The proposed system integrates an Arduino Uno, NodeMCU, MPU6050 accelerometer and gyroscope, crash sensor, impact switch, SIM800L GSM module, Neo-6M GPS module, 16×2 LCD display, and buzzer to provide an intelligent, reliable, and cost-effective safety solution.

The system continuously monitors vehicle motion, orientation, and impact parameters to detect abnormal events such as collisions, sudden falls, and rollovers. By employing a multi-sensor approach that combines accelerometer, gyroscope, crash sensor, and impact switch data, the system significantly enhances detection accuracy while minimizing false alarms. When the system detects an accident, it immediately triggers an alarm and starts a 15-second countdown. This brief delay lets the rider cancel the alert if the detection was a mistake or if help isn't needed. If the rider doesn't respond in that time, the system automatically sends an emergency SMS with the rider's exact GPS location to save emergency contacts using the SIM800L GSM module.

To improve safety and usability, the system includes a NodeMCU module for IoT connectivity. This feature allows others to track the vehicle's location in real time through a smartphone app, making it easier to monitor the rider when necessary. During testing, the system was quick and reliable. It reduced false alerts, making it suitable for real-world use. Overall, the proposed smart accident detection system provides a simple, effective way to improve safety for two-wheeler riders. By ensuring a quick emergency response and accurate location sharing, the system can play an important role in delivering timely help during emergencies and has the potential to save lives.

**Keywords:** Accident Detection, IoT, NodeMCU, GPS, GSM, Two-Wheeler Safety, Embedded Systems, MPU6050.

## INTRODUCTION

Two-wheelers have become one of the most popular ways to travel because they are affordable, fuel-efficient, and can move through traffic with ease. From daily commuters to delivery riders, motorcycles and scooters play a major role in everyday transportation. Despite these advantages, they also come with a serious drawback—they offer very little protection to the rider during accidents. As a result, two-wheeler riders are among the most vulnerable road users.

According to road safety statistics, a large percentage of traffic-related deaths involve motorcycles and scooters. In many cases, the severity of an accident is made worse by delays in getting medical assistance. Often, accident reporting depends on passersby, nearby drivers, or the injured person themselves. This can be unreliable, especially when the accident occurs in isolated areas or when the rider is unconscious. Even a few minutes of delay can significantly affect the chances of survival.

To address this issue, an automated and dependable accident detection system is essential. This project introduces an IoT-based smart accident detection and alert system developed specifically for two-wheelers. The system continuously monitors the vehicle, detects accidents in real time, determines the exact location using GPS, and immediately sends alert messages to emergency contacts and rescue services. Since the entire process happens automatically, no manual action is required from the rider. By reducing response time and ensuring timely medical attention, this system has the potential to save lives and improve road safety for two-wheeler users.

## LITERATURE REVIEW

Many researchers have played an important role in developing accident detection systems using embedded systems and IoT. Their work has helped make roads safer by enabling quicker accident detection and faster emergency response.

**Dangat *et al(2022)***. proposed a GSM and GPS-based accident detection system employing vibration sensors for crash detection. Their system effectively identified accident events and transmitted the vehicle's location to emergency contacts via SMS, thereby reducing rescue time and improving emergency response efficiency.

Similarly, **Lavanya *(2024)et al***. developed a bike crash detection system utilizing accelerometers and gyroscopes integrated with Arduino, GPS, and GSM modules. Their approach offered improved detection accuracy compared to conventional vibration-based systems by continuously monitoring vehicle motion and orientation. The system successfully detected sudden impacts and automatically alerted emergency contacts with precise location details.

Although these existing systems provide valuable solutions, they exhibit certain limitations, including susceptibility to false triggering, limited IoT capabilities, lack of real-time remote monitoring, and absence of rider verification mechanisms. These shortcomings can reduce system reliability in practical scenarios.

To overcome these challenges, the proposed system incorporates a multi-sensor validation approach using a crash sensor, accelerometer, gyroscope, and impact switch, combined with cloud-based IoT connectivity. Furthermore, a rider cancellation feature is included to prevent false emergency alerts, thereby enhancing system accuracy, reliability, and real-world applicability.

## OBJECTIVE OF THE STUDY

Two-wheeler accidents represent a major public safety concern, often resulting in serious injuries or fatalities due to delays in emergency assistance. After a serious accident, the rider may be unconscious or too badly injured to call for help, especially if the incident happens in a remote or isolated location. In such cases, relying on bystanders or the rider to report the accident can cause valuable time to be lost.

Many existing accident detection systems also have certain drawbacks. They may trigger false alarms, fail to detect accidents accurately, or lack features such as real-time monitoring and proper IoT integration. These issues can reduce their reliability in practical situations.

Because of this, there is a strong need for a smart and fully automated solution. An ideal system should accurately detect accidents, instantly share the rider's exact location with emergency contacts, and allow continuous remote monitoring. By doing so, it can significantly reduce emergency response time, enhance rider safety, and improve the chances of receiving timely medical care.

## PROBLEM STATEMENT

Road accidents involving two-wheelers are increasing rapidly due to factors such as over-speeding, poor road conditions, careless driving, and lack of immediate emergency assistance. In many accident cases, victims do not receive timely medical help because the accident location is unknown or there is no person nearby to inform emergency services or family members. This delay in communication and rescue operations often leads to serious injuries and loss of life.

Existing accident reporting methods mainly depend on manual communication, which may not be possible if the rider is unconscious or severely injured. Some existing accident detection systems also suffer from limitations such as false triggering, inaccurate accident detection, limited tracking capability, and dependence on internet connectivity. Therefore, there is a need for a reliable, automated, and real-time accident detection and alerting system that can accurately detect accidents and immediately send emergency notifications with the exact location details.

The proposed project aims to solve this problem by developing a smart sensor-based accident detection and alerting system for two-wheelers using IoT and embedded technologies. The system continuously monitors vehicle movement using sensors and automatically sends emergency alerts through GSM communication along with GPS coordinates when an accident occurs. This helps in reducing emergency response time, improving rider safety, and increasing the chances of saving lives during critical situations. ensures miners are continuously protected, supervisors are informed instantly, and long-term safety strategies can be developed using historical data.

The system is designed to function efficiently in both urban and rural areas where immediate medical assistance may not be easily available. By combining multiple sensors, the project improves accident detection accuracy and minimizes false alerts caused by road bumps or sudden vehicle movements. The inclusion of GSM technology allows alert messages to be delivered even without smart phone dependency. GPS integration helps emergency responders quickly identify the accident location and reach the victim faster.

## PROPOSED SYSTEM

The proposed system is a Smart Sensor-Based Real-Time Accident Detection and Alerting System designed for two-wheelers to improve rider safety and reduce emergency response time during accidents. The system uses embedded systems and IoT technology to automatically detect accidents and send emergency alerts without requiring human intervention. The main aim of the system is to provide quick communication and accurate location details to emergency contacts when a bike accident occurs.

The system is built around the UNO &NodeMCU microcontroller, which acts as the central processing unit. AnMPU6050 sensor is used to continuously monitor the motion, acceleration, and tilt angle of the vehicle. Sudden changes in acceleration or abnormal tilt conditions are treated as possible accident events. To improve the accuracy of accident detection and reduce false triggering caused by road bumps or sudden braking, a switch sensor is included to confirm physical impact.

Once an accident is detected, the system activates a buzzer and provides a short delay time for the rider to cancel the alert if no serious accident has occurred. If the alert is not canceled within the specified time, the SIM800L automatically sends an SMS notification to predefined emergency contacts. The message contains the accident alert along with the real-time GPS coordinates obtained from the Neo-6M. The system also includes a 16x2 LCD display to show system status and notifications to the rider.

In addition, IoT integration allows remote tracking and monitoring of vehicles through mobile devices. The proposed system is compact, reliable, cost-effective, and easy to install on motorcycles. By combining sensor technology, GSM communication, GPS tracking, and IoT monitoring, the system helps improve road safety, reduce emergency response time, and increase the chances of saving lives during accidents.

The system operates with low power consumption, making it suitable for continuous usage in real-world conditions. It provides a dependable and automated safety mechanism for riders traveling in isolated or high-risk areas. The project can also be extended in the future with cloud storage, mobile applications ,& advanced AI-based accident analysis features.

## METHODOLOGICAL FRAMEWORK

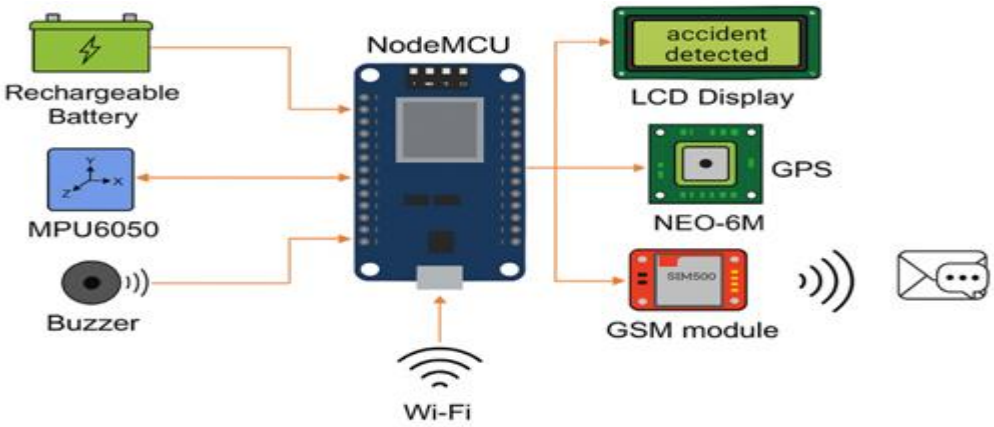
The accident detection and alert system work by constantly monitoring the movement of the two-wheeler using the MPU6050 sensor. This sensor measures acceleration and angular velocity in real time. The collected data is continuously analyzed to identify unusual situations such as sudden braking, extreme tilting, or rapid rotational movement, all of which may indicate an accident.

Whenever these values cross the preset safety limits, the system begins a verification process. To ensure accurate detection and avoid false alarms, a mechanical impact switch is used as an additional confirmation. This helps the system differentiate between an actual collision and normal road conditions like potholes, speed breakers, or sudden braking.

Once both the MPU6050 sensor and the impact switch confirm a crash, the rider verification process starts immediately. A buzzer sounds, and a 15-second timer begins. During this period, the rider can cancel the alert if no emergency has occurred. If there is no response within the given time, the system automatically assumes that the rider needs assistance.

The system then retrieves the current GPS coordinates and prepares an emergency message containing the accident details and exact location. Using the SIM800L GSM module, this alert is instantly sent as an SMS to the registered emergency contacts.

At the same time, the NodeMCU continuously updates the vehicle's live location to a cloud platform. This allows family members, emergency responders, or fleet managers to track the vehicle in real time through a mobile application. By combining all these features, the system provides a reliable, intelligent, and effective solution for accident detection and emergency response.




Smart Sensor Based Real Time Accident Detection & Alert System

## SYSTEM ARCHITECTURE

The proposed system consists of the following major components:

- ESP8266 NodeMCU microcontroller
- MPU6050 accelerometer and gyroscope
- SIM800L GSM communication module
- Neo-6M GPS module
- Impact detection switch
- 16×2 LCD display
- Buzzer
- Rechargeable Li-ion battery
- Additional NodeMCU for IoT tracking

The NodeMCU serves as the central controller, processing sensor data and coordinating communication between all modules. The MPU6050 continuously tracks the vehicle's movement, including acceleration and tilt. If an unusual impact is detected, the impact switch confirms whether a crash has actually occurred. Once an accident is verified, the system immediately

retrieves the vehicle's GPS location and sends an emergency SMS through the GSM module. At the same time, the rider's real-time location is updated on the IoT platform, allowing family members or emergency responders to monitor the vehicle instantly.

## RESULTS

Experimental testing was conducted under simulated accident conditions.

**Observations:**

- Accurate detection of sudden impacts and falls.
- Successful elimination of false alerts during normal riding.
- SMS delivery within seconds of confirmation.
- GPS coordinates accurately identified accident location.
- IoT platform provided seamless live tracking.

Performance Metrics:

- Detection Accuracy - High
- False Alarm Rate - Low
- SMS Transmission Time - < 10 s
- GPS Position Accuracy - ±5 m
- System Reliability - Excellent

The integrated switch sensor significantly improved detection precision compared to single-sensor systems. The rider cancellation mechanism further enhanced usability.

- Practical for Real-World Deployment – Robust performance under varying road conditions.

## CONCLUSION

This paper presents an efficient and reliable smart accident detection and alerting system for two-wheelers using embedded systems and IoT technologies. By combining motion sensing, impact verification, GSM communication, GPS tracking, and cloud connectivity, the proposed system ensures rapid emergency response following an accident.

The inclusion of rider verification minimizes false alarms, while IoT integration enhances monitoring capabilities. Experimental results confirm the system's practicality, robustness, and effectiveness. The proposed solution has strong potential to improve road safety and save lives.

Future work may include machine learning-based accident classification, integration with emergency service networks, and mobile application enhancements.

## FUTURE SCOPE

Currently, the Smart Sensor-Based Real-Time Accident Detection and Alerting System is in the documentation and design phase. In the upcoming semester, the project will be further developed into a working prototype by integrating all hardware and software components. The prototype implementation will include real-time accident detection using sensors, GSM-based emergency communication, GPS location tracking, and IoT-based monitoring features.

In the future, the system can be improved by developing a compact PCB design and installing the prototype directly on a motorcycle for real-time testing under different road conditions. Advanced sensors and machine learning algorithms can also be added to improve accident detection accuracy and further reduce false alerts. Mobile application integration can be implemented to provide live vehicle tracking, emergency notifications, and cloud-based data storage.

Additional future enhancements may include automatic ambulance notification, integration with nearby hospital systems, voice assistance features, and camera-based accident recording. Solar-powered charging systems and advanced battery management can also be introduced for better energy efficiency. Overall, the future scope of the project is to transform the current design into a fully functional smart safety system that can contribute significantly to reducing accident-related fatalities and improving road safety for two-wheeler

The system can be further improved by integrating artificial intelligence and machine learning techniques to increase accident detection accuracy and reduce false alerts. Mobile application support and cloud storage can be added for live vehicle tracking and data monitoring. Future enhancements may also include smart helmet integration, automatic ambulance notification, and communication with nearby hospitals for faster emergency response. The hardware design can be made more compact and durable for real-time deployment in commercial two-wheelers.

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