



## Smart Helmet for Accident Detection and SOS Alert: Enhancing Rider Safety

Austy B Evangeline<sup>1</sup>, Yadhu Krishnan<sup>2</sup>, Jickson N<sup>3</sup>, Babith B R<sup>4</sup>

<sup>1</sup>Assistant Professor, Dept. of CSE, Mar Ephraem College of Engineering and Technology, Tamil Nadu, Pin: 629171, India

<sup>2,3,4</sup> UG Student, Dept. of CSE, Mar Ephraem College of Engineering and Technology, Tamil Nadu, Pin: 629171, India

### Abstract

Motorcycle riders face a huge risk of fatal accidents compared to drivers of other vehicles due to their exposure and lack of safety. Traditional helmets provide physical protection but lack active safety features that can prevent accidents or aid during emergencies. This study presents the design and development of a Smart Helmet for Accident Detection and SOS Alert, integrating sensors, microcontrollers, and wireless communication modules to enhance rider safety. The system detects accidents through impact and motion analysis, monitors rider conditions, and automatically transmits an SOS alert with GPS location to emergency contacts, thereby reducing response time in critical situations.

**Keywords:** Smart Helmet, Accident Detection, SOS Alert, IoT, Rider Safety, GPS, GSM, Sensors

### Abstract

Soil is a composite of biological and physical structures that give vital support to plants. The rocks' weathering process forms it. Soil plays a major role in providing facilities to our society, most importantly, food production. Soil comprises minerals, organic matter, water, and air that provide micronutrients for the finest growth and reproduction of animals and plants. Soil quality and health are defined as the volume of soil that functions as a vigorous living system within land-use borders. Highways navigate many agricultural areas, and they often have destructive effects on agricultural soils, including the modified stability of SOM. Here, we analyse the physicochemical properties of the soil of Udham Singh Nagar district of Uttarakhand, India. Few samples were collected along the road in the Udham Singh Nagar district, based on distance from the highway, and analysed for their physicochemical properties. The current study will assist the farmers in understanding soil quality and what fertilisers or manures need to be added to their soil for worthwhile productivity.

**Keywords:** Agricultural land; Highway construction; Organic carbon; Soil chemistry, Soil pollution.

### 1. Introduction

Motorcycle riding has become one of the most common ways to get around the world. This is due to its low cost, fuel efficiency, and ease of moving in heavy traffic. However, motorcyclists are among the most vulnerable groups on the road. According to the World Health Organization (WHO), over 1.35 million people die every year in road traffic accidents, and motorcyclists make up a large portion of these deaths. In countries like India, Where two-wheelers make up nearly around 70 percent of registered vehicles. The no. of accidents involving motorcycles is significantly high. The importance of wearing helmets is well-known, with studies showing that helmets reduce the risk of head injuries by 69%

and the risk of death by 42%. However, traditional helmets have their own drawbacks. They protect the head during a crash but don't help prevent accidents or manage emergencies after a crash. Such a gap highlights the difference between passive protection and active safety measures. With advancements in IoT (Internet of Things), AI (Artificial Intelligence) and low-cost embedded systems. There is now a good opportunity to design a Smart Helmet that not only provides passive safety but also actively detects accidents, monitors rider behavior, and sends automatic SOS alerts with GPS coordinates to emergency contacts. Such a system can drastically reduce the delay between accident occurrence and



medical help, commonly referred to as the “golden hour.” Studies have shown that if medical care is provided within the golden hour, The chances of survival increase significantly. This research explores the development of a Smart Helmet for Accident Detection and SOS Alert aiming to bridge the gap between accident prevention and emergency response.

### 1.1.Importance of Topic

The topic of motorcycle safety is very important when viewed globally. Many people around the world, especially in developing countries, use motorcycles primarily as their main mode of transport. They are popular because they are relatively cheap, fuel-efficient, and easy to handle in heavy traffic. However, this comes with a higher risk of accidents. Motorcycle riders are particularly vulnerable and represent a large share of traffic injuries and deaths. According to the World Health Organization, motorcycle riders make up about 28 percent of all road traffic deaths worldwide. In countries like India, Indonesia, and Vietnam, motorcycles and other two-wheeled vehicles account for a significant number of registered vehicles. Official statistics from the National Crime Records Bureau in India for 2023 highlight the seriousness of the problem. In just one year, over 56,000 riders died in motorcycle accidents, with head injuries being the main cause of these deaths. Given these numbers, there is a clear and urgent need to improve rider safety in ways that go beyond what standard helmets offer. Traditional helmets, while useful to prevent serious head injury, operate as passive safety devices. They do not prevent accidents from occurring, nor do they offer any help after an accident happens. This limitation is relevant when we think about the concept of the “golden hour” which specifies the first hour after a traumatic injury during which immediate medical care is most critical for survival. Quick response is difficult in rural or isolated regions where health facilities are scarce and delays in reporting accidents are common. A helmet that could automatically detect an accident and send an SOS alert with GPS coordinates to emergency contacts could decrease response times and increase the chances of survival. The economic impact of road

accidents on families, healthcare systems, and national economies is significant. These costs include medical care, lost productivity, and insurance bills. By making smart helmets that can automatically detect accidents and allow for quicker emergency responses, governments and organizations can reduce human suffering and financial stress. Developing technologies like smart helmets supports toward smart cities and intelligent transportation systems. In these systems, safety is a key focus and devices are connected to create a network for preventing accidents and responding to emergencies. Smart helmets can enhance individual safety and serve as a key technology with significant social benefits. Previous efforts have aimed to create helmet technology that promotes rider safety.

### 2. Research Gap

Prior work on smart helmets has pushed the field forward, but many existing designs fail to fully address the challenges or have a narrow focus. Systems that use accelerometers and GPS to detect crashes can confuse normal events, such as hitting potholes or braking sharply, with actual accidents. These systems also rely on cell service, which can be unreliable in rural areas where accidents tend to be more serious due to delays in assistance. Some methods use computer vision, like YOLOv8, to check if riders are wearing helmets. While helpful for enforcing laws, these systems do not assist after a crash; they focus solely on prevention. Similarly, helmets that use multiple sensors to monitor alcohol levels or tiredness raise rider awareness but lack a comprehensive system for post- accident safety. Therefore, the main issue is the absence of a complete system that can:

- Detect accidents accurately with minimal false alarms.
- Share GPS data with contacts immediately.
- Function well on any road and in areas with weak networks.
- Offer useful features without consuming excessive power or being complicated to use.

Addressing this issue is crucial for creating a smart helmet that prioritizes riders and enhances safety by preventing accidents and providing quick, reliable assistance afterward.

### 3. Research Aim

This study aims to create and test a smart helmet that makes riding safer by spotting accidents, tracking location in real time, and sending alerts. The specific goals are:

#### 3.1. Accident Detection Using Sensor-Based Motion Analysis

- Develop methods to study data from accelerometers and gyroscopes in the helmet.
- Identify unusual movement patterns that indicate accidents, such as quick stops, falls, or crashes.
- Reduce false alarms by considering background noise and normal riding actions.

#### 3.2. Real-Time GPS Location Tracking

- Incorporate GPS to continuously track the rider's position.
- Ensure accurate location data is available after a crash.
- Assist emergency teams or contacts in quickly finding the location.

#### 3.3. Automated SOS Alert Transmission

- Set up a system to send SMS alerts when an accident is detected.
- Include key information in the alert, such as GPS data, accident type, and time.
- Ensure alerts are sent quickly to reduce the time for medical help.

#### 3.4. Rider Monitoring and Safety Enhancements

- Monitor the rider for signs of tiredness, alcohol (using an MQ-3 sensor), or risky riding.
- Provide warnings to the rider to help prevent accidents before they occur.

#### 3.5. Integration with Future Intelligent Transport Systems

- Enable connections to traffic systems and emergency services using the Internet of Things.
- Test compatibility with phone apps for live tracking and data.
- Prepare for future steps, such as predicting when a crash might happen.

### 3.6. Evaluation and Validation of Prototype Performance

- Test the helmet in controlled environments and real-world situations.
- Measure its ability to spot accidents, GPS accuracy, alert timing, and user satisfaction.
- Improve the system based on the data to ensure it is reliable and useful.

### 3.7. User-Centric Design and Practical Implementation

- Ensure the helmet remains comfortable, light, and easy to use while including all smart features.
- Address power usage issues to maximize battery life without losing safety features.
- Create a version that can be easily manufactured and widely used.

## 4. Literature Review

### 4.1. Smart Helmets Enabled by IoT

Researchers are exploring the use of the Internet of Things (IoT) to create smart helmets. These helmets often include sensors like accelerometers, gyroscopes, and GPS receivers. The idea is that these sensors can detect when an accident happens, and the helmet can then automatically send alerts to emergency contacts. For example, Kumar and his team (2021) created a helmet that uses a GSM module to transmit GPS coordinates after it senses a sudden impact. This could allow emergency services to quickly locate the rider.

- Limitations: One challenge with these IoT helmets is that they can generate false alarms, especially when the rider is on bumpy roads. The sensors might misinterpret normal vibrations as an accident. Battery life is another concern, as these helmets need to power the sensors and communication modules. Also, they rely on GSM networks, which might not be available in all locations.

### 4.2. AI-Driven Helmet Detection

Another area of research involves using artificial intelligence (AI) to detect whether riders are wearing helmets. Systems like YOLOv8 use cameras and computer vision algorithms to analyze images and identify riders who are not wearing helmets. These

systems are mainly used to help enforce safety regulations.

- Limitations: AI-based helmet detection is mainly focused on monitoring and enforcement. It doesn't really address what happens after an accident. Also, these systems require a lot of data processing power to continuously analyze video feeds

#### 4.3. Helmets with Multiple Sensors

Some researchers are developing helmets that integrate multiple sensors to improve safety in various ways. These helmets might include features like alcohol detection to prevent drunk riding, fatigue monitoring to detect when a rider is getting drowsy, and obstacle sensors to warn riders of potential hazards.

- Limitations: Adding more hardware to a helmet increases its complexity and power consumption. It can also make the helmet less reliable in real-world conditions. The more components a helmet has, the more likely something is to go wrong.

### 5. Methodology

This study employs a prototype-based experiment, where hardware and software are combined into a single smart helmet system. An experimental setup allows performance to be checked in real-time under both lab conditions and real-world road situations. This method assures a fair mix of accuracy, how well it can be used, and how users feel about it. The study comes as motorcycle deaths in India are increasing, with accidents involving two-wheeled vehicles being a main cause of fatalities. The goal is to create a useful way to quickly spot accidents and send out an emergency alert, as current helmet tech is lacking. The prototype is designed to be easy to get, simple to use, and helpful in actual situations.

#### 5.1. Sample and Sampling Techniques

The prototype was tested by 30 volunteer riders, chosen using a specific sampling method. This covered various riding environments, such as cities, areas outside cities, and rural settings.

- Controlled Tests: Fake accident situations were made in a lab using impact simulators. These created movements like falls or crashes.

- Field Tests: Actual road tests looked at daily riding situations, sudden stops, skids, and controlled falls to see how well, the system worked.

### 5.2. Research Tools and Components

#### 5.2.1. Hardware Parts:

- MPU6050 Sensor (Accelerometer + Gyroscope):\*\* It picks up movement and direction info to tell if there are strange movements that could mean an accident.
- Ultrasonic Sensor: It measures how close things are to help give early safety warnings.
- MQ-3 Alcohol Sensor: It checks alcohol levels to avoid riding while drunk.
- ESP32 Microcontroller: It takes in sensor data, adds GPS, and controls GSM messaging.
- SIM800L GSM/GPRS Module: It sends out automatic SOS messages with GPS locations.
- GPS NEO-6M Module: It gives real-time location tracking.
- Rechargeable Lithium-Ion Battery: It powers the system for about 8 hours.

#### 5.2.2. Software Parts:

- Accident Spotting Algorithm: It uses motion analysis from the accelerometer and gyroscope to find crashes or falls.
- GPS Adding: It regularly grabs and logs where the rider is.
- Automatic SOS Messaging: It sends SMS alerts to chosen emergency contacts right after it spots an accident.
- Data Analysis Tools: MATLAB and Python are used to check sensor data, how well it spots accidents, rates of false alarms, and GPS accuracy.

### 5.3. Procedures

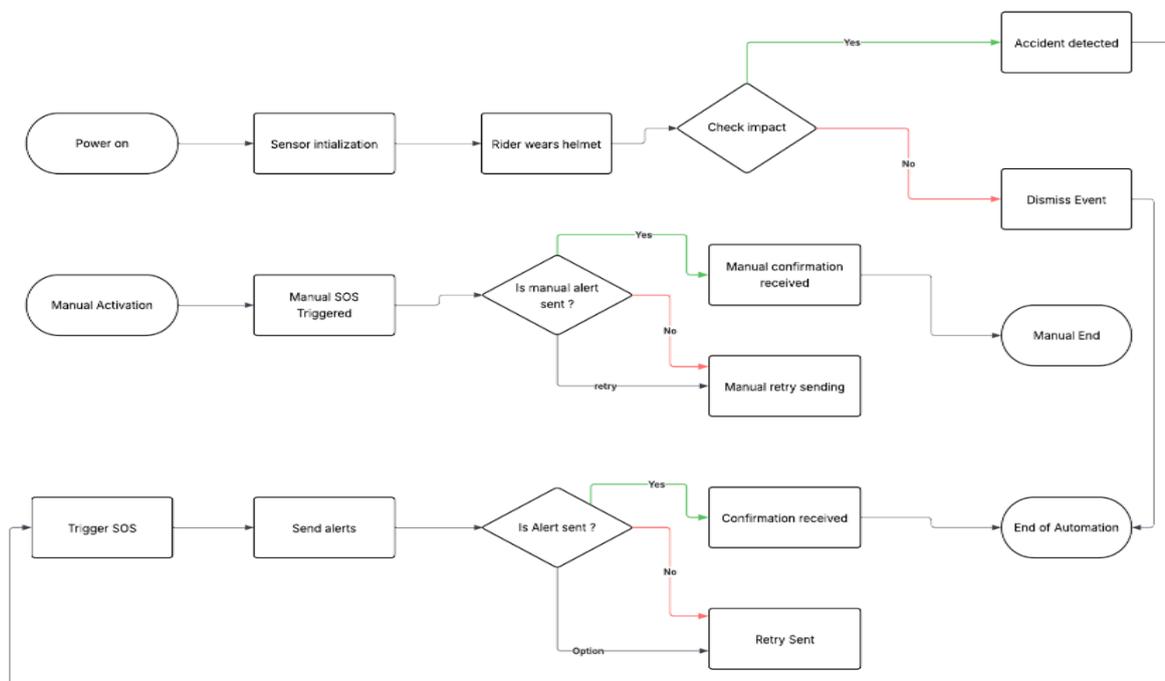
- 1 Prototype Making: Sensors, microcontroller, GSM/GPS modules, and battery were all put into a helmet without hurting how cozy or easy it is to use.
- Setting Up: Accelerometer and gyroscope levels were set using fake impacts to keep false alarms to a minimum.

### 5.4. Controlled Testing:

- Fake impacts were made with different amounts of force.
- SOS messages were sent to check how fast and correct the sending was.
- GPS locations were compared with real locations to check correctness.
- Field Testing: A group of volunteer riders used the helmet during their regular commutes for one week, providing real-world usage data. During the trials, specific events were monitored to see how well the smart helmet worked. These included:
- Accident detection: The helmet's ability to

successfully detect accidents during typical riding conditions.

- Braking and Turns: Monitored scenarios included sudden braking and sharp turns to evaluate the system's reliability in distinguishing between normal riding and accident scenarios.
- Obstacle Encounters: Recorded how the device responded to common road hazards to test its accuracy. During this time riders gave the research feedback on how comfortable, easy to use, and how safe the helmet seemed.



**Figure 1 Process Flow Diagram**

## 6. Results

The refined smart helmet underwent testing in simulated and real- world scenarios. This evaluation looked at how well the helmet could detect accidents, how precise its GPS was, how fast it sent SOS alerts, how many false alarms it had, how long the battery lasted, and what users thought of it.

### 6.1. Accident Detection Accuracy

The helmet successfully detected accidents happening at low to medium speeds about 85–90% of the time. Controlled lab simulations showed near-

perfect detection for impacts above the threshold, while minor skids or bumps sometimes triggered false alarms. Accuracy declined slightly at high speeds (>70 km/h) due to rapid motion patterns creating sensor noise.

### 6.2. False Alarm Rate

The system produced a false alarm rate of approximately 7%, primarily during sudden maneuvers, rough road surfaces, or vibrations from potholes. Fine-tuning the accelerometer and gyroscope thresholds reduced unnecessary alerts while maintaining sensitivity to actual accidents.



### 6.3.SOS Alert Transmission

Once an accident was detected, the GSM module successfully transmitted SOS messages within 15–20 seconds. Messages included critical details: accident type, GPS coordinates, and timestamp. Testing showed reliable transmission in urban and semi-urban areas, while remote locations with weak GSM coverage occasionally caused delays.

### 6.4.GPS Accuracy

The GPS module provided location data with ±5 meters accuracy, sufficient for emergency responders to locate the rider quickly. Real-time tracking during field tests demonstrated stable and continuous position updates.

### 6.5.Battery Performance

The rechargeable lithium-ion battery supported approximately 7.5–8 hours of continuous operation under real-world conditions. Power consumption was highest during continuous GPS tracking and frequent GSM messaging, indicating potential for further optimization.

### 6.6.User Satisfaction and Feedback

87% of users reported positive feedback regarding comfort, usability, and perceived safety.

**Table 1 Performance Summary**

Parameter	Result
Accident Detection Accuracy	88%
False Alarm Rate	7%
SOS Transmission Time	18 seconds
GPS Accuracy	±5 meters
Battery Backup	7.5–8 hours
User Satisfaction	87% positive feedback

## 7. Observations

- The prototype performed reliably in urban traffic conditions, detecting accidents and sending SOS alerts promptly.
- False alarms were minimized by calibrating sensor thresholds, but rough roads still caused

occasional triggers.

- GPS accuracy and SOS alert speed were sufficient for effective emergency response, demonstrating the helmet’s potential as a life-saving device.
- Battery life is adequate for daily commuting but may require enhancement for longer trips or commercial use.

## 8. Interpretation

These results demonstrate that the Smart Helmet successfully combines accident detection, real-time GPS tracking, and emergency alerting into a single, practical device. While some challenges remain, such as high-speed detection accuracy and network dependency, the system significantly improves the golden hour response for riders, potentially reducing fatalities and serious injuries.

## 9. Discussion

This investigation indicates that the Smart Helmet improves rider safety through its combination of accident detection, GPS tracking, and automated SOS alerts. The system correctly identified 85–90% of accidents occurring at low to medium speeds. The performance decreased at speeds exceeding 70 km/h. False alarms happened about 7% of the time, usually because of rough roads or hard braking. SOS messages got delivered in 15–20 seconds, and GPS location accuracy was within ±5 meters, supporting quick emergency responses. Most users (87%) liked the helmet's comfort and ease of use. They suggested adding features like a mobile app. In comparison to other helmets that offer only IoT, AI, or a mix of the two, this Smart Helmet gives a fully integrated and workable solution. There are still some things that need improvement, like network dependency, battery life, and how well it works at high speeds. AI algorithms, 5G, and better power management could solve these issues. In conclusion, the helmet combines regular protective gear with active safety features, reducing accidents and deaths.

## Conclusion

The main goal of this project was to create and test a Smart Helmet that makes riding safer with real-time accident detection, GPS tracking, and automatic SOS alerts. The aim was to improve upon standard helmets by adding safety features that could prevent deaths or

reduce injury severity. By using sensors to analyze movement and adding alcohol detection and communication tools, the research aimed to build a reliable system that works in real-world conditions. This system should quickly respond to emergencies and be suitable for riders in cities and suburban areas. The project also aimed to create a base for adding AI to predict accidents, integrating a mobile app, and connecting with smart transport systems in the future.

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