

# Smart Helmet with Night Safety, Accident Alert and Navigation Assist

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*Abstract- Road accidents involving two-wheeler riders remain a significant safety concern, mainly due to delayed emergency response and poor visibility during night travel. This paper presents the design and development of a Smart Helmet with Night Safety, Accident Alert, and Navigation Assist to improve rider safety using IoT-based technologies. The proposed system integrates an ESP32 microcontroller, SW-420 vibration sensor, NEO-6M GPS module, LED visibility system, and wireless communication through Wi-Fi. The helmet automatically detects accidents using vibration sensing and sends the rider's real-time GPS location to emergency contacts through cloud services such as Firebase. In addition, the integrated LED lighting system enhances night-time visibility, while the audio-based navigation assist helps reduce rider distraction during travel. The system is designed to be lightweight, cost-effective, and user-friendly, making it suitable for everyday commuting. The proposed smart helmet demonstrates how embedded systems and IoT technologies can transform conventional protective gear into an intelligent safety device capable of improving emergency response and overall rider protection.*

## I. INTRODUCTION

Two-wheeler riders are among the most vulnerable road users due to minimal physical protection and delayed emergency response after accidents. Conventional helmets provide basic protection but lack intelligent safety features. With the increasing number of road accidents and smartphone distractions during navigation, there is a need for an integrated safety solution. The proposed Smart Helmet incorporates accident detection, night visibility, and hands-free navigation to enhance rider safety using IoT technologies.

The system uses an ESP32 microcontroller, SW-420 vibration sensor, and NEO-6M GPS module to detect accidents and transmit the rider's real-time location to emergency contacts through wireless

communication. High-intensity LEDs improve visibility during night travel, while audio-based navigation reduces the need to check smartphones while riding. The proposed smart helmet offers a lightweight, cost-effective, and reliable solution that transforms conventional helmets into intelligent safety devices for modern transportation.

## II. LITERATURE SURVEY

Several researchers have proposed smart helmet systems to improve rider safety using IoT technologies. A study on a Smart Helmet System with GPS and GSM for Emergency Notification demonstrated that accident alerts can be automatically sent to emergency contacts through SMS along with a Google Maps location link, enabling faster response after accidents. Another research on an AI-Integrated Smart Helmet utilized accelerometer data and artificial intelligence techniques to analyze accident severity and reduce false alarms, though the system required higher computational power and was still in the prototype stage. Additionally, open-source smart helmet implementations using ESP32, GPS modules, and cloud platforms such as Firebase have shown the feasibility of real-time accident detection and location sharing through mobile applications. However, many existing systems face limitations such as dependency on GSM networks, higher cost due to advanced processing requirements, limited battery life, and lack of real-world testing. These gaps highlight the need for a low-cost, reliable smart helmet system capable of detecting accidents and sending instant location alerts to family members to improve rider safety and emergency response.

### III. PROBLEM STATEMENT

Road accidents involving two-wheeler riders are a major cause of injuries and fatalities, especially when accidents occur in isolated areas or during nighttime where visibility is low. In many cases, accidents remain unnoticed for a long time, which delays emergency medical assistance and increases the risk to the rider's life. Traditional helmets mainly provide physical protection but lack advanced features such as accident detection, real-time location tracking, and automatic emergency alerts to family members or authorities. Due to the absence of such smart safety mechanisms, timely help is often not provided to accident victims. Therefore, there is a need for an intelligent helmet system that can detect accidents instantly, obtain the rider's GPS location, and automatically notify family members or emergency contacts to ensure faster response and improved rider safety.

### IV. SCOPE AND LIMITATIONS

#### A. Scope

The proposed smart helmet system aims to enhance the safety of two-wheeler riders by integrating accident detection, GPS location tracking, and instant emergency alert features. The system can automatically detect accidents using sensors and send the rider's real-time location to family members or emergency contacts through mobile applications or cloud platforms. It also supports safer riding conditions during nighttime and provides optional navigation assistance through audio guidance. The technology can be further expanded for applications in delivery services, fleet monitoring, and industrial worker safety. With advancements in IoT and mobile connectivity, the system can be integrated with smart traffic systems, emergency services, and data analytics platforms to improve overall road safety and reduce accident response time.

#### B. Limitations

Despite its advantages, the smart helmet system has certain limitations. The system depends on battery power, requiring regular charging to function properly. It also relies on internet or network connectivity to transmit accident alerts, which may not be available in remote areas. Sensors such as

vibration detectors may sometimes generate false triggers due to minor shocks or road conditions. GPS signals may also become inaccurate in tunnels, dense urban environments, or indoor locations. Additionally, the inclusion of electronic components increases the cost of the helmet compared to traditional helmets, which may affect large-scale adoption.

### V. METHODOLOGY

The proposed smart helmet system is designed using IoT technology to improve the safety of two-wheeler riders by detecting accidents and sending emergency alerts automatically. The system mainly consists of an ESP32 microcontroller, SW-420 vibration sensor, GPS module (NEO-6M), Wi-Fi communication, and a mobile application or cloud platform. When the helmet is powered on, the ESP32 initializes all connected components and starts monitoring sensor data continuously. The vibration sensor is used to detect sudden shocks or strong impacts that may indicate a road accident. The system continuously checks the sensor readings to determine whether the detected vibration exceeds a predefined threshold value.

When an abnormal impact is detected, the ESP32 processes the signal and verifies the accident event. After confirming the accident, the GPS module retrieves the real-time geographical location of the rider in the form of latitude and longitude coordinates. This location data is then combined with the accident alert information. The system ensures that the location is accurate so that emergency responders or family members can easily identify the exact position of the rider. The GPS module continuously communicates with satellites to obtain the current coordinates of the accident location.

Once the location information is obtained, the ESP32 transmits the data through Wi-Fi to a cloud platform or mobile application using IoT protocols. The system then sends an instant notification to the rider's emergency contacts containing the accident alert and a Google Maps link of the detected location. Family members can open the link to view the exact accident location and reach the rider quickly. This automated alert system helps reduce the delay in emergency

response and improves the chances of timely medical assistance for accident victims.



Fig 1. system design and workflow plan for developing smart helmet

## VI. IMPLEMENTATION

### 1. System Design and Planning

The first step in the implementation process is to design the architecture of the smart helmet system. The system is planned to integrate multiple hardware components such as the ESP32 microcontroller, SW-420 vibration sensor, GPS module (NEO-6M), mini speaker, and a Li-ion battery. The ESP32 acts as the central processing unit that collects sensor data and controls communication between modules. The overall design focuses on detecting accidents, obtaining the rider's real-time location, and sending emergency alerts to family members through a mobile application or cloud service.

### 2. Hardware Component Selection

In this stage, the required hardware components are selected according to the system requirements. The

ESP32 development board is chosen due to its built-in Wi-Fi capability and efficient processing power. The SW-420 vibration sensor is used to detect sudden shocks or impacts that may occur during an accident. The NEO-6M GPS module is responsible for capturing accurate latitude and longitude coordinates. A mini speaker is integrated to provide navigation assistance to the rider. The system is powered using a 3.7V Li-ion battery, which ensures portability and compact integration within the helmet.

### 3. Hardware Integration

After selecting the components, the hardware modules are connected to the ESP32 microcontroller. The vibration sensor is connected to the digital input pins of the ESP32 to detect impact signals. The GPS module communicates with the ESP32 through serial communication using TX and RX pins. The mini speaker is connected to provide audio output for navigation alerts. Proper wiring and connectors are used to ensure stable connections between components. All modules are carefully mounted inside the helmet to maintain comfort and safety while riding.

### 4. Software Development

The software for the system is developed using the Arduino IDE, which supports programming for the ESP32 microcontroller. Several libraries such as WiFi.h, TinyGPS++, SoftwareSerial.h, and HTTPClient or FirebaseESP32 are used for communication and data processing. The program continuously reads data from the vibration sensor to monitor sudden impacts. If the sensor detects a vibration level above the predefined threshold, the program identifies it as a possible accident event.

### 5. Accident Detection and Location Retrieval

When an accident is detected, the ESP32 immediately activates the GPS module to retrieve the rider's real-time location. The GPS module communicates with satellites to obtain the latitude and longitude coordinates. The TinyGPS++ library processes the GPS data and extracts the accurate position of the rider. This location information is then formatted into a Google Maps link so that the accident location can be easily viewed by emergency contacts.

## 6. IoT Communication and Data Transmission

After obtaining the GPS location, the ESP32 uses its built-in Wi-Fi module to send the data to a cloud platform such as Firebase, ThingSpeak, or Blynk. The system transmits the accident alert along with the GPS coordinates through the internet. APIs such as Twilio or IFTTT can also be used to send SMS notifications containing the accident information and location link.

## 7. Mobile Application Integration

A mobile application is developed using platforms such as MIT App Inventor, Android Studio, or Flutter. The application receives accident alerts from the cloud platform and displays the rider's location on Google Maps. When an accident occurs, the app generates a push notification to inform family members or emergency contacts. By opening the notification, users can directly access the accident location through the integrated Google Maps link.

## 8. System Testing and Validation

Once the system is assembled and programmed, testing is conducted to verify its functionality. The vibration sensor is tested by simulating different impact conditions to ensure accurate accident detection. The GPS module is tested to verify that it provides correct location coordinates. Communication between the ESP32, cloud platform, and mobile application is also checked to confirm that alerts are delivered successfully.

## 9. Final Deployment in Helmet

After successful testing, all electronic components are securely placed inside the helmet structure. Proper insulation and mounting techniques are used to protect the circuits from damage during riding. The helmet is then tested in real riding conditions to evaluate its performance in detecting accidents and sending alerts.

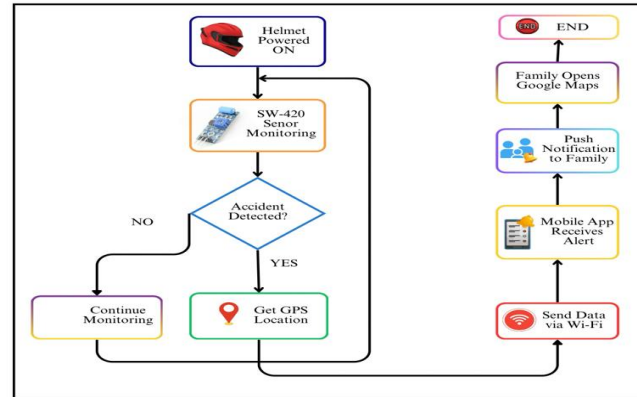


Fig 2. flowchart for implementation of smart Helmet

## VII. CONCLUSION

This paper presented a multi-modal railway track inspection system integrating computer vision, deep learning, and infrared sensing within an ESP32-CAM based embedded platform. The proposed approach enables real-time monitoring of railway tracks by combining geometric rail analysis with AI-based surface defect classification and IR sensor-based crack detection. By leveraging the lightweight MobileNetV2 architecture, the system achieves efficient edge inference while maintaining reliable detection performance.

The integration of vision-based analysis and sensor-level validation enhances fault detection robustness and reduces false alarms compared to conventional single-method approaches. The use of built-in Wi-Fi communication and GPS localization allows immediate reporting of detected faults to a remote monitoring interface, enabling faster maintenance response and improved operational safety.

Overall, the proposed system demonstrates a cost-effective, scalable, and intelligent solution for railway infrastructure monitoring. By transitioning from periodic manual inspection to autonomous, data-driven monitoring, the framework contributes toward predictive maintenance strategies and enhanced railway safety standards.

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