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Ride Safe Intelligent Helmet for Emergency Detection and Response

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Abstract - Ride Safe is an IoT-based smart helmet designed to improve two-wheeler safety by detecting accidents and sending real-time emergency alerts. It uses an ESP32 microcontroller along with an accelerometer and impact sensor to identify sudden falls or collisions. A GPS module (NEO-6M) captures the rider's live location, while a GSM module (SIM800L) transmits SMS alerts to family members or emergency services. To ensure reliability, the system activates only when the helmet is worn using a helmet-wear detection switch, and a cancel switch allows the rider to stop alerts in case of false triggers. This low-cost, reliable, and portable solution not only reduces emergency response time but also increases survival chances, enforces helmet usage, and offers applications in personal safety, fleet monitoring, and smart city systems.

Keywords – Intelligent helmet, IoT, accident detection, emergency response, wearable safety system.

INTRODUCTION

In this project, a Smart Helmet for Accident Detection and Emergency Response is developed to enhance the safety of two-wheeler riders. The system is designed to automatically detect accidents or falls and ensure that timely help is provided. It continuously monitors rider safety and, in case of an emergency, sends instant alerts with the rider's location to family members or emergency contacts. The helmet includes features to prevent false alerts and ensures operation only when it is worn, providing reliability and accuracy. This smart solution improves road safety, reduces response time, and increases the chances of saving lives, making it a valuable advancement in rider protection. By integrating sensors, communication modules, and intelligent control, the system provides seamless automation with minimal user effort. It not only benefits individual riders but also supports broader road safety initiatives.

II. SYSTEM ARCHITECTURE

- Accident Detection Module (MPU6050Sensor): This module detects sudden falls, collision, or abnormal movements using the accelerometer and impact sensor. By sensing acceleration and angular velocity, it identifies unusual forces on the helmet that indicate a possible accident.
- Location Tracking Module (GPS Module):
- This module captures the rider's live location using satellite signals. It calculates accurate latitude and longitude coordinates and provides real-time tracking details during emergencies to help rescuers reach the rider quickly.
- Emergency Communication Module (GSM Module-SIM800L):
- This module ensures that an instant SMS alert is sent to emergency contacts when an accident is detected. It uses GSM cellular networks to transmit accident details and GPS coordinates, even in remote areas with basic signal coverage.
- Central Control Module (ESP32 Microcontroller):
- This module acts as the brain of the system. It processes sensor data, confirms accidents through logic, and coordinates between GPS and GSM modules. It also manages the helmet detection switch and cancel button to ensure accurate and reliable operation.

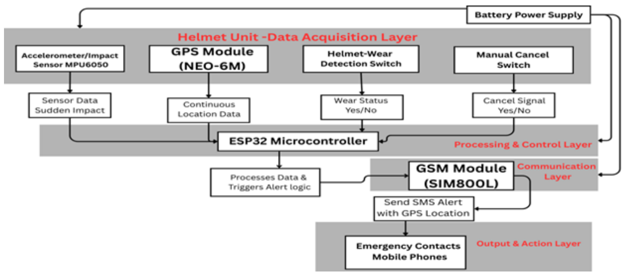

Fig.1. Architecture Diagram

III. RELATED WORK

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Several research studies and prototypes have attempted to address accident detection using smartphones, in-vehicle sensors, and wearable devices.

- Smartphone-Based Systems – Some models use accelerometers and GPS in smartphones for crash detection. However, their reliability is limited as riders may not always carry or mount their phones during rides. Additionally, battery drain and network dependency are critical issues.
- Vehicle-Mounted Solutions – Some cars and premium bikes have built-in crash sensors. However, such solutions are not available to the majority of two-wheeler users.
- Previous Smart Helmet Prototypes – Existing helmet prototypes have implemented basic crash detection but lack integration with health monitoring, IoT communication protocols, and cloud-based services.
- IoT in Healthcare – Wearable IoT devices such as fitness trackers and health bands have shown reliability in continuous health monitoring. Integrating these with a helmet ensures real-time medical data transfer during accidents.
- Thus, while related works provide partial solutions, there is a gap in combining accident detection, rider health monitoring, and IoT-enabled emergency response into a single wearable device. The proposed Smart Helmet addresses this gap comprehensively.

IV. PROPOSED METHODOLOGY

The architecture of the Smart Helmet is divided into four core modules:

Crash Detection Module

- Uses a 3-axis accelerometer and gyroscope to measure sudden changes in speed, orientation, or angular velocity.
- An accident is detected when impact values cross a pre-defined threshold (e.g., >5g force).

Health Monitoring Module

- Includes sensors such as pulse oximeter (SpO2) and heart rate monitor.
- Monitors the rider's vital parameters before and after an accident.
- Helps emergency responders evaluate injury severity in real time.

IoT Communication Module

- Equipped with GPS for live tracking and GSM/4G IoT module for data transmission.
- Sends alerts containing rider's location, crash details, and health data to emergency services and family contacts.
- Can integrate with cloud platforms for data logging and analytics.

Emergency Response System

- Triggers automatic SMS, app notification, or cloud alerts.
- Provides real-time map tracking for ambulances and nearby hospitals.
- May include integration with government traffic control systems for faster clearance.

V. SYSTEM WORKFLOW

Helmet sensors detect abnormal impact → verify crash with vital signs → transmit data to IoT server → alerts emergency contacts and hospitals → ensures quick medical assistance.

Fig.2. Arduino IDE Code Snippet

Power Supply Module

The power supply module is the backbone of the entire system. The helmet is powered by a rechargeable Li-ion battery, which provides a nominal voltage of 3.7V to 7.4V depending on the pack configuration. Since sensors, GPS, GSM, and the ESP32 require stable voltages, a DC-DC buck/boost converter is used to provide regulated 5V and 3.3V outputs. The 5V rail powers the GPS, GSM module, and sensors, while the 3.3V rail powers the ESP32 microcontroller. Capacitors and inductors are used to filter voltage spikes and noise, ensuring stable operation. Protection features like over-current protection, reverse polarity protection, and thermal shutdown safeguard the system during operation and charging.helmet. It uses an MPU6050 accelerometer and gyroscope to continuously monitor motion and orientation. An additional impact sensor confirms strong shocks. The ESP32 processes.

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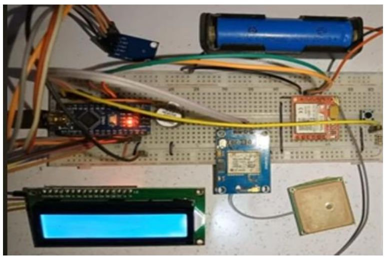

Fig.3. Hardware Implementation

Accident Detection Module

The accident detection module is responsible for detecting sudden falls, collisions, or abnormal tilts of the helmet. It uses an MPU6050 accelerometer and gyroscope to continuously monitor motion and orientation. An additional impact sensor confirms strong shocks. The ESP32 processes data from both sensors and applies logical conditions to differentiate between normal bumps and actual accidents. This ensures that false alarms are minimized while accurately detecting dangerous events. The sensors are carefully mounted inside the helmet to maximize sensitivity to sudden impacts.

Location Tracking Module

The Location Tracking Module is responsible for identifying the exact position of the rider when an accident occurs. It uses a NEO-6M GPS module to capture real-time latitude and longitude coordinates. Once an accident is detected, these coordinates are sent to the processing unit, which formats them into a Google Maps link. This link is included in the emergency SMS sent to family or medical contacts.Continuous tracking helps in reducing response time during emergencies, increasing the chances of timely medical assistance.

Communication/Alert Module

The communication module enables automatic alert transmission after an accident. A SIM800L GSM module sends SMS messages containing the accident information and GPS coordinates to pre-defined emergency contacts. The module is powered through a stable 4–5V supply with high-capacitance decoupling to handle current spikes during transmission. The ESP32 controls the GSM module using AT commands to format and send

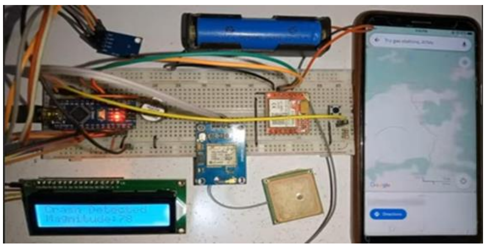

Fig.4. Hardware Prototype with Accident detection and Location Tracking

messages reliably. Multiple retries and verification mechanisms ensure that alerts are successfully delivered, even in areas with weak network signals.

Processing & Control Module

The ESP32 microcontroller acts as the brain of the system. It continuously reads data from the MPU6050, impact sensor, GPS module, helmet-wear switch, and cancel button. The ESP32 executes the accident detection algorithm, confirms events, manages the cancel window, and triggers the GSM alert module. It also monitors system status indicators like LEDs and battery voltage. By centralizing control, this module ensures coordinated and timely operation of all components, providing reliable accident detection and emergency response.

Helmet-Wear Detection Module

This module ensures that the system is active only when the helmet is worn. A micro or reed switch installed inside the helmet detects contact with the rider's head. When the helmet is worn, the system is armed and ready to detect accidents. When the helmet is not worn, the system remains inactive, preventing false alarms and unnecessary battery drain. The ESP32 continuously monitors this switch and enables or disables other modules accordingly.

VI. FUTURE WORK

- IoT Integration: Extend the system with cloud platforms (Blynk, Firebase, ThingsBoard) to store accident logs, monitor helmet health, and allow remote diagnostics.
- Mobile Application: Develop a dedicated Android/iOS app to provide real-time location tracking, accident notifications, ride history, and emergency contact management.
- Health Monitoring: Integrate biometric sensors (pulse rate, body temperature, SpO_2) to assess the rider's physical condition after an accident and share critical health data with responders.
- Power Optimization: Incorporate low-power modes, rechargeable batteries, and explore renewable sources such as solar or kinetic energy harvesting for sustainable operation.
- Scalability: Adapt the design for wider use in other safety gear such as jackets and gloves, and extend compatibility for riders of bicycles, e-scooters, and other light vehicles.

VII. CONCLUSION

The Ride Safe Intelligent Helmet represents a significant advancement in personal safety for motorcyclists by integrating smart technology with protective gear. Through real-time accident detection using sensors such as accelerometers and gyroscopes, along with GPS tracking and automated emergency alert systems, this helmet can drastically reduce the response time in critical situations. By instantly notifying emergency contacts or services with the rider's location, it can potentially save lives and minimize the severity of injuries. Moreover, the helmet promotes a culture of safety and accountability among riders by encouraging the consistent use of protective gear. As smart technologies continue to evolve, such innovations pave the way for a safer, more connected future for road users. Overall, the intelligent helmet is not just a gadget, but a life-saving tool that bridges the gap between technology and road safety.

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