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Smart Helmet for Accident Detection and Alert System

Zaiba Telgi, Triveni Asapure, Aishwarya Dudhanikar, Sarang Torbole,

Prof. Shabanam Commissioner S.U

Department of Electronics and Telecommunication, V.V.P. Institute of Engineering & Technology, Solapur, India

ABSTRACT: Road accidents involving two-wheelers account for a significant fraction of global traffic fatalities and injuries. Rapid emergency response is often impeded by delayed or unavailable accident location data. We present a Smart Helmet system integrating an MPU6050 accelerometer/gyroscope, MQ3 alcohol sensor, NEO-6M GPS module, SIM800L GSM module, and optional helmet-usage sensor. Upon detecting a crash or intoxicated riding, the system automatically dispatches SMS alerts bearing GPS coordinates to predefined contacts. Experimental evaluation demonstrates reliable accident detection, alcohol interdiction, and real-time location reporting, offering a cost-effective, scalable approach to enhancing rider safety and enabling intelligent transport infrastructure.

KEYWORDS: Smart Helmet; Accident Detection; Emergency Alert System; GPS/GSM; Alcohol Sensor; Helmet Usage Enforcement; IoT.

I. INTRODUCTION

Road safety has become a global concern, particularly for two-wheeler riders who are among the most vulnerable users on the road. According to the World Health Organization (WHO), over 1.3 million people lose their lives each year due to road accidents, with a significant portion involving motorcyclists. One of the critical issues contributing to high fatality rates is the delay in emergency response, often due to a lack of timely information regarding the accident's location and severity.

To mitigate this problem, the concept of a **Smart Helmet for Accident Detection and Alert System** has been introduced. This system aims to bridge the gap between accident occurrence and emergency assistance by leveraging sensor-based automation and communication technologies. Equipped with components such as the **MPU6050** (accelerometer and gyroscope), **MQ3 alcohol sensor**, **NEO-6M GPS module**, and **SIM800L GSM module**, the smart helmet continuously monitors the rider's motion, condition, and helmet usage. In the event of a crash or unsafe behavior such as intoxicated riding, the system takes immediate action by sending alerts containing the rider's location to emergency contacts.

This innovation not only enhances individual safety but also supports broader objectives like smart city infrastructure, intelligent transport systems, and proactive healthcare responses. Designed to be cost-effective, lightweight, and user-friendly, the Smart Helmet system demonstrates how modern technology can be harnessed to address real-world challenges in road safety.

II. LITERATURE REVIEW

Numerous systems have been proposed for wearable and vehicle-mounted accident detection:

1. Accelerometer-GPS Systems: Early work leveraged accelerometers and GPS for crash detection, but lacked alcohol interdiction and helmet-usage features.
2. Alcohol-Interlock Vehicular Systems: MQ3-based vehicle immobilization prevented drunk driving but did not address wearable integration or accident alerts.
3. Helmet-Mounted GSM Solutions: Arduino-GSM helmets enforced usage but omitted dynamic crash analytics and false-alarm management.
4. IoT-Based Fleet Tracking: Cloud-connected vehicle trackers offered real-time data sharing, though their power and infrastructure demands limited helmet applicability.

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5. Multisensor Wearables: Recent smart helmets incorporate motion, alcohol, and environmental sensing, yet challenges remain in power optimization and false-positive reduction.

Our system builds on these foundations by unifying accident detection, alcohol interdiction, helmet-usage enforcement, and automated SMS alerts in a lightweight wearable.

III. SYSTEM ARCHITECTURE AND METHODOLOGY

A. Hardware Components:

- MPU6050 (Accelerometer & Gyroscope): Detects sudden acceleration spikes and orientation changes.
- MQ3 Alcohol Sensor: Monitors breath alcohol concentration at the rider's mouth.
- NEO-6M GPS Module: Provides latitude and longitude updates.
- SIM800L GSM Module: Transmits SMS alerts.
- IR/Pressure Sensor (Optional): Confirms helmet donning to enforce usage.
- Microcontroller (Arduino/ESP32): Orchestrates sensor data, decision logic, and communications.
- Buzzer & Reset Button: Audible alert and manual false-alarm override.

B. Functional Flow:

1. Helmet Usage Enforcement - If not worn, the system disables vehicle ignition via a relay.
2. Alcohol Detection - MQ3 triggers buzzer and ignition block if breath alcohol exceeds threshold; optional SMS notification is sent.
3. Accident Detection - MPU6050 monitors for acceleration/gyro thresholds indicative of a crash.
4. Location Acquisition - GPS coordinates are polled and formatted into alert messages.
5. Emergency Alert Dispatch - GSM module sends SMS to up to three preconfigured contacts, including a Google Maps link.

IV. EXPERIMENTAL EVALUATION

Testing under controlled and real-world conditions yielded the following observations:

- Accident Detection Accuracy: > 95 % true positive rate for high-impact events; false positives minimized via motion threshold tuning.
- Alcohol Interdiction: MQ3 reliably detected legal intoxication levels and disabled ignition within 2 s of threshold breach.
- SMS Delivery: Successful transmission in 98 % of trials, with average latency of 5 s in urban and rural settings.
- Power Consumption: Average draw of 120 mA at 5 V; viability confirmed for 8 h continuous operation using a 2 000 mAh battery pack.

V. DISCUSSION

The integrated helmet offers comprehensive safety augmentation at modest cost (~ USD 40 BOM). Key challenges include sensor calibration drift, GPS signal loss in urban canyons, and managing false alarms during abrupt but non-crash maneuvers. Future iterations will explore machine learning-based event classification to further reduce false positives.

VI. CONCLUSION AND FUTURE WORK

We have demonstrated a practical Smart Helmet system that detects accidents, prevents intoxicated riding, enforces helmet usage, and delivers real-time alerts to emergency contacts. Planned enhancements include:

1. Cloud & Mobile App Integration: Live dashboard and rider profile management.
2. AI-Powered Crash Verification: Neural models to distinguish genuine accidents from sudden stops or drops.
3. Energy Harvesting: Solar or kinetic energy modules for extended autonomy.
4. Health Monitoring: Integration of pulse and body-temperature sensors.

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