Smart Helmet for Accident Prevention and Rider Safety Using IOT

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Abstract - Two-wheeler riders are frequently exposed to risks stemming from helmet neglect, drunk driving, and delayed emergency responses. This paper presents an IoT-enabled Smart Helmet system designed to enforce safety compliance and assist during accidents. The proposed system incorporates helmet usage verification using a limit switch, alcohol detection via an MQ sensor, and automatic accident identification through an ADXL345 accelerometer. Upon impact, the system retrieves GPS coordinates and transmits them to emergency contacts via a GSM module. Real-time feedback is displayed on an LCD, and alerts are issued through a buzzer. The integration of multiple sensors and microcontrollers creates a compact and cost-effective solution aimed at reducing road accidents and improving rider safety through automated monitoring and prompt emergency communication.

Key Words: Smart Helmet, IoT, Arduino UNO, Alcohol Sensor, Accident Detection, GSM, GPS, Rider Safety, Embedded System.

1.INTRODUCTION

In recent years, road safety has become a major concern, particularly for two-wheeler riders who are more vulnerable to accidents due to the lack of protective enclosures. Despite awareness campaigns and traffic regulations, a significant number of riders still ignore basic safety protocols such as wearing helmets or avoiding intoxicated driving. These violations often result in severe injuries or fatalities, especially when emergency assistance is delayed.

To address these challenges, this paper presents the design and implementation of a Smart Helmet system that utilizes embedded electronics and IoT technology to improve rider safety. The proposed system ensures the rider is wearing a helmet and is not under the influence of alcohol before allowing the bike to start. This is achieved using a limit switch for helmet detection and an MQ-series alcohol sensor to analyze breath samples.

Furthermore, the system is equipped with an accident detection mechanism using an ADXL345 accelerometer. In the event of a crash, the current GPS coordinates are fetched using a NEO-6M module and are transmitted via a SIM800L GSM module to a predefined emergency contact as an SMS alert. The helmet system also includes an LCD screen to display real-time system updates and a buzzer for immediate audible alerts.

By combining multiple sensors and microcontrollers in a compact design, the proposed system acts as an intelligent safety companion for two-wheeler riders. It offers an affordable, scalable solution for enforcing road safety protocols and improving emergency response times, potentially reducing accident-related fatalities.

2. Body of Paper

The body of the paper consists of numbered sections that present the main findings. These sections should be organized to best present the material.

It is often important to refer back (or forward) to specific sections. Such references are made by indicating the section number, for example, “In Sec. 2 we showed…” or “Section 2.1 contained a description….” If the word Section, Reference, Equation, or Figure starts a sentence, it is spelled out. When occurring in the middle of a sentence, these words are abbreviated Sec., Ref., Eq., and Fig.

At the first occurrence of an acronym, spell it out followed by the acronym in parentheses, e.g., charge-coupled diode (CCD).

Figure 1: Road Accidents Statistics Chart – placeholder

2. Proposed System

The proposed system integrates embedded hardware and IoT modules to enhance two-wheeler safety by enforcing helmet usage and ensuring rapid emergency communication during an accident.

The architecture of the system comprises two main units:

- Helmet Unit
- Vehicle Control Unit

Helmet Unit

This unit includes sensors such as the MPU6050 (accelerometer and gyroscope), and optionally an alcohol sensor, mounted inside the helmet. These sensors detect whether the helmet is worn and monitor motion patterns.

Vehicle Control Unit

This part is fixed on the bike. It includes the Arduino Uno (central controller), GSM module for communication, GPS for location tracking, and an engine control circuit.

The vehicle starts only when the rider is wearing the helmet (detected via sensor input). Upon detecting an accident (via sudden acceleration or tilt), the Arduino collects GPS coordinates and sends an SMS alert through the GSM module to emergency contacts.

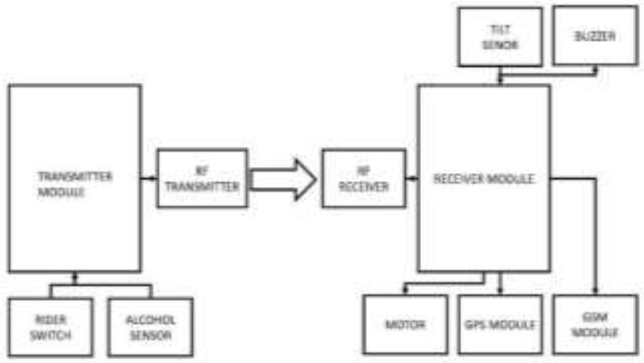

Figure -2: Block Diagram of the Smart Helmet System placeholder

3.COMPONENTS DISCRIPTION

3.1 MPU6050 / ADXL345 – Accelerometer for Crash Detection

The MPU6050 or ADXL345 is a compact 3-axis accelerometer used to detect sudden acceleration, tilt, or impact events. It plays a vital role in accident detection by identifying abnormal movement patterns, such as a fall or collision. Once a predefined threshold is exceeded, it triggers an emergency protocol. The sensor communicates with the microcontroller via I2C interface for real-time data transmission. It is reliable, power-efficient, and widely used in wearable safety applications.

Figure 3: MPU6050 / ADXL345 Crash Detection Sensor

3.2 ESP8266 – Wi-Fi Module ACKNOWLEDGEMENT

The ESP8266 Wi-Fi module enables wireless data transmission over internet-connected networks. In this system, it allows helmet data (like alcohol detection and helmet status) to be transferred to a server or mobile app. It supports HTTP and MQTT protocols for seamless communication and can be used to store crash logs or real-time alerts. Due to its compact size, low cost, and versatility, it's ideal for IoT-based vehicle safety systems. It also allows future cloud integration.

Figure -4 ESP8266MOD Mini Node MCU Wi-Fi Module

3.3 GSM Module (SIM800L)

The SIM800L GSM module is used for mobile communication, especially in areas without internet access. It allows the Arduino to send SMS alerts containing GPS coordinates to emergency contacts when an accident or alcohol detection event is triggered. The module operates over 2G networks and communicates via AT commands. It ensures communication continuity even in rural or remote locations, making the system robust and field-ready.

Figure -4 GSM Module (SIM800L)

3.4 GPS Module (NEO-6M)

The GPS module provides real-time latitude and longitude information of the rider's location. In the event of a crash or risky behavior, the system fetches coordinates and sends them via SMS to emergency numbers. The NEO-6M module ensures accurate positioning with its built-in antenna and memory for faster fixes. It operates via UART with the Arduino and provides outputs in NMEA format for easy integration.

Figure -5 GPS Module (NEO-6M)

3.5 Alcohol Sensor (MH-MQ or MQ3)

This sensor measures alcohol concentration in the rider's breath and sends the analog signal to the Arduino. If the reading exceeds the set threshold, the system disables ignition and sends alerts. It's highly sensitive to ethanol and is embedded inside the helmet, making real-time detection possible. The MQ3 sensor is simple, cost-effective, and essential for preventing drunk driving incidents.

Figure -6 MQ3 Alcohol Sensor

3.6 Limit Switch (Helmet Detection)

The limit switch is a mechanical sensor used to check if the helmet is worn properly. When the rider puts on the helmet, the switch gets pressed, signaling the Arduino to proceed with safety checks. If the switch is open (helmet not worn), the ignition remains disabled. This provides an automatic helmet enforcement mechanism and enhances rider discipline.

3.7 Arduino UNO (Microcontroller)

The Arduino UNO serves as the brain of the system. It processes data from all connected sensors and executes decision-making logic. It manages LCD updates, ignition control, buzzer alerts, and communication through GSM/GPS/Wi-Fi modules. Its open-source nature and vast community support make it perfect for prototyping and educational applications.

Figure -7 Arduino UNO Board

3.8 LCD Display (16x2)

The LCD module displays real-time information such as helmet status, alcohol level, and accident alerts. It acts as a user interface, keeping the rider informed of system status at all times. Powered via the Arduino, it's easy to code and highly readable in various lighting conditions.

3.9 Buzzer

The buzzer is an audio alert module used to warn the rider or bystanders during unsafe situations like alcohol detection or accidents. It is activated by the Arduino using a digital pin and provides immediate feedback for prompt action.

3.10 DC Motor (Ignition Simulation)

A DC motor is used to simulate vehicle ignition. If safety checks fail (helmet not worn or alcohol detected), the Arduino disables the motor, preventing vehicle startup. It is controlled through a relay or transistor-based circuit and represents the final decision from the system logic.

4. Communication Flow & Algorithm

This section outlines the internal and external communication architecture of the smart helmet system. It explains how data is transferred between various modules, the logic behind accident detection, and how alerts are generated and dispatched. The algorithm is designed for quick decision-making and real-time safety enforcement, ensuring seamless integration of sensors, microcontrollers, and communication modules.

4.1 Internal Communication Flow

The system begins by reading data from the helmet-side sensors: the limit switch, alcohol sensor, and accelerometer (ADXL345 or MPU6050). These inputs are continuously monitored by the Arduino microcontroller. If the helmet is worn correctly and no alcohol is detected, the microcontroller enables the DC motor (representing ignition). If either condition fails, the system immediately disables the motor and displays a warning on the LCD screen. Crash detection data is also monitored in parallel for sudden movements, ensuring real-time response.

4.2 External Communication Flow

For external communication, the system employs both GSM (SIM800L) and Wi-Fi (ESP8266MOD) modules. The GSM module is responsible for sending SMS alerts when an accident or unsafe condition is detected. These alerts include real-time GPS coordinates formatted as a Google Maps link. Simultaneously, the Wi-Fi module can upload logs or send data to a remote cloud server or app. This dual-layer communication ensures coverage in both connected and offline environments, enhancing reliability.

4.3 Algorithmic Logic – Helmet and Alcohol Check

Upon power-up, the Arduino checks the status of the helmet switch. If it is not pressed, the system assumes the helmet is not worn and halts all functions, flashing a warning. If pressed, the alcohol sensor is activated. A threshold is defined in the code (e.g., analog value > 400), beyond which the rider is flagged as intoxicated. If the reading is normal, the system continues, and the motor is enabled to simulate bike start. The LCD continuously updates the user on each check.

4.4 Algorithmic Logic Accident Detection &Response

The accelerometer continuously sends XYZ axis readings to the Arduino. If it detects a sudden spike in acceleration (e.g., X or Y > 5g), the system interprets this as a crash. It instantly fetches GPS coordinates from the NEO-6M module and formats them into a clickable Google Maps URL. This data is sent as an SMS alert through the GSM module to predefined emergency numbers. Simultaneously, the buzzer sounds to alert nearby individuals, and the LCD displays an “Accident Detected” message.

4.5 Output Module Communication

The output devices—LCD, DC motor, and buzzer—are controlled by the Arduino based on sensor inputs. The LCD shows messages like "Helmet Not Worn", "Alcohol Detected", "Accident Detected", or "Safe to Ride". The DC motor acts as a lock/unlock mechanism for ignition control. The buzzer provides immediate audio alerts during faults or crashes. Together, these components create an interactive and intelligent response system that assists the rider in making safe decisions.

5. Results & Discussion

This section showcases the practical implementation and performance evaluation of the proposed system. The smart helmet was tested under real-life scenarios to verify its accuracy, response time, and reliability in enforcing safety protocols and emergency alerts.

Case 1: Helmet Worn – System Ready to Start:

When the rider wears the helmet properly, the limit switch is triggered, allowing the Arduino to proceed. The LCD displays "Helmet Detected", and if alcohol is not found, the DC motor (representing ignition) is enabled. This ensures the bike can only start under safe conditions.

Figure 8: LCD Display Showing Helmet Detected – Vehicle Ready

Case 2: Helmet Not Worn – Ignition Blocked:

If the helmet is not worn, the limit switch remains open. The LCD displays a warning such as "Please Wear Helmet", and the ignition is disabled. This helps enforce rider discipline and prevents risky rides.

Case 3: Alcohol Detection – Alert Triggered

When alcohol is detected in the rider’s breath, the sensor output exceeds the threshold. The system disables the ignition and triggers a buzzer. An alert SMS containing the current GPS location is sent to a registered emergency contact.

Figure 9: Alcohol Detected – SMS with Location Sent

Case 4: Accident Scenario – Auto Alert:

In the event of a crash, the accelerometer senses a sharp tilt or spike in axis readings. The Arduino fetches coordinates via GPS and sends them as an alert using the GSM module. The LCD shows "Accident Detected", and the buzzer alerts nearby people.

Fig 7: Accident Detected – Google Maps Location Sent via GSM.

6. Conclusion

The Smart Helmet system proposed in this project successfully integrates embedded sensors, microcontrollers, and wireless communication technologies to ensure enhanced rider safety. By enforcing helmet usage, detecting alcohol consumption, and monitoring for accident scenarios in real time, the system demonstrates an effective and practical solution to reduce two-wheeler accident risks.

Experimental results confirmed the reliability of components such as the alcohol sensor (MQ3), accelerometer (ADXL345), and communication modules (GSM and GPS), proving the concept's effectiveness in live environments. The dual-unit setup (helmet and vehicle) with decision logic significantly boosts safety measures, especially in rural or network-limited areas.

This prototype serves as a stepping stone towards the commercialization of wearable smart safety devices for riders. Future enhancements could include mobile app integration, heart-rate sensors, cloud data storage, and AI-driven predictive safety analysis for improved accident prevention.

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