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Smart Helmet for Accident Detection and Alert Using IoT, GPS, and Alcohol Sensing

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Abstract

In today's fast-paced world, two-wheeler riders face increasing risks on the road due to accidents and reckless driving, often influenced by alcohol consumption. Quick access to medical help and preventive safety measures can make a significant difference in saving lives. This paper presents a Smart Helmet designed to detect accidents and alert emergency contacts instantly using GPS and IoT. The helmet also features an alcohol sensor that checks the rider's breath before the bike starts and disables the ignition if alcohol is detected. The system uses simple, low-cost components like an Arduino Uno, GPS and GSM modules, and an alcohol sensor (MQ3), making it suitable for mass adoption. This innovation is not just technical but also social—it aims to change how we think about rider safety and responsible driving. Through real-time testing and user feedback, the prototype proved effective in detecting impacts, sending alerts, and blocking ignition during alcohol detection. This smart helmet is a step toward smarter cities and safer streets.

Keywords: Smart Helmet, Accident Detection, Alcohol Sensing, IoT in Transportation, GPS Tracker, GSM Alerts, Road Safety, Embedded Systems

Introduction

In India, road safety is a growing concern, especially for two-wheeler riders who often lack the protection that larger vehicles offer. Every year, thousands of people lose their lives or are seriously injured due to road accidents involving motorbikes. What makes this even worse is the delay in providing emergency medical assistance, especially when the location of the accident is not immediately known. In many cases, bystanders are unaware or unwilling to act quickly, and victims are left helpless on the road.

On the other hand, driving under the influence of alcohol continues to be a major cause of road accidents. Despite strict traffic rules, many riders still take the risk. While breath analyzers and police checks exist, they are occasional and do not prevent someone from starting their vehicle while intoxicated.

This paper introduces a Smart Helmet that combines accident detection and alcohol sensing in one compact system. The idea is simple: if a rider meets with an accident, the helmet will detect the impact, find the rider's location using GPS, and immediately send an alert message to emergency contacts using a GSM module. In addition, before starting the bike, the helmet checks the rider's breath. If alcohol is detected, the ignition system is blocked, preventing the bike from starting.

The goal is not just to build a device, but to offer a meaningful solution to two of the biggest challenges in road safety: delayed accident response and drunk driving. By making it affordable and easy to use, this project aims to make safety smarter, more proactive, and accessible to everyone

Materials and Methodology

To build the Smart Helmet, my approach was grounded in three core goals: **affordability**, **functionality**, and **real-world practicality**. Every material chosen and every method followed was aimed at delivering a working prototype that's not just theoretical, but something that could be used by everyday riders — especially in India, where road safety needs immediate innovation.

Selection of Components

The project required a mix of sensors, communication modules, and a control board that could process everything in real time. I opted for components that are budget-friendly and easy to interface, especially for a student environment.

- **Arduino Uno**: This was the main controller — it's simple, reliable, and perfectly suited for IoT-level projects. It also has enough analog and digital pins to connect all the modules I needed.
- **MPU6050 Accelerometer + Gyroscope**: I used this to detect rapid changes in motion or orientation. It would help identify if the rider had fallen, crashed, or if there was an unusual tilt that could indicate an accident.
- **MQ3 Alcohol Sensor**: This was placed close to the rider's mouth inside the helmet to detect alcohol vapors in the breath. If detected, the system cuts the ignition.
- **Neo-6M GPS Module**: To track the rider's live location after an impact. It outputs the exact latitude and longitude which can be sent in an alert message.
- **SIM800L GSM Module**: Used to send an SMS to emergency contacts with the GPS coordinates. This way, help can reach the rider even if no one witnessed the crash.
- **Relay Module**: To control the ignition system. If alcohol is detected, the relay acts like a switch to disconnect the ignition and prevent the vehicle from starting.
- **Power Source**: I tested both a 9V battery and a standard USB power bank. The power bank worked better for longer sessions.

Helmet Integration and Mounting

After assembling the prototype on a breadboard for initial testing, I transferred all components into a real full-face helmet. I used industrial-grade double-sided tape, foam cushioning, and wire sleeves to safely secure the modules inside the helmet lining. Care was taken to avoid sharp bends in wires and to maintain ventilation around the sensors, especially the MQ3 which needs clear airflow to function accurately.

The MPU6050 was positioned at the top of the helmet for better motion tracking. The MQ3 was placed near the mouth opening, behind a breathable grille. The GSM and GPS modules were housed near the rear sides to improve signal reception without interfering with head comfort.

Programming and Logic Flow

The system was coded using the Arduino IDE. I wrote a modular codebase where each sensor had its own function, and the main loop controlled decision-making based on real-time data. Key logic included:

- The alcohol sensor is activated first. If alcohol is detected, the relay disables the ignition and the rest of the system halts.
- If alcohol is not detected, the system shifts to monitoring motion using the MPU6050.
- If a sudden impact (exceeding a threshold value) is detected, the GPS module gets a location fix.

- Once the coordinates are acquired, an SMS is sent through the GSM module to the saved emergency number.

Interrupts and timed delays were used to make the system responsive without crashing under sensor noise or data overflow.

Testing and Validation

I tested the prototype in phases. First, I exposed the MQ3 to spirit and mild alcohol vapors. The response time was within 2–4 seconds. For the impact test, I simulated crashes by dropping the helmet from various heights (30 cm to 100 cm) onto a cushion and a carpet. The system correctly detected the impact and triggered the GPS and GSM.

The location accuracy from the GPS module averaged 6–10 meters in open areas and 10–15 meters near buildings. SMS alerts were successfully received on multiple phones in less than 15 seconds from crash detection in most cases.

Results and Discussion

The development and testing of the smart helmet system yielded promising outcomes, validating the feasibility of integrating low-cost sensors and communication modules into a single wearable safety device. The prototype was tested under different controlled and semi-controlled conditions to evaluate sensor response, system coordination, and reliability in real-time operations.

During accident simulations, the MPU6050 sensor reliably detected abrupt changes in acceleration and orientation consistent with fall or crash scenarios. The sensitivity of the sensor was carefully calibrated to avoid false positives during regular head movements, such as turning or adjusting the helmet. In multiple drop tests conducted from varied heights, the system accurately interpreted the impact and proceeded to activate the emergency response protocol. Only in cases of very mild movements, where injury was unlikely, did the sensor remain inactive — an indication of the system's precision in discriminating between actual accidents and normal activity.

The alcohol detection component also functioned as intended. The MQ3 sensor was able to detect ethanol vapors within seconds of exposure. The relay module successfully triggered upon reaching the predefined threshold, interrupting the ignition signal and effectively preventing the simulated vehicle system from starting. No false positives were observed during exposure to non-alcoholic substances such as water vapor, indicating good sensor specificity. This preventive mechanism adds a valuable safety layer, particularly in regions where alcohol-related traffic incidents are prevalent.

The location tracking and communication modules worked in coordination with minimal delay. The GPS module typically required 10 to 15 seconds to obtain an initial fix, after which accurate latitude and longitude coordinates were generated. These coordinates were transmitted via the GSM module through SMS, reaching the designated emergency contact within 20 seconds of crash detection in areas with good mobile network coverage. The message format was kept simple, with embedded coordinates allowing recipients to easily track the rider's location using any map application. In areas with weak signals, there was a slight delay in message delivery, but the system still operated reliably without failure.

Power supply was provided through a standard 5V rechargeable battery pack. The system remained stable and responsive during continuous monitoring periods of up to five hours, with no overheating or functional disruptions. The Arduino Uno managed all input and output operations efficiently, maintaining responsiveness across sensor input, GSM communication, and relay control.

User feedback was collected informally from students and local riders who interacted with the helmet. Despite the additional embedded electronics, users reported acceptable comfort levels and minimal interference with normal helmet use. The integrated safety features, especially the automatic alert mechanism, were well received. Suggestions from test users included adding a visual or sound alert to indicate message dispatch, which is considered for future iterations.

The results affirm that the smart helmet is a technically viable and socially impactful innovation. It combines crash detection, alcohol prevention, and real-time location tracking into a unified system without compromising on cost or usability. Such solutions can play a vital role in improving road safety, especially in developing regions where two-wheeler accidents are a leading cause of fatalities.

Conclusion

This project successfully demonstrates the design and implementation of a smart helmet that enhances road safety through real-time accident detection, alcohol level monitoring, and automated emergency alerting. The system integrates commonly available components like the MPU6050 sensor, MQ3 alcohol sensor, GPS, and GSM modules, all coordinated through an Arduino Uno microcontroller. The prototype was tested under various controlled conditions and consistently responded to crash simulations and alcohol detection with minimal delays.

One of the key strengths of this system is its affordability and simplicity, making it suitable for everyday users, especially two-wheeler riders in high-risk areas. The alcohol detection mechanism adds a preventive safety layer by disabling the vehicle ignition if the rider is intoxicated. Meanwhile, the accident alert system ensures faster emergency response by sharing the rider's live location with pre-registered contacts.

The smart helmet, as developed, not only functions as a protective gear but also as a proactive safety solution. While the current version has shown encouraging results, future work may include the addition of mobile app integration, health sensors, or solar charging for extended usage. Overall, the project serves as a strong step toward using embedded systems and IoT for public safety and has the potential to make a meaningful difference in reducing accident-related fatalities.

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