SMART HELMET WITH ACCIDENT DETECTION AND ALERT SYSTEM

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College : *Cmr Institute Of Technology, Bengaluru*
Branch : *Department Of Electronics And Communication Engineering*
Guide(S) : *Prof. Sushma TV*
Prof. Sushmitha Alamuru
Student(S) : *Mr. Siddharth P*
Mr. S Tanuj
Mr. Swami T
Mr. Shreyas N H

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Introduction:

Road accidents involving two-wheeler riders continue to be one of the major causes of injuries and fatalities, especially in countries with high motorcycle usage. A significant number of these accidents occur because riders do not wear helmets, drive under the influence of alcohol, or are unable to receive medical assistance immediately after an accident. Traditional helmets provide only passive protection and are not capable of communicating with emergency systems or preventing unsafe riding conditions.

The Smart Helmet Protect project is designed to overcome these limitations by combining safety equipment with modern electronics, sensors, and communication technologies. The project aims to create an intelligent helmet system that not only protects the rider physically but also actively contributes to preventing accidents and improving emergency response.

The proposed smart helmet is equipped with multiple sensors and modules integrated into a standard motorcycle helmet. A helmet-wearing detection sensor ensures that the motorcycle can only start when the rider is wearing the helmet properly. This encourages safe riding habits and reduces the chances of riding without protection.

An alcohol detection sensor is included to monitor whether the rider has consumed alcohol before riding. If the detected alcohol level exceeds a predefined safe limit, the system prevents the ignition of the vehicle. This feature helps reduce accidents caused by drunk driving and promotes responsible behavior.

The project also includes an accident detection mechanism using sensors such as an accelerometer, vibration sensor, or gyroscope. These sensors continuously monitor the movement and condition of the rider. In the event of a severe collision, sudden impact, or abnormal tilt, the system recognizes that an accident may have occurred.

Once an accident is detected, the communication module automatically sends an emergency alert to predefined contacts. The alert message can include the rider’s location obtained through a GPS module. This allows family members, friends, or emergency

services to reach the accident site quickly and provide immediate assistance. Fast response can significantly reduce the severity of injuries and increase the chances of survival.

Apart from improving safety, the project also increases awareness about traffic rules and responsible riding practices. It encourages helmet usage, discourages drunk driving, and provides a sense of security to both riders and their families.

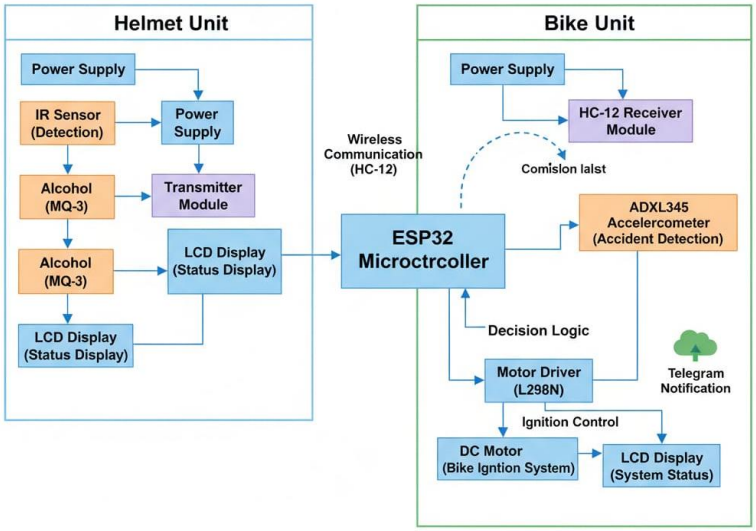

Figure 1: Block diagram of the Smart Helmet System

Objectives:

1. To ensure that the motorcycle starts only when the rider is wearing the helmet properly.
2. To detect alcohol consumption and prevent the vehicle from starting if the rider is intoxicated.
3. To detect accidents automatically using sensors.
4. To send the rider's live location and emergency alert to predefined contacts after an accident.
5. To improve overall rider safety and reduce road accident fatalities.

Methodology:

The Smart Helmet with Accident Detection and Alert System is implemented using two independent modules: the Helmet Unit and the Bike Unit. Both modules communicate wirelessly using HC-12 transceiver modules. The complete methodology followed in the project is described below.

1. Helmet Unit Design

The helmet unit is designed to monitor whether the rider is wearing the helmet and whether the rider is under the influence of alcohol.

a) Helmet Detection

An IR sensor is placed inside the helmet near the head region. When the rider wears the helmet, the IR rays are reflected from the rider's head and the sensor produces a signal. If the helmet is not worn, no reflection is detected.

Helmet worn → IR sensor output HIGH
Helmet not worn → IR sensor output LOW
The sensor output is continuously monitored by the ESP32 microcontroller.

b) Alcohol Detection

An MQ-3 alcohol sensor is mounted near the mouth area inside the helmet. The sensor detects alcohol vapors present in the rider's breath.
The analog output from the MQ-3 sensor is read by the ESP32. The sensed value is compared with a predefined threshold value.
Alcohol value below threshold → Rider is safe
Alcohol value above threshold → Rider is unsafe
If alcohol is detected beyond the threshold, the system blocks ignition.

c) Helmet Data Transmission

The helmet unit ESP32 combines the outputs of the IR sensor and MQ-3 sensor and sends the helmet status wirelessly to the bike unit using an HC-12 transceiver module through UART communication.
The transmitted data contains:
Helmet status
Alcohol status

2. Bike Unit Design

The bike unit receives data from the helmet unit and controls ignition, accident detection, and alert generation.

a) Receiving Helmet Data

An HC-12 transceiver connected to the bike-side ESP32 receives the data sent by the helmet unit. The received data is decoded and checked.
The bike unit verifies two conditions:
1. Helmet is worn
2. Alcohol is not detected
Only if both conditions are true, the bike ignition is enabled.

b) Ignition Control

The ignition control is implemented using an L298N motor driver connected to a DC motor, which represents the vehicle ignition in the prototype.
Helmet worn + No alcohol → Motor ON (Ignition enabled
Helmet not worn or Alcohol detected → Motor OFF (Ignition disabled)
Thus, the rider cannot start the vehicle without wearing the helmet or after consuming alcohol.

c) LCD Display

A 16×2 LCD display is connected to the bike-side ESP32 to provide real-time information to the rider.
The LCD displays messages such as:
Wear Helmet
Alcohol Detected
Ignition ON
Accident Detected
This improves user awareness and makes the system easier to operate.

3. Accident Detection Method

An ADXL345 3-axis accelerometer is connected to the bike unit. The accelerometer continuously measures acceleration along the X, Y, and Z axes.

During normal riding, the acceleration values remain within a safe range. If a sudden impact or fall occurs, the acceleration exceeds a predefined threshold.

The ESP32 continuously compares the measured acceleration with the threshold value.

Acceleration within limit → Normal riding

Acceleration exceeds threshold → Accident detected

A threshold of approximately ±7.5 m/s² is used to distinguish actual accidents from normal road disturbances such as bumps or speed breakers.

4. Emergency Alert Generation

When an accident is detected, the ESP32 immediately performs two actions:

1. Turns OFF the ignition
2. Sends an emergency alert message

The ESP32 uses its built-in Wi-Fi feature to connect to the internet and send a notification through the Telegram Bot API.

The emergency message contains information such as:

Accident detected

Rider may need help

The message is delivered instantly to the predefined Telegram account or emergency contact.

5. Complete Working Sequence

1. The rider wears the helmet.
2. The IR sensor checks helmet usage.
3. The MQ-3 sensor checks alcohol level.
4. Helmet data is transmitted to the bike unit through HC-12.
5. The bike unit checks whether both safety conditions are satisfied.
6. If conditions are satisfied, ignition is enabled.
7. During riding, the ADXL345 continuously monitors acceleration.
8. If an accident occurs, the system detects the impact.
9. Ignition is turned OFF automatically.
10. A Telegram alert is sent to emergency contacts.

Thus, the project combines prevention of unsafe riding with real-time accident detection and emergency alert generation.

Result and Conclusion:

In conclusion, The Smart Helmet project provides an effective solution for improving two-wheeler safety. It ensures that the rider wears a helmet and is not under the influence of alcohol before starting the vehicle. It also detects accidents and sends emergency alerts automatically. The project is low-cost, reliable, and easy to implement on real vehicles. Therefore, this system can help reduce road accidents and save lives.

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Future Scope:

The future scope of this project includes:

1. Add a GPS module to send the exact accident location along with the emergency alert message.
2. Integrate a GSM module so that alerts can be sent through SMS and calls even when Wi-Fi is not available.
3. Use AI or machine learning to improve accident detection and reduce false alerts caused by speed breakers or sudden braking.
4. Develop a mobile application to monitor helmet status, alcohol level, accident history, and emergency notifications in real time.
5. Implement the system directly in real bikes by connecting it with the actual ignition circuit and making the helmet fully waterproof and compact.