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# IoT-Based Smart Helmet

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**Abstract**: This project focuses on the design and implementation of an IoT-based Smart Helmet System to enhance the safety of two-wheeler riders. Statistics indicate that a significant number of road accidents are caused by alcohol consumption, negligence, and fatigue. The proposed system integrates multiple sensors, including an alcohol sensor to detect the presence of alcohol in the rider's breath and a detection mechanism to ensure helmet usage before vehicle ignition. The system also incorporates environmental monitoring to identify accident-prone zones. A communication module is used to send real-time alerts and emergency notifications in case of accidents. The integration of embedded systems and IoT technology enables real-time monitoring and preventive measures. This solution aims to reduce human errors, enforce safety compliance, and provide a cost-effective approach to minimizing road accidents and fatalities among two-wheeler users. This paper presents the design and implementation of an IoT-based smart helmet system aimed at enhancing the safety of two-wheeler riders. The proposed system integrates multiple sensors, including an alcohol sensor to detect the presence of alcohol in the rider's breath and a helmet detection mechanism to ensure proper usage before vehicle ignition. An accident detection module is incorporated using motion and impact sensors to identify potential crashes in real time. In the event of an accident, a communication module sends immediate alerts and location details to emergency contacts. Additionally, environmental monitoring is utilized to identify accident-prone conditions. The integration of embedded systems and IoT technology enables real-time monitoring and preventive safety measures. This system aims to reduce road accidents caused by human error, enforce safety compliance, and provide a cost-effective solution for improving rider safety.

**Keywords:** Smart Helmet, IoT, Alcohol Detection, Accident Detection, Rider Safety, Sensors, Emergency Alert System, Two-Wheeler Safety.

## I.INTRODUCTION

Road accidents and workplace hazards are major concerns affecting human safety. Many incidents occur due to negligence such as not wearing helmets or driving under the influence of alcohol. With the advancement of IoT technology, smart safety solutions can be developed to address these issues.The smart helmet system combines sensors and communication modules to monitor rider behavior and environmental conditions.

This approach helps in enforcing safety measures and providing timely assistance during emergencies. With the rapid advancement of Internet of Things (IoT) technology, it is now possible to develop intelligent systems that can monitor, detect, and prevent accidents in real time. Smart safety devices integrated with sensors and communication modules can significantly reduce risks and improve emergency response time.

This paper proposes an IoT-based smart helmet designed to enhance the safety of two-wheeler riders. The system incorporates an alcohol sensor to detect the presence of alcohol in the rider's breath and prevents vehicle ignition if alcohol is detected. Additionally, a helmet detection mechanism ensures that the rider is wearing the helmet before starting the vehicle.

An accident detection module is implemented using sensors to identify sudden impacts or abnormal movements. Road accidents have become a major global concern, especially among two-wheeler riders, due to the lack of adequate safety measures and negligence such as not wearing helmets and driving under the influence of alcohol. According to recent statistics, a significant percentage of road fatalities occur due to human errors, including alcohol consumption, fatigue, and non-compliance with safety regulations. Ensuring rider safety has therefore become a critical area of research in modern transportation systems.

  

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## II. LITERATURE REVIEW

Several researchers have proposed smart helmet systems to improve road safety using IoT, sensors, and intelligent technologies. The major focus of these studies is on preventing accidents, detecting crashes, and ensuring rider safety through automation and real-time communication.

In [1], an IoT-based smart helmet system was developed integrating MQ-3 alcohol sensors, IR sensors, GPS, and GSM modules to prevent drunk driving and detect accidents. The system ensures that the bike ignition starts only when the rider wears the helmet and is not under the influence of alcohol. Additionally, accident detection is achieved using vibration sensors, and emergency alerts are sent to predefined contacts with location details. Similarly, in [2], a cost-effective smart helmet model was proposed using Arduino and multiple sensors such as ultrasonic, vibration, IR, and alcohol sensors. The system enforces helmet usage and prevents ignition in case of alcohol detection. It also provides real-time accident notification and location tracking to ensure quick medical assistance.

Another study in [3] introduced a smart helmet with speed regulation features. The system uses sensors to detect whether the helmet is properly worn and restricts the vehicle speed if safety conditions are not met. This approach enhances safety by not only preventing accidents but also controlling risky driving behavior. In [4], an AI and IoT-based smart helmet system was proposed that uses machine learning algorithms (Random Forest) to predict accident probability. The system integrates sensors such as accelerometers, vibration sensors, and alcohol detectors to analyze rider conditions and provide warnings. It also sends alerts to emergency contacts, improving response time and survival rates.

A smart helmet system designed for delivery riders was presented in [5], where IoT-based sensors like MPU-6050 and FSR were used for fall detection and helmet compliance. The system also integrates mobile applications and cloud platforms for real-time monitoring, communication, and operational efficiency. Earlier work in [6] focused on accident detection using piezoelectric sensors to measure trauma levels during crashes. The system sends emergency alerts along with GPS location to authorities and relatives, emphasizing timely medical assistance.

In [7], an IoT-based smart helmet named "Konnect" utilized accelerometers, cloud computing, and GPS for real-time accident detection and notification. The system highlights the importance of immediate data transmission to reduce fatalities during the critical post-accident period. Another research work [8] proposed a smart helmet using Arduino Nano with features such as alcohol detection, accident identification, and ignition control. The system uses RF communication between helmet and bike to ensure that safety conditions are met before starting the vehicle.

Furthermore, in [9], an IoT-based accident prevention system was developed that combines sensors, Wi-Fi modules, and cloud services to detect accidents and notify emergency contacts. The study emphasized the importance of helmet usage and timely medical response in reducing fatalities.

| Ref | Key Features | Sensors Used | Technology | Limitations |
|---|---|---|---|---|
| [1] | Alcohol detection, helmet detection, accident alert | MQ-3, IR, vibration | IoT, GSM, GPS | No predictive analysis |
| [2] | Helmet check, alcohol detection, accident reporting | IR, MQ-3, ultrasonic, vibration | IoT, Arduino | Limited intelligence |
| [3] | Speed control based on helmet usage | IR sensors | Microcontroller | No accident alert system |
| [4] | Accident prediction using AI | Accelerometer, vibration, alcohol sensor | AI + IoT | Moderate accuracy (~70%) |
| [6] | Trauma-based accident detection | Piezoelectric sensor | IoT, Bluetooth | Limited features |
| [7] | Real-time accident notification | Accelerometer, GPS | IoT, Cloud | High power consumption |

Table 1: Comparison of Existing Smart Helmet Systems

  

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## III. PROPOSED SYSTEM & METHODOLOGY

The proposed smart helmet system is designed to improve the safety of motorcycle riders by integrating IoT technology with multiple sensors and communication modules. The system ensures that the motorcycle starts only when the rider wears the helmet correctly and is not under the influence of alcohol. An IR sensor is used to detect helmet usage, while an MQ-3 alcohol sensor detects alcohol concentration in the rider's breath. If alcohol is detected above the predefined threshold, the ignition system remains disabled, preventing the rider from operating the vehicle. The system also incorporates a vibration sensor to detect accidents. When a severe impact is detected, the GPS module acquires the accident location, and the GSM module automatically sends an emergency alert message containing the rider's location to predefined emergency contacts. This reduces the response time for medical assistance and increases the chances of saving lives. The entire system is controlled by an Arduino Uno microcontroller, which processes sensor data and coordinates all system operations.

The proposed system operates through the following sequence of steps:

1. The rider wears the smart helmet.
2. The IR sensor verifies that the helmet is worn properly.
3. The MQ-3 sensor checks the rider's breath for the presence of alcohol.
4. If the helmet is worn correctly and no alcohol is detected, the Arduino enables the ignition system, allowing the motorcycle to start.
5. If either condition is not satisfied, the ignition remains OFF.
6. During the ride, the vibration sensor continuously monitors for accident impacts.
7. If an accident is detected, the GPS module retrieves the current location.
8. The GSM module automatically sends an emergency SMS containing the accident location to the registered contacts.
9. This enables immediate assistance and improves rider safety.

The proposed methodology combines helmet detection, alcohol monitoring, accident detection, GPS tracking, and GSM-based emergency communication into a single integrated IoT system. This approach provides a reliable, low-cost, and effective solution for reducing road accidents and improving emergency response.

### 3.1 System Architecture

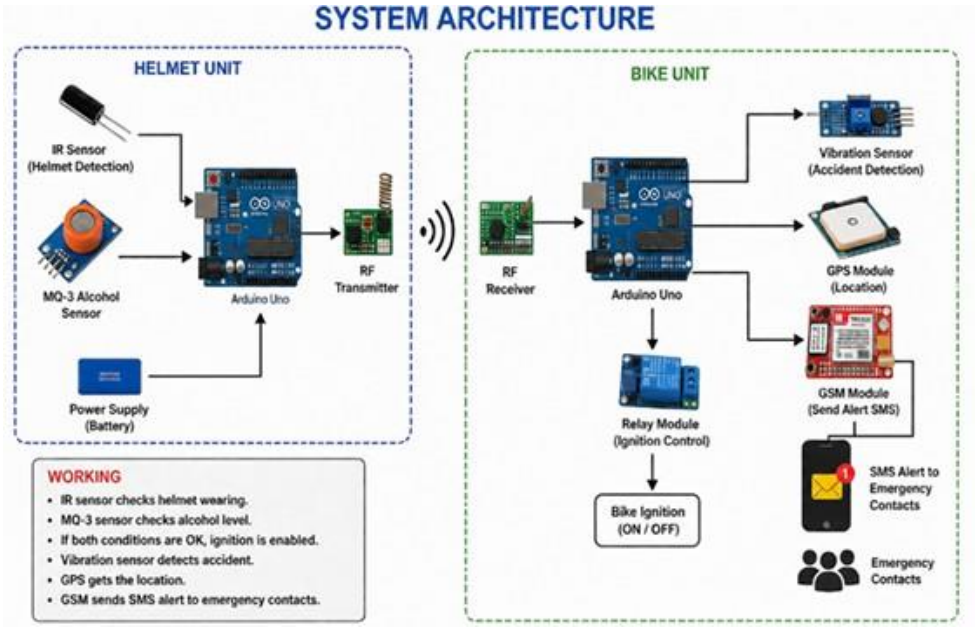


Fig 1. System Architecture

  

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### 3.2 Hardware Components

Arduino Uno: Serves as the central controller that processes sensor inputs and controls the entire smart helmet system. IR Sensor: Detects whether the rider is wearing the helmet properly. The motorcycle ignition is enabled only after successful helmet detection. MQ-3 Alcohol Sensor: Detects alcohol concentration in the rider's breath. If the detected value exceeds the preset threshold, the ignition remains OFF. Vibration Sensor: Detects strong vibrations caused by accidents and triggers the emergency alert mechanism. GPS Module: Determines the exact geographical location of the accident. GSM Module: Sends an emergency SMS containing the accident location to predefined family members or emergency contacts. Relay Module: Controls the motorcycle ignition by allowing or blocking power based on safety conditions.

### 3.3 Software Requirements

The proposed system is developed using both hardware and software platforms.

- Arduino IDE for programming the Arduino Uno.
- Embedded C programming language.
- Arduino libraries for GSM, GPS, and sensor interfacing.
- Serial Monitor for testing sensor outputs.
- Proteus (optional) for simulation before hardware implementation.

## IV. IMPLEMENTATION

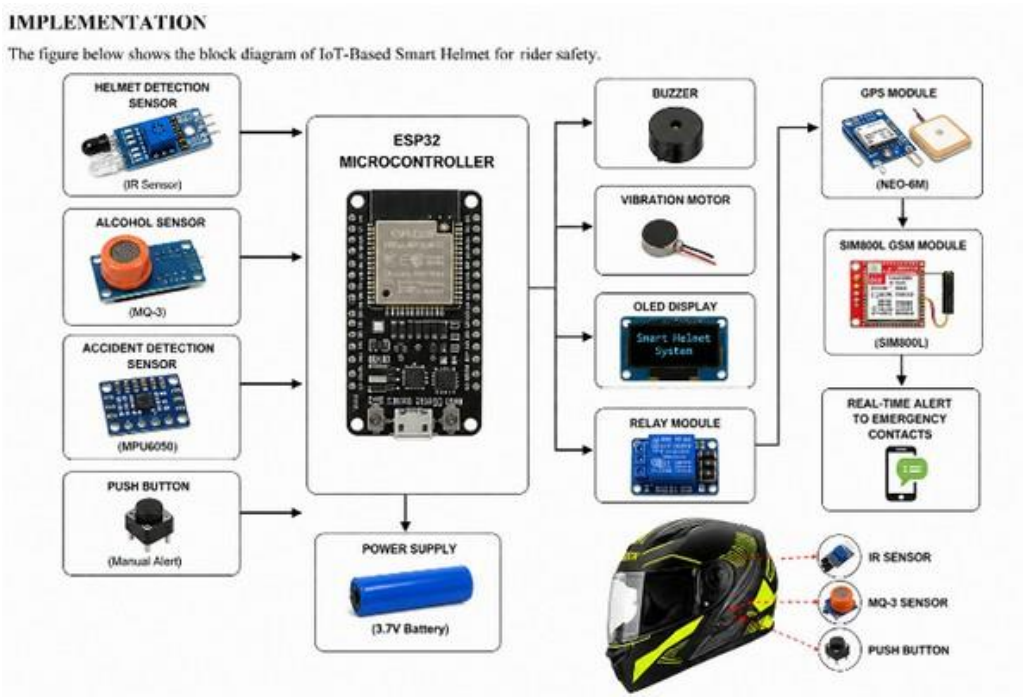


Fig 2. Implementation

**Implementation Steps:**

1. Initialize the ESP32 microcontroller and connect all sensors.
2. Detect whether the rider is wearing the helmet.
3. Measure the rider's breath using the MQ-3 alcohol sensor.
4. Allow ignition only if the helmet is worn and no alcohol is detected.
5. Continuously monitor the rider using the accident detection sensor.
6. Detect collisions or abnormal impacts.
7. Obtain the rider's location through the GPS module.
8. Send an emergency alert with location details to registered contacts.
9. Continue monitoring until the system is switched off.

This implementation provides a complete IoT-based rider safety solution by combining helmet detection, alcohol sensing, accident detection, and real-time emergency communication into a single system.

  

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## V. RESULT AND DISCUSSION

The developed smart helmet system was successfully implemented and tested under different operating conditions. The IR sensor accurately detected helmet usage and prevented the vehicle ignition when the helmet was not worn, ensuring rider safety.

The MQ-3 alcohol sensor effectively detected alcohol levels in the rider's breath. If the alcohol concentration exceeded the predefined threshold, the ignition was automatically disabled, preventing drunk driving.
The accident detection module successfully identified sudden impacts using the vibration sensor. Upon detecting an accident, the GPS module obtained the rider's location, and the GSM module immediately sent an emergency SMS to the registered contact.

Overall, the integrated system performed reliably by combining helmet detection, alcohol monitoring, accident detection, GPS tracking, and GSM communication. The proposed smart helmet effectively enhances two-wheeler rider safety and provides timely emergency assistance during accidents.

## VI. FUTURE SCOPE

The proposed system can be enhanced by integrating advanced technologies such as artificial intelligence and cloud computing. A mobile application can be developed for real-time rider monitoring and live location tracking. Additional sensors such as heart-rate and body temperature sensors can be incorporated to monitor the rider's health. Cloud-based data storage and analytics can be used for accident analysis, while machine learning algorithms can improve accident prediction accuracy.

Camera modules and voice assistance can also be integrated to further enhance rider safety and smart transportation. In the future, the system can support automatic emergency calling to nearby hospitals or family members during critical situations. GPS-based geofencing can be added to alert the rider when entering unsafe or restricted areas. The bike can also be connected with smart traffic systems for better road awareness and navigation support. Solar charging support may be introduced to improve energy efficiency and battery life. These improvements will make the system more intelligent, reliable, and useful for modern two-wheeler safety applications.

## CONCLUSION

The proposed IoT-based smart helmet system improves motorcycle rider safety by integrating helmet detection, alcohol detection, accident detection, GPS tracking, and GSM-based emergency alerts. It prevents vehicle ignition if the helmet is not worn or alcohol is detected, reducing unsafe riding practices. In the event of an accident, the system automatically detects the impact, tracks the rider's location using GPS, and sends an emergency SMS through GSM.

The system is cost-effective, reliable, and suitable for real-world implementation using an ESP32 and commonly available sensors. It also supports future enhancements such as cloud connectivity, mobile app integration, voice alerts, and advanced accident analysis. Overall, the proposed smart helmet provides an efficient solution for safer and smarter two-wheeler transportation.

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