

Smart Helmet for Accident Detection and Prevention

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Abstract - The Smart Helmet for Bike Accident Prevention is an innovative approach toward enhancing the safety of two-wheeler riders by integrating modern technology with traditional protective gear. With the increasing number of motorcycle accidents caused by factors such as neglecting helmet usage, drunk driving, and lack of situational awareness, there is a growing need for intelligent safety solutions. This project introduces a smart, IoT-enabled helmet system that focuses on accident prevention, real-time monitoring, and automated safety enforcement. By combining sensing technologies, intelligent control mechanisms, and wireless communication, the system aims to significantly reduce risks associated with bike riding.

A primary feature of the system is its helmet-wearing detection mechanism, which ensures that the rider properly wears the helmet before the vehicle can be started. The system continuously monitors whether the helmet strap is securely fastened. If the helmet is not worn or the strap is loose, the ignition system remains disabled, preventing the rider from operating the motorcycle. This automatic safety enforcement eliminates dependency on human behavior and ensures that riders follow essential safety practices, thereby reducing the chances of severe head injuries during accidents [1].

Another important aspect of the system is alcohol detection. The helmet is equipped with sensors that analyze the rider's breath to determine the presence of alcohol. If the detected level exceeds the permissible limit, the system restricts the ignition of the vehicle, preventing unsafe riding. Additionally, the detected alcohol level is displayed on a connected mobile application in percentage form, allowing both the rider and authorized individuals to monitor the condition in real time. This feature promotes responsible behavior and adds an extra layer of accountability.

The proposed system also incorporates environmental monitoring by measuring air quality in real time. The helmet detects harmful gases and pollution levels in the surrounding environment and sends this information to the mobile application. This allows riders to stay informed about the quality of air they are exposed to during their journey. By

integrating this feature, the system not only focuses on accident prevention but also contributes to health awareness and safer travel decisions in polluted areas.

A key advancement in this project is the inclusion of an Advanced Driver Assistance System (ADAS) tailored for two-

wheelers. This system continuously observes the distance between the motorcycle and nearby objects or vehicles. When a potential collision risk is detected, the system responds by reducing speed or disabling the ignition to prevent accidents. This proactive safety mechanism enhances rider awareness and provides technological assistance in critical situations, making riding safer and more intelligent.

Furthermore, the entire system is supported by IoT technology, enabling seamless communication between the helmet, the motorcycle, and a mobile application. Real-time data such as helmet status, alcohol level, air quality, and obstacle alerts are transmitted to the user's smartphone. The mobile interface provides continuous updates and notifications, helping riders make informed decisions while traveling. This interconnected system creates a smart safety ecosystem that bridges human actions with automated responses.

Key Words: Smart Helmet, Internet of Things (IoT), Accident Prevention, Alcohol Detection, Helmet Detection System, Air Quality Monitoring, Advanced Driver Assistance System (ADAS), Real-Time Monitoring, Wireless Communication, Two-Wheeler Safety, Embedded Systems, Sensor Technology.

1. INTRODUCTION

Road safety has become a major concern in today's fast-growing world, especially with the rapid increase in the use of two-wheelers. Motorcycles are widely preferred due to their affordability, fuel efficiency, and ease of movement in crowded urban areas. However, this convenience also brings significant risks, as riders are more exposed to external dangers compared to those traveling in enclosed vehicles. Even minor accidents can lead to serious injuries or loss of life. As a result, enhancing the safety of motorcycle riders has become an important focus area, encouraging the development of advanced technological solutions that can prevent accidents and protect lives.

Although safety measures such as helmets and traffic regulations have played a vital role in reducing accident-related fatalities, their effectiveness largely depends on the rider's awareness and responsibility. Many individuals still neglect essential

precautions, such as properly fastening helmet straps or avoiding alcohol consumption before riding. Despite legal enforcement, improper helmet usage remains common, reducing its protective capability. In addition, drunk driving

continues to be one of the leading causes of road accidents, as it affects judgment, reaction time, and overall control of the vehicle. These issues emphasize the need for a smarter system that not only provides safety but also ensures compliance with essential precautions.

To address these challenges, the concept of a Smart Helmet for Bike Accident Prevention is introduced as an advanced and integrated solution. Unlike traditional helmets that offer only passive protection, this system actively contributes to rider safety through automation and intelligent monitoring. One of its key features is the helmet detection mechanism, which verifies whether the helmet is worn correctly. The system ensures that the motorcycle can only be started when the helmet is properly secured. If the helmet is not worn or the strap is loose, the ignition system remains disabled. This feature enforces safe riding habits and ensures that riders cannot ignore this fundamental safety requirement.

The system also tackles the issue of alcohol-impaired driving by incorporating an alcohol detection mechanism. Sensors installed in the helmet analyze the rider's breath to detect alcohol levels. If the detected value exceeds the safe limit, the system prevents the bike from starting. This not only protects the rider but also safeguards other road users. Additionally, the alcohol level is displayed on a mobile application, allowing real-time monitoring and promoting responsible behavior. This transparency further strengthens accountability and discourages unsafe practices.

Apart from accident prevention, the smart helmet also focuses on the rider's health and environmental awareness. Two-wheeler riders are directly exposed to polluted air, especially in urban areas where vehicle emissions are high. To address this issue, the system includes air quality monitoring that detects harmful gases and pollution levels in real time. The collected data is displayed on a mobile application, enabling riders to understand their surroundings and take necessary precautions. This feature transforms the helmet into a device that not only protects from accidents but also contributes to overall well-being.

Another significant aspect of this project is the integration of Advanced Driver Assistance System (ADAS) technology. This

system continuously observes the surroundings and detects nearby vehicles or obstacles that may pose a risk. If a potential collision is identified, the system can respond by reducing speed or stopping the vehicle to prevent accidents. This intelligent assistance acts as an additional safety layer, supporting the rider in making safer decisions during critical situations. By combining preventive measures with real-time hazard detection, the smart helmet enhances both awareness and safety.

2. LITERATURE ANALYSIS

The literature on smart helmet systems highlights significant advancements in enhancing road safety using IoT and embedded technologies. The study by S. Johnpaul et al. proposes an IoT-based smart helmet that utilizes touch and gas sensors to ensure helmet usage and detect alcohol consumption, preventing bike ignition under unsafe conditions. Similarly, Piyush Gahane et al. introduced a multi-functional smart helmet incorporating obstacle detection, anti-theft mechanisms, and traffic-adaptive features using an ATmega16 microcontroller. Md. Jahidul Islam et al. further extended this concept by integrating NodeMCU, multiple sensors, and a mobile application to monitor rider conditions and send emergency alerts to authorities and relatives. Additionally, Tejaswini Panse et al. focused on responsible driving by combining alcohol detection with GPS-based accident notification systems. Another IoT-based smart helmet system emphasizes mandatory helmet usage, alcohol detection, accident identification, and night-time safety through LED indicators. Overall, these systems demonstrate the effective use of sensors, wireless communication, and automation to reduce accidents; however, future improvements can include AI-based predictive analytics, enhanced real-time communication with traffic systems, and broader integration with smart city infrastructure for improved road safety management.

TABLE 1.LITERATURE WORK

Sr. No	Platform / System	Author / Year	Methods Used	Future Scope
1	IoT-based Smart Helmet System for Accident Prevention	S. Johnpaul; C. Thirumalai Selvan; P. J. Raguraman	Touch sensor to detect helmet wearing; Gas sensor for alcohol detection; Bike ignition control based on helmet/alcohol status	Integration with GPS tracking and real-time accident alert systems; enhanced sensor accuracy and cloud-based monitoring
2	Smart Helmet: A New Generation Helmet	Piyush Gahane; Yash Lambat; Pawan Rathi; Shreyash Sahare;	Gas sensing, obstacle detection, anti-theft warning system; ATmega16 microprocessor-based control; traffic-adaptive	Expansion to AI-based traffic hazard prediction; integration with vehicle-to-vehicle communication;

		Archana R. Raut	music player; wireless bike authentication	improved anti-theft and hazard detection algorithms
3	An IoT-Based Smart Helmet for Riding Security and Emergency Notification	Md. Jahidul Islam; Md. Naimul Pathan; Abida Sultana; Anichur Rahman	Helmet circuit with NodeMCU, alcohol sensor, crash sensor, motion sensor; Mobile app integration; Tachometer for speed measurement; notifications to police, hospitals, and relatives	Enhanced emergency response integration; predictive accident analytics using IoT and ML; integration with national traffic management systems
4	Smart Helmet for Responsible Driving and Accident Prevention	Tejaswini Panse; Monica Kalbande; Shweta Gaidhani; Aditi Bhardwaj	Alcohol detection sensor; GPS module to send location in case of accidents; Electronic circuit to prevent intoxicated riders from starting the vehicle	Integration with insurance systems for real-time accident claims; AI-based risk assessment for preventive alerts; expansion to fleet management applications
5	Smart Safety Helmet for Bike Riders using IoT	—	Helmet wearing detection; Alcohol detection; Motor ignition control; Accident detection with location tracking; LED strip for night visibility	AI-based accident prediction; cloud-connected dashboards for traffic authorities; enhanced night-time visibility and emergency response systems

3. SYSTEM REQUIREMENT

3.1 HARDWARE REQUIREMENT

Sr. No	Component	Description
1	ESP32 / Arduino Uno	Used for processing sensor data and enabling connectivity
2	Helmet Strap Sensor	Pressure or IR-based sensor to detect whether the helmet is worn
3	MQ-3 sensor	Detects alcohol consumption level of the rider
4	MQ-135 sensor	Monitors real-time air quality around the rider
5	Ultrasonic / Radar Sensor	Used for ADAS to detect nearby obstacles or vehicles
6	Ignition Control Relay Module	Controls bike ignition based on safety conditions
7	Speed Control Module	Automatically reduces bike speed using PWM/motor driver
8	Bluetooth / Wi-Fi Module	Enables communication with mobile app (if ESP32 not used)
9	Power Supply Unit	Rechargeable Li-ion battery or 12V DC regulated supply
10	Vibration / Impact Sensor	Detects accidents or collisions
11	Buzzer and LED Indicators	Provides alerts and warning indications
12	Mobile Phone (Android/iOS)	Used for real-time monitoring via IoT application

13	Relay Module	Controls ignition and speed limiting functions
14	Helmet Shell & Mounting	Physical structure to integrate all components safely

3.2 SOFTWARE REQUIREMENT

Sr. No	SOFTWARE
1	Arduino IDE
2	ESP RainMaker
3	Programming Language (C++ / Arduino)
4	Machine Learning Model (Decision Tree)
5	Blynk
6	Data Visualization (Blynk Widgets)

4. WORKING METHODOLOGY

1. System Startup

The Smart Helmet for Bike Safety and Environmental Monitoring begins its operation when the system is powered on via a rechargeable 18650 lithium battery. The incoming power is first regulated using a buck converter to supply a stable voltage to the ESP32 microcontroller and all connected sensors. This ensures that the electronic components operate safely and reliably.

Once power stabilization is achieved, the ESP32 initializes by configuring its input/output pins for sensors and other peripherals. Communication protocols necessary for wireless transmission and GPS tracking are also established. The firmware sets up connections with the DHT11 sensor for temperature and humidity readings, the MQ135 sensor for air quality monitoring, the GPS module, and the LEDs used for alerts.

During initialization, the microcontroller performs a self-diagnostic check to verify proper functioning of all sensors and modules. Any detected faults trigger warning indicators. Upon successful completion of these checks, the system moves into continuous monitoring mode, gathering and processing sensor data in real time.

2. Environmental Data Collection

Once operational, the helmet continuously monitors surrounding environmental conditions. The DHT11 sensor measures temperature and humidity, converting these into digital signals. The ESP32 reads these signals periodically, processes them, and provides accurate environmental data. Monitoring temperature and humidity helps maintain rider comfort, alertness, and safety, especially under extreme conditions.

Simultaneously, the MQ135 sensor measures the concentration of harmful gases such as CO₂, ammonia, nitrogen oxides, benzene, and smoke. It outputs an analog voltage proportional to pollutant levels, which the ESP32 converts into meaningful air quality values using calibration formulas and thresholds. This allows the system to estimate the pollution level in the rider's vicinity. Real-time acquisition ensures prompt alerts if any parameter exceeds safe limits.

3. Air Quality Detection and Alerts

Air pollution is a significant concern for urban riders. The MQ135 sensor continuously analyzes ambient air, detecting gas concentrations that indicate pollution levels. Changes in the sensor's electrical resistance due to gas exposure generate an analog signal. The ESP32 interprets this signal, compares it with stored air quality thresholds, and determines the safety of the surrounding environment.

If the air quality is acceptable, data is transmitted to the mobile application without alerts. If pollution levels exceed safe limits, the helmet activates LED indicators to warn the rider and simultaneously sends notifications to the connected mobile application. This allows the rider to take precautionary measures, such as adjusting the route or reducing exposure to polluted areas.

4. Temperature and Humidity Monitoring

The DHT11 sensor also tracks temperature and humidity to ensure rider comfort. It measures humidity via a moisture-sensitive capacitor and temperature using an internal thermistor. These readings are converted to digital signals and processed by the ESP32.

The system stores temporary data and sends it to the mobile application. If abnormal environmental conditions are detected—such as extreme heat, poor ventilation, or high humidity—the helmet activates visual alerts through LEDs to inform the rider. Continuous monitoring of these parameters enhances comfort and reduces the risk of fatigue or distraction during travel.

5. GPS-Based Location Tracking

The helmet integrates a GPS module for real-time location tracking. It receives satellite signals and calculates the rider's precise latitude and longitude coordinates. These coordinates are sent to the ESP32 via serial communication and prepared for transmission.

Location tracking is vital in emergencies. In case of an accident, the rider's exact position can be quickly shared with family members or emergency responders via the mobile application. The app also allows real-time route monitoring, providing additional safety and situational awareness.

6. Wireless Data Transmission

The ESP32 microcontroller supports wireless communication, enabling the helmet to transmit collected data to a smartphone. Sensor readings from the DHT11, MQ135, and GPS module are processed and formatted before transmission.

Data is continuously sent at regular intervals, ensuring the mobile application always display updated environmental conditions and location information. Wireless connectivity transforms the helmet into a smart IoT device that combines environmental monitoring with real-time mobile accessibility.

7. Mobile Application Interface

The mobile application serves as the user interface for the smart helmet. It presents temperature, humidity, air quality levels, and GPS location in an organized format.

Users can view live environmental conditions and receive alerts for abnormal readings. The GPS data allows real-time tracking of the rider's location on a map. By integrating environmental monitoring with location tracking, the mobile app provides a complete safety and awareness solution for riders.

8. Integrated System Operation

With all components working together, the smart helmet operates as a unified monitoring system. Sensors continuously gather data, the ESP32 processes it, and wireless transmission delivers real-time updates to the mobile app. LEDs on the helmet provide immediate feedback for unsafe conditions.

Continuous monitoring ensures rider safety, environmental awareness, and quick response during emergencies. The integrated system functions seamlessly without compromising rider comfort or mobility, providing a smart, IoT-based helmet solution for enhanced travel safety

SMART HELMET FOR BIKE SAFETY AND ENVIRONMENTAL MONITORING

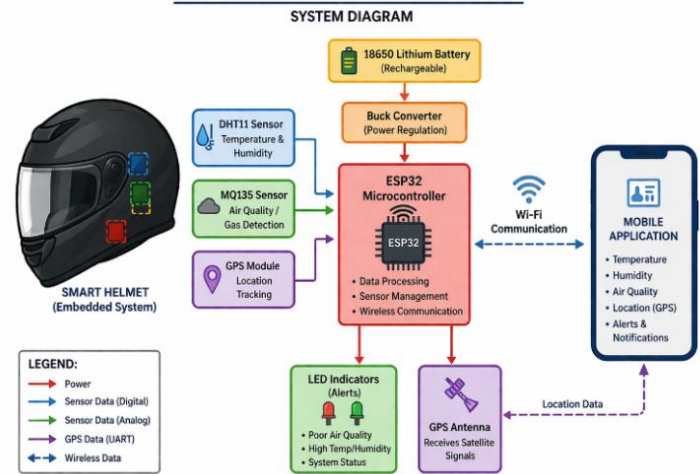


Fig -2: System Diagram Level-2

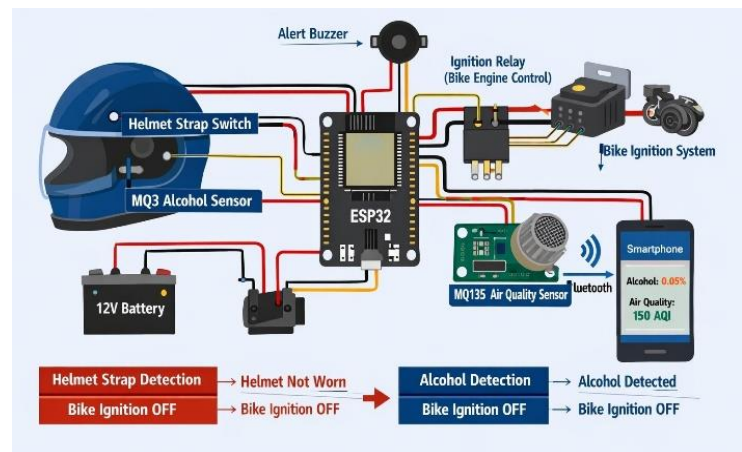


Fig -3: Data Flow Diagram

5. RESULTS AND DISCUSSION

The implementation of the Smart Helmet for Bike Safety and Environmental Monitoring demonstrates the effective integration of IoT technology, environmental sensing, and real-time communication to enhance rider safety and awareness. The system was tested under different environmental and riding conditions to evaluate its performance, reliability, and responsiveness. During system operation, the ESP32 microcontroller successfully initialized all connected sensors and maintained stable communication with the mobile application. The power regulation using the buck converter ensured consistent voltage supply, allowing uninterrupted functioning of the system. The initialization and self-check process helped in identifying hardware issues at an early stage, improving system reliability. The environmental monitoring results showed that the DHT11 sensor provided accurate temperature and humidity readings within acceptable ranges. Variations in environmental conditions were detected in real time,

SMART HELMET FOR BIKE SAFETY AND ENVIRONMENTAL MONITORING

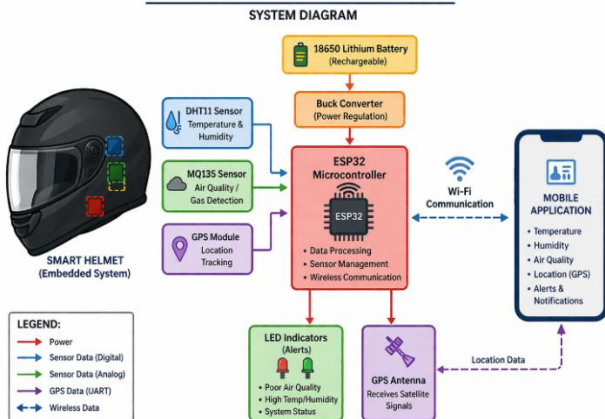


Fig -1: System Diagram-Level-1

allowing the system to notify the rider when temperature or humidity exceeded comfort thresholds. This feature proved useful in identifying uncomfortable riding conditions such as excessive heat and humidity. Similarly, the MQ135 gas sensor effectively detected changes in air quality by sensing harmful gases such as carbon dioxide, ammonia, and smoke. When pollution levels increased beyond predefined limits, the system triggered LED alerts and mobile notifications. This real-time air quality monitoring enables riders to make safer decisions, such as avoiding highly polluted routes. The GPS module demonstrated reliable performance in tracking the rider's location. The system successfully transmitted latitude and longitude coordinates to the mobile application, which displayed the real-time position on a map interface. This functionality is particularly beneficial during emergency situations, as it allows quick identification of the rider's location and facilitates faster response from emergency services. Wireless communication using the ESP32 was stable and efficient, ensuring continuous data transmission between the helmet and the mobile application. The application interface displayed all sensor data clearly, including temperature, humidity, air quality, and location. Notification alerts were generated promptly whenever abnormal conditions were detected, enhancing user awareness without causing distraction. Overall, the system achieved continuous monitoring with minimal delay, demonstrating the feasibility of integrating environmental sensing and safety features into a wearable device. The results indicate that the proposed smart helmet system improves rider safety by providing real-time environmental insights and location tracking. However, certain limitations were observed, such as sensor calibration dependency, limited accuracy under extreme conditions, and reliance on network connectivity for data transmission. Future improvements can focus on enhancing sensor precision, integrating advanced analytics such as machine learning for predictive alerts, and expanding system compatibility with smart city infrastructure.



Fig- 4 Result Picture

6. CONCLUSIONS

The Smart Helmet for Bike Safety and Environmental Monitoring system successfully demonstrates how IoT-based technologies can be integrated into wearable safety equipment to enhance rider protection and awareness. By combining sensors such as the DHT11 sensor and MQ135 gas sensor with the ESP32 microcontroller, the system is capable of continuously monitoring environmental conditions and transmitting real-time data to a mobile application. The inclusion of GPS tracking further strengthens the system by enabling location monitoring, which is crucial during emergency situations.

The system effectively addresses key safety concerns by providing alerts for poor air quality, extreme temperature, and humidity conditions, thereby improving rider awareness and decision-making during travel. Additionally, the wireless communication feature ensures seamless interaction between the helmet and the user interface, making the system user-friendly and efficient.

Overall, the proposed solution offers a practical and scalable approach to improving road safety and environmental awareness for two-wheeler riders. While the system performs reliably under normal conditions, future enhancements such as improved sensor accuracy, AI-based predictive analytics, and deeper integration with smart transportation systems can further increase its effectiveness. This smart helmet system represents a significant step toward the development of intelligent, connected safety solutions in modern transportation.

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