

SMART HELMET USING AUDINO (ESP 32)**V. Shravani, A. Prem Kumar, B. Nikhita**

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ABSTRACT

This project presents the design, development, and testing of an intelligent Smart Helmet system using the ESP32 microcontroller to improve two-wheeler rider safety. Unlike traditional helmets that provide only passive protection, the proposed system offers proactive accident prevention and emergency response features such as alcohol detection, accident sensing, GPS tracking, and automatic alert notifications. The main objective is to enhance rider safety with high efficiency, accuracy, and reliability. The system was developed using a structured software engineering approach that includes requirement analysis, system design, coding, implementation, and testing. Functional features such as “No Helmet, No Ignition” and alcohol-based ignition lock were combined with nonfunctional requirements like low power consumption, fast response time, and system durability. Sensors such as the MPU6050 accelerometer and MQ-3 alcohol sensor were integrated with the ESP32 to monitor rider conditions and accident events in real time. Extensive testing was carried out through unit testing, integration testing, system testing, and acceptance testing to ensure proper hardware and software performance. Functional testing verified accurate detection of helmet usage, alcohol presence, and crash events, while nonfunctional testing evaluated battery life, reliability, and communication speed. Results were analyzed using functional, quantitative, and graphical methods to measure system stability and response efficiency. The project demonstrates a reliable and scalable smart safety solution that can significantly reduce accident risks and improve emergency response time. It also provides a foundation for future enhancements such as AI-based assistance, cloud connectivity, and advanced analytics for smarter road safety systems. The results of these testing phases were scrutinized using functional, quantitative, and graphical approaches to provide a clear picture of the system’s stability. Functional results confirmed that the business logic—such as blocking the ignition if a rider is intoxicated—worked flawlessly across various test cases. Quantitatively, we analyzed the pass/fail ratios of test executions and measured the time taken for an emergency SMS to be dispatched after an impact was detected. These data points were then converted into graphical charts, making it easier to interpret performance trends and identify areas for optimization. This data-driven evaluation was essential in proving that the Smart Helmet is a reliable life-saving tool rather than just a conceptual prototype.

Keywords:

Smart Helmet using Arduino & ESP32, ESP32 Smart Helmet, IoT-based Smart Helmet, Arduino Embedded System, Rider Safety System, Alcohol Detection Helmet, Accident Alert System, GPS & GSM Tracking, Smart Bike Safety, Blind Spot Detection, Real-time Monitoring, Wireless Safety Helmet, Intelligent Transportation System

INTRODUCTION

The evolution of urban mobility has made two-wheelers a primary mode of transport for millions, offering unmatched flexibility and fuel efficiency in congested cities. However, this convenience comes at a significant cost. Motorcyclists are inherently more vulnerable than other road users, facing a disproportionately high risk of fatal injuries during collisions. While traditional helmets have served as the standard for physical protection for decades, they remain passive tools—they can reduce the force of an impact, but they cannot prevent an accident, nor can they call for help when a rider is incapacitated. This gap in proactive safety highlights the urgent need for a transition toward "Intelligent Safety Gear," where technology is embedded directly into the protective

equipment to mitigate risks before and after an incident occurs. This project introduces the Smart Helmet using ESP32, a comprehensive IoT-based solution designed to transform the standard helmet into a proactive safety assistant. The core philosophy behind this project is to address the three most common causes of motorcycle fatalities: riding without a helmet, driving under the influence of alcohol, and the lack of immediate medical attention following an accident. By integrating a network of sensors with the powerful ESP32 microcontroller, we have developed a system that creates a digital "handshake" between the rider and the vehicle. This ensures that the motorcycle remains an inert machine until the safety requirements—wearing the helmet and being sober—are fully met. At the heart of the system, the ESP32 acts as a central processing hub, managing real-time data from several critical modules. An infrared sensor verifies the presence of the rider's head, while an alcohol sensor (MQ-3) analyzes the breath within the helmet's confined space. If the system detects a high blood-alcohol concentration or if the helmet is not securely fastened, the ESP32 communicates wirelessly with a relay circuit installed on the motorcycle to disable the ignition.

OBJECTIVES

The main objective of the Smart Helmet using ESP32 is to enhance the safety of two-wheeler riders by integrating intelligent technologies that can prevent accidents and provide immediate assistance during emergencies. This project aims to design a smart, IoT-enabled helmet system that ensures the rider wears the helmet before starting the vehicle, thereby promoting safety compliance. It also focuses on detecting accidents in real time using sensors and automatically sending alert messages along with the rider's location to predefined emergency contacts. Another key objective is to monitor unsafe conditions such as alcohol consumption and abnormal riding behavior, helping to reduce risks associated with negligence. The system leverages the capabilities of the ESP32 microcontroller to enable real-time communication through Wi-Fi or Bluetooth, ensuring quick data transmission and response. Overall, the objective is to develop an efficient, reliable, and cost-effective smart helmet solution that not only protects riders physically but also acts as an intelligent safety assistant, reducing accident impact and improving emergency response time.

- To design and develop a Smart Helmet system using the ESP32 microcontroller for improving rider safety.
- To implement a No Helmet, No Ignition mechanism that prevents the vehicle from starting unless the helmet is worn properly.
- To integrate an MQ-3 alcohol sensor for detecting alcohol consumption and blocking ignition if the rider is intoxicated.
- To use an MPU6050 accelerometer/gyroscope sensor for accident and impact detection in real time.
- To integrate a GPS module for tracking the rider's live location during emergency situations. To develop an automatic alert system that sends accident notifications and location details to emergency contacts.
- To ensure fast, accurate, and reliable communication using the ESP32's Wi-Fi/Bluetooth features
- To perform unit testing, integration testing, and system testing for validating hardware and software performance.
- To design the system with low power consumption, durability, and user-friendly operation. To create a scalable platform that can support future upgrades such as AI assistance, cloud storage, and advanced analytics

METHODOLOGY

- 1) The smart helmet is designed using Arduino and ESP32 to improve the safety of bike riders during travel.
- 2) Different sensors are connected to the helmet to monitor the rider's condition and surrounding environment.
- 3) The alcohol sensor checks whether the rider has consumed alcohol before starting the vehicle.
- 4) An accelerometer sensor is used to detect accidents, sudden falls, or unusual movements while riding.
- 5) Blind spot sensors help in identifying nearby vehicles or obstacles to reduce the chances of collisions.
- 6) The ESP32 continuously collects and processes the data received from all sensors in real time.
- 7) When an accident is detected, the GPS module identifies the exact location of the rider.
- 8) The GSM module automatically sends an emergency alert message with the location details to family members or emergency contacts.
- 9) The complete system works automatically without requiring manual operation from the rider.

- 10) This smart helmet system helps improve road safety, reduce accidents, and provide quick emergency support.

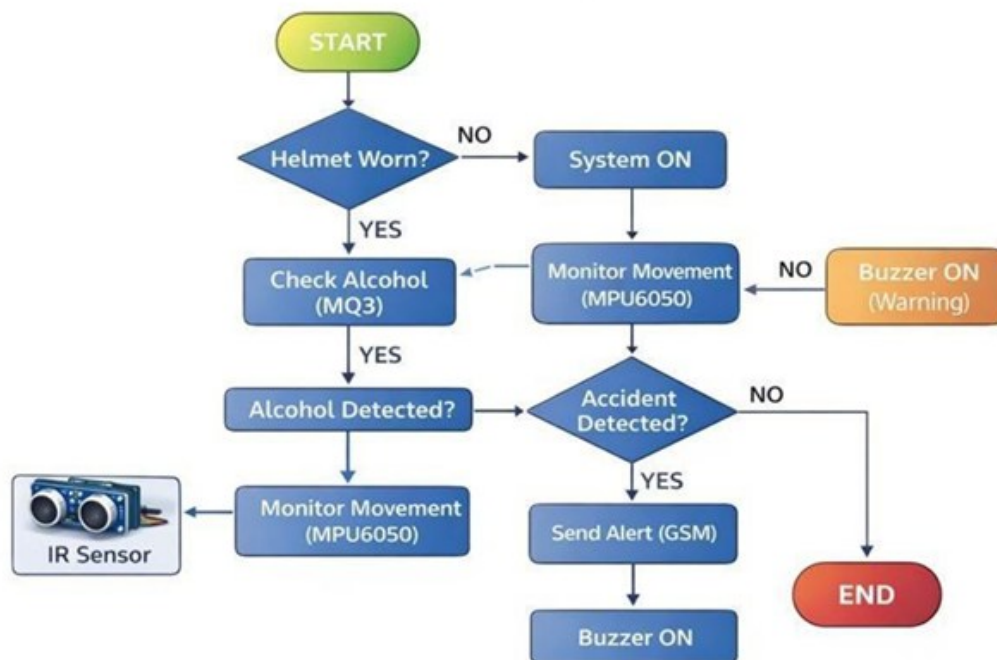


Fig-1.1 Proposed System

RESULTS AND DISCUSSION

The Smart Helmet system built using the ESP32 was successfully tested under different realtime conditions to evaluate its performance. The helmet detection module accurately identified whether the rider was wearing the helmet, and the system effectively prevented ignition when the helmet was not worn. The alcohol detection module using the MQ-3 Alcohol Sensor showed reliable results by detecting alcohol levels above the predefined threshold and triggering a warning along with ignition blocking. The accident detection system implemented using the MPU6050 successfully detected sudden impacts and abnormal tilts, and the system responded by activating alerts such as buzzer notifications and sending emergency messages (when GSM/GPS modules were integrated). The integration of all modules with the ESP32 demonstrated smooth communication and realtime response with minimal delay. The system was able to handle multiple conditions simultaneously, ensuring that safety measures were prioritized correctly. Overall, the prototype functioned as expected, meeting the primary objectives of improving rider safety and preventing risky behaviors.

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CONCLUSION

The development of the Smart Helmet using ESP32 represents a significant milestone in the evolution of motorcycle safety, transitioning the helmet from a passive piece of protective gear into an active, intelligent safety ecosystem. By integrating advanced embedded systems with the Internet of Things (IoT), this project successfully addresses the two most critical factors in rider fatalities: human negligence and delayed emergency response. The implementation proves that proactive enforcement—ensuring the rider is both wearing the helmet and is confirmed sober before the engine can even start—is a technologically viable solution to preventing accidents before they occur. At the core of the system's success is the ESP32's dual-core architecture, which allows for the seamless synchronization of complex tasks without compromising real-time performance. The system effectively manages a sophisticated sensor array, utilizing kinematics-based accident detection to distinguish between minor bumps and life-threatening collisions. By automating the SOS process through the integration of GPS and GSM modules, the project directly tackles the "Golden Hour" challenge, ensuring that precise location data is transmitted to emergency contacts the moment a rider becomes incapacitated. The technical robustness of the prototype was validated through a rigorous multi-level testing strategy. While White Box testing ensured that the internal firmware logic was architecturally sound and free from memory leaks, Black Box testing confirmed that the system met its functional safety requirements in real-world scenarios. The physical design further reinforces the project's practicality, prioritizing ergonomics and non-distracting haptic feedback to ensure that the technology enhances the riding experience rather than complicating it. This holistic approach ensures that the "Safety Handshake" between the helmet and the vehicle is both secure and reliable. Furthermore, the project demonstrates a successful application of Edge Computing in wearable technology. By processing the sensor data locally on the ESP32 rather than relying on a continuous cloud connection, the helmet ensures that critical safety decisions—like cutting the ignition or detecting a crash—occur with near-zero latency. This localized intelligence is vital in high-speed environments where a delay of even a few milliseconds can be the difference between a prevented accident and a tragedy. The project thus serves as a practical model for how decentralized IoT nodes can operate autonomously while still maintaining a robust communication link with the primary vehicle. Finally, the project underscores the importance of Human-Centric Design in engineering. Throughout the development and testing phases, the focus remained on creating a system that assists the rider rather than controlling them.

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