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SMART HELMET

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Abstract:

According to the investigation in India, nearly 25% of the road accidents are caused by two wheelers. The foremost causes for the fatalities are due to drunken driving, rash driving, and drowsiness due to long drive. The rapid increase in road accidents involving two-wheeler riders has become a major public safety concern, emphasizing the need for intelligent and proactive safety solutions. The aim of this work is to build an interesting and efficient Smart Helmet system that protects riders from accidents and also helps in identifying accident-prone situations. This paper presents an IoT-based Smart Helmet system aimed at enhancing rider safety through real-time monitoring and rapid emergency response. The proposed system integrates multiple sensors including an accident detection sensor, alcohol detection sensor, GPS module, and GSM communication unit to continuously monitor the rider's condition and riding environment. The system detects abnormal behavior such as sudden impact or collision and checks for alcohol consumption before and during vehicle operation. In the event of an accident, the Smart Helmet automatically transmits real-time alerts along with precise location details to pre-registered emergency contacts and relevant authorities using GSM connectivity, ensuring timely medical assistance. The helmet is designed to be lightweight, user-friendly, and easily adaptable to conventional helmets without compromising rider comfort. By combining accident prevention mechanisms with automated emergency notification, the proposed Smart Helmet provides an effective, low-cost, and scalable solution to reduce accident severity and fatalities among two-wheeler riders and demonstrates the potential of IoT technology in improving road safety and saving lives.

Keywords: *Smart Helmet, Internet of Things (IoT), Accident Detection, Alcohol Detection Sensor, GPS, GSM*

I. INTRODUCTION

Nowadays, road accidents have become a serious concern worldwide, particularly for two-wheeler riders. Even with the use of conventional helmets, riders often face severe injuries or fatalities due to fatigue, carelessness, distraction, or sudden loss of vehicle control. Traditional helmets provide protection only during an impact, but they cannot actively prevent accidents, warn the rider of potential hazards, or ensure immediate assistance in case of an emergency. Considering these limitations, there is a growing need for *intelligent and proactive safety systems* to enhance rider protection. To address this challenge, an *IoT-based Smart Helmet* has been developed that continuously monitors the rider's condition, movements, and surrounding environment in real-time. The helmet integrates multiple sensors, including an accelerometer, gyroscope, alcohol detection sensor, and GPS module. These sensors help detect abnormal behavior, potential risks, and emergencies, allowing the system to alert the rider and initiate timely intervention. *The device is completely safe and comfortable for two-wheeler riders,* ensuring it can be worn during long rides without restricting movement or causing discomfort. This project goes beyond basic head protection by promoting responsible riding behavior, providing proactive accident prevention, and enabling faster emergency response. By combining modern IoT technology with wearable safety devices, the Smart Helmet serves as a connected and intelligent safety solution.

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It not only enhances road safety and protects riders but also demonstrates how technology can be applied to address real-world safety challenges effectively. Ultimately, this system represents an innovative step toward reducing accidents, saving lives, and creating a safer riding experience for all two-wheeler users.

Fig. 1*: Smart Helmet System Block Diagram*

Figure 1 illustrates the overall architecture and working principle of the Smart Helmet System designed to enhance rider safety. The IR sensor is used to detect whether the helmet is properly worn by the rider, ensuring vehicle operation only when safety conditions are met. The alcohol sensor continuously monitors the rider's breath to detect alcohol consumption and helps prevent riding under the influence. An accelerometer sensor is integrated to sense sudden changes in speed or orientation, which indicates a possible accident or fall. Upon accident detection, the GPS module obtains the exact geographical location of the rider. This location information, along with the accident alert, is transmitted through the GSM module in the form of an SMS to predefined emergency contacts or rescue services. By integrating these sensors and communication modules, the smart helmet provides real-time monitoring, accident detection, and rapid emergency response, thereby significantly improving road safety for two-wheeler riders.

II.LITERATURE SURVEY

The increasing number of road accidents among two-wheeler riders has necessitated the development of advanced safety systems such as IoT-based smart helmets. Several studies have demonstrated the integration of various sensors and communication technologies into smart helmets to enhance rider safety by monitoring real-time conditions and detecting potential hazards. Components such as accelerometers, gyroscopes, GPS modules, and environmental sensors including temperature, humidity, and air quality sensors are widely used to track riding conditions effectively [1]. In addition, smart helmets equipped with GSM modules can immediately alert emergency contacts in the event of an accident, significantly reducing response time in critical situations [1]. Helmets with embedded alcohol detection sensors have also been highlighted as a preventive measure to reduce accidents caused by intoxicated riding [2]. Furthermore, intelligent helmets featuring accident detection, GPS tracking, and automated alert systems have been proposed to improve overall road safety for two-wheeler riders [3]. Recent smart helmet systems also demonstrate the integration of alcohol detection, helmet usage verification, GPS, and GSM modules, enabling continuous monitoring of rider behaviour, sending emergency notifications, and ensuring rapid response during critical situations [5].Overall, the integration of IoT technologies in helmets facilitates continuous monitoring of rider behaviour, environmental conditions, and potential hazards, thereby contributing to smarter and safer transportation systems. These advancements indicate a progressive shift toward predictive and automated safety solutions, underscoring the potential of smart helmets to significantly reduce accident-related injuries and fatalities [1][2][3][5].

III. OBJECTIVE

The primary objective of the Smart Helmet project is to enhance the safety of two-wheeler riders by integrating advanced sensing and communication technologies. The system ensures that the helmet is worn correctly before the vehicle can start, promoting mandatory helmet usage. It also incorporates alcohol detection to prevent riding under the influence, addressing a major cause of road accidents. In the event of an accident or sudden

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fall, the smart helmet automatically alerts predefined emergency contacts or authorities, enabling immediate assistance. By combining preventive measures, continuous rider monitoring, and rapid emergency notifications, the system reduces the severity of accidents and minimizes response time. This IoT-based solution is designed to be cost-effective and practical, making it suitable for widespread adoption by riders. Overall, the proposed smart helmet provides a comprehensive safety mechanism that not only discourages risky behaviours but also ensures timely help in critical situations, thereby improving overall road safety.

IV.METHODOLOGY

The proposed IoT-based Smart Helmet system is designed to continuously monitor the rider's condition, accurately detect accidents, and provide immediate response during emergencies situations. The overall methodology is divided into four major stages: *sensor data acquisition, data processing and decision-making, communication and alert generation, and cloud-based data storage and monitoring using the Firebase database.* Initially, the helmet unit is equipped with an *accelerometer sensor.* These sensors are used to detect sudden impacts, intense vibrations, and unusual movements that may indicate an accident. Real-time data from these sensors is continuously collected to enable reliable accident detection. An *alcohol detection sensor* is also integrated into the system to determine whether the rider is under the influence of alcohol. If alcohol concentration exceeds the predefined threshold value, the system takes preventive action to restrict unsafe riding. All sensor data is transmitted to the *microcontroller (Arduino/ESP8266),* which acts as the central control unit of the system. The microcontroller analyzes the received data by comparing it with predefined threshold values to distinguish between normal and unusual conditions and makes appropriate safety decisions accordingly. When an accident occurs, the *vibration sensor and accelerometer sensor* detect the impact or sudden unusual movement. Once the accident is confirmed, the emergency response mechanism is immediately activated. The *GPS module* retrieves the rider's precise geographical location (latitude and longitude), and the *GSM module* sends emergency alert messages containing the accident details and location information to *predefined emergency contacts such as family members* via SMS. This ensures timely assistance and a faster emergency response. Overall, the proposed methodology effectively integrates sensing, data processing, wireless communication, and cloud technology. By combining real-time accident detection, automated emergency alerts, and cloud-based monitoring, the IoT-based Smart Helmet system significantly improves two-wheeler rider safety. The system is cost-effective, efficient, suitable for real-world implementation, and reduces accident severity and fatalities.

A. Proposed Methodology

i. The smart helmet system is powered ON and all integrated sensors are initialized.
ii. The *alcohol sensor* continuously monitors the rider's breath to detect alcohol consumption.
iii. If the detected alcohol level exceeds the predefined threshold, the system restricts vehicle ignition to prevent drunk-and-drive conditions.
iv. The *accelerometer sensor* continuously monitors rider motion to identify sudden impacts or unusual vibrations.
v. After confirmation, the microcontroller activates the GSM module to send an alert message to predefined emergency contacts.
vi. The alert message includes the real-time location of the accident obtained from the GPS module, enabling quick identification of the accident site.

V.DISCUSSION

The smart helmet system offers an effective IoT-based solution to enhance the safety of two-wheeler riders. By integrating modern sensors and microcontroller technology, the system goes beyond the limitations of conventional helmets, helping to detect and prevent various risks associated with

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riding. One of the key features is the IR sensor, which ensures that the helmet is worn correctly before the vehicle can start. Additionally, the alcohol detection sensor monitors the rider's intoxication level, helping to prevent drunk driving and reduce the likelihood of accidents. Accident detection is managed by the accelerometer, which continuously monitors sudden impacts and abnormal movements. When an accident occurs, the GPS module provides the exact location, and through the GSM system, an instant message is sent to the rider's emergency contacts. This rapid communication significantly reduces response time and *can help* ensure timely medical assistance, thereby increasing the chances of saving lives. The display unit keeps the rider informed in real time, allowing immediate awareness of any potential hazards. The system is powered by the ESP32 microcontroller, making it energy-efficient, reliable, and cost-effective. Despite its advantages, the system has some limitations. Its effectiveness depends on GSM network availability, and the sensors require proper calibration to maintain accuracy. Environmental factors, such as extreme weather or physical shocks, may also affect sensor performance. Nonetheless, the smart helmet encourages responsible riding behaviour and *can help* substantially improve the overall safety of two-wheeler riders. Overall, the combination of real-time monitoring, automated accident detection, alcohol sensing, and instant alerts establishes this project as a practical, technology-driven, and cost-efficient solution. It not only reduces the risk of accidents but also promotes a culture of safety-conscious riding. The project demonstrates that IoT-based wearable technology *can help* address real-world safety challenges effectively and *can help* save lives by ensuring rapid emergency response for two-wheeler riders globally.

Fig. 2*: Smart Helmet Safety Dashboard*

This figure represents the *Smart Helmet Safety Dashboard*, which is used for real-time monitoring of the rider's safety. The dashboard displays important safety parameters collected from sensors installed in the smart helmet.
It shows the *helmet status,* indicating whether the rider is wearing the helmet or not. The *alcohol level* section confirms if alcohol is detected using the MQ-3 sensor. The *accident status* module displays whether an accident has occurred or not. The *GPS location* section provides the live geographical coordinates of the rider for tracking and emergency response.
Overall, this dashboard helps in improving rider safety by continuously monitoring helmet usage, alcohol consumption, accident detection, and live location tracking in real time.

VI. CONCLUSION

The IoT-based Smart Helmet project is an innovative and comprehensive solution designed to significantly improve the safety of two-wheeler riders. Unlike conventional helmets that provide only passive protection during accidents, the smart helmet actively monitors the rider's movements in real-time, detecting sudden impacts, abnormal behaviour, and potential hazards. By integrating multiple sensors—including an IR sensor, accelerometer, alcohol detection sensor, and GPS

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module—the system ensures that riders are not only protected during accidents but also prevented from engaging in unsafe behaviour, such as riding under the influence of alcohol. The IR sensor ensures that the helmet is worn correctly before the vehicle can start, while the alcohol sensor helps reduce the risk of drunk-driving accidents, which are a leading cause of fatalities among two-wheeler riders. When an accident occurs, the accelerometer detects abnormal impacts, and the GPS module provides the precise location of the incident. Through the GSM system, an instant alert is sent to predefined emergency contacts, ensuring rapid response and timely medical assistance. This real-time alert mechanism *can help* save lives by drastically reducing the time taken for emergency response. Additionally, the display unit provides immediate information to the rider, keeping them aware of their status and any potential risks, even in situations where human intervention may not be possible. Powered by the ESP32 microcontroller, the system is energy-efficient, reliable, and cost-effective, making it feasible for real-world implementation. While certain limitations exist, such as dependency on network coverage, battery life, and the need for proper sensor calibration, these challenges are outweighed by the benefits of improved safety, accident prevention, and faster emergency response. Overall, the Smart Helmet project demonstrates the effective application of IoT technology in wearable safety systems. By combining passive protection with active monitoring, accident detection, and instant alerts, the system provides a holistic safety solution for two-wheeler riders. Furthermore, its implementation lays the foundation for future advancements, including integration with mobile applications, cloud-based monitoring, and AI-based predictive accident prevention. This project highlights the potential of connected safety devices to reduce road accidents, save lives, and promote responsible riding behaviour, ultimately contributing to a safer and more secure environment for all two-wheeler riders globally.

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