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IoT Based Intelligent Helmet for Accident Prevention and Hazard Detection

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Abstract - Road accidents are a major global concern, particularly for two-wheeler riders who face a high risk of injuries and fatalities due to factors such as drowsiness, alcohol consumption, and improper helmet usage. Existing safety systems mainly focus on post-accident reporting and lack real-time preventive capabilities. This paper presents an IoT-based intelligent helmet system designed to enhance rider safety through continuous monitoring and automated control. The system is built around the ESP32 microcontroller, which integrates multiple sensors embedded within the helmet, including an eye blink sensor for detecting drowsiness, an infrared sensor to ensure proper helmet usage, and an MQ-3 alcohol sensor to identify alcohol levels in the rider's breath. An ADXL345 accelerometer is also used to detect sudden impacts or abnormal tilts that may indicate accidents. The system ensures that the vehicle operates only under safe conditions by reducing speed during drowsiness and disabling ignition if alcohol is detected or the helmet is not properly worn. In case of an accident, the system sends the rider's real-time GPS location to emergency contacts via a Telegram bot, improving response time and road safety.

1. INTRODUCTION

Road safety has become one of the most critical global concerns in recent decades due to the rapid growth in vehicular population and the increasing complexity of transportation systems, with two-wheeler riders being particularly vulnerable because they lack the structural protection provided by four-wheeled vehicles. As a result, even minor accidents can lead to severe injuries or fatalities, and studies consistently show that a significant proportion of road accidents involve motorcycles, often caused by rider drowsiness, alcohol consumption, over-speeding, and failure to wear helmets. Despite the enforcement of strict traffic regulations and awareness campaigns, these issues continue to persist, highlighting the limitations of conventional safety approaches and the need for more in real time. This limitation emphasizes the need for a shift toward proactive safety systems capable of identifying risks and taking preventive actions before accidents occur. With advancements in embedded systems, the Internet of Things (IoT), and wearable technology, it has become possible to design intelligent systems that continuously monitor rider conditions and environmental factors while enabling real-time decision-making and automated intervention. The proposed intelligent helmet system is an example of such innovation, designed to enhance rider safety by integrating multiple sensors, communication modules, and embedded processing into a single wearable device. The system is built around the ESP32 microcontroller, which acts as the central processing unit due to its high performance, low power consumption, and built-in wireless connectivity, making it suitable for IoT-based applications. It integrates an eye blink detection sensor to monitor the rider's alertness level and detect drowsiness by identifying prolonged eye closure or irregular blinking patterns, thereby enabling timely preventive measures such as reducing vehicle speed or alerting the rider. To ensure compliance with safety regulations, an infrared sensor is used to verify proper helmet usage, allowing the vehicle ignition only when the helmet is correctly worn, which encourages responsible riding behavior. Additionally, an MQ-3 alcohol sensor is incorporated to detect alcohol levels in the rider's breath, and if the detected level exceeds a predefined threshold, the system disables the ignition mechanism to prevent unsafe operation. The system also includes an ADXL345 accelerometer for accident detection, which continuously monitors motion and identifies sudden impacts or abnormal tilts that may indicate a crash, triggering an emergency alert that sends the rider's real-time GPS location to predefined contacts via a Telegram bot, thereby ensuring quick response and assistance. By combining sensor fusion, real-time monitoring, IoT communication, and automated control, the intelligent helmet system provides a comprehensive and proactive approach to accident prevention and emergency response, reduces dependency on manual intervention, improves reliability, and demonstrates the practical application of smart wearable technology in enhancing road safety for two-wheeler riders while offering scalability for future enhancements such as mobile integration, cloud-based analytics, and predictive safety mechanisms.

1. LITERATURE REVIEW AND OBJECTIVE

Recent research on intelligent helmet systems highlights the growing role of Internet of Things (IoT), sensor integration, and real-time communication in enhancing safety for riders and workers. Iván Campero-Jurado et al. [1] demonstrated the use of IoT and artificial intelligence for real-time hazard detection, while Yonghoon Choi and Yongtae Kim et al. [2] emphasized the importance of sensor fusion and connectivity in smart helmet applications. G. Sireesha et al. [3] and Rahul Pawar et al. [4] developed IoT-based helmets incorporating sensors for accident detection, helmet usage verification, and ignition control, improving rider safety. Similarly, S. A. Khan et al. [5] and M. Anuradha et al. [11] focused on alcohol detection and emergency alert systems, contributing to preventive safety measures. Paul Lee et al. [6] highlighted the effectiveness of multimodal sensing, while Pankaj Kuhar et al. [7] and B. Kartik et al. [8] extended smart helmet applications to industrial environments for hazard detection. Ehsan Soltanikazemi et al.

[9] introduced computer vision techniques for helmet violation detection, and Yasir Saleem et al. [10] discussed scalable IoT architectures for real-time monitoring systems. Additional studies by K. G. Mohanavalli et al. [12], R. Kamdi et al. [13],

B. Shahare et al. [14], and E. A. Teja et al. [15] focused on integrating multiple sensors and communication modules to improve accident detection and alert mechanisms. Although these works provide effective solutions, many systems focus on specific features and lack a fully integrated, real-time preventive approach. Therefore, the objective of this work is to develop an IoT-based intelligent helmet that combines multiple sensors for detecting helmet usage, alcohol consumption, and rider drowsiness, along with accident detection and real-time GPS-based alerting. The proposed system aims to provide a comprehensive, automated, and reliable solution that not only prevents accidents but also ensures immediate emergency response, thereby improving overall safety for two-wheeler riders. Furthermore, the system emphasizes cost-effectiveness and ease of implementation using widely available components, making it suitable for large-scale adoption. It also supports continuous monitoring and quick decision-making, enhancing reliability and efficiency. This approach contributes toward the development of smarter transportation systems and promotes safer riding behavior through the use of advanced IoT-enabled wearable technology.

2. MATERIALS AND METHODS

The intelligent helmet system is developed using the ESP32 microcontroller as the central unit for processing and communication due to its built-in Wi-Fi, Bluetooth, and efficient performance. The helmet acts as a wearable platform integrating multiple sensors while ensuring comfort and safety. An eye blink detection sensor monitors rider alertness and detects drowsiness, while the MQ-3 alcohol sensor identifies alcohol levels and prevents ignition if unsafe conditions are detected. An infrared (IR) sensor ensures that the helmet is properly worn before enabling the vehicle, promoting safety compliance. Additionally, the ADXL345 accelerometer detects sudden impacts or abnormal motion to identify accidents, and a GPS module (NEO-6M) provides real-time location tracking to send emergency alerts via IoT platforms like Telegram. Together, these components form a compact, integrated system that enables real-time monitoring, prevents unsafe riding conditions, and ensures quick emergency response, thereby improving overall road safety for two-wheeler riders.

The proposed methodology focuses on designing a smart, efficient, and reliable IoT-based system to enhance rider safety through continuous monitoring and automated response mechanisms. The system integrates multiple sensors, including the ADXL345 accelerometer for accident detection, the MQ-3 alcohol sensor for identifying intoxication, the IR sensor for helmet usage verification, and the NEO-6M GPS module for real-time location tracking. All these components are interfaced with the ESP32 microcontroller, which acts as the central processing and communication unit responsible for collecting, analyzing, and transmitting sensor data. The methodology begins with real-time monitoring, where each sensor continuously provides input regarding the rider's condition and surrounding environment. The ESP32 processes this data and evaluates it against predefined safety conditions to determine whether the system is operating under safe or unsafe parameters. In situations where unsafe conditions are detected—such as the helmet not being worn, alcohol levels exceeding the permissible limit, or abnormal motion indicating a potential accident—the system immediately initiates appropriate actions. Preventive measures include restricting vehicle ignition if the helmet is not properly worn or if alcohol is detected, thereby ensuring that the vehicle operates only under safe conditions. In the event of an accident, the accelerometer detects sudden impacts or unusual tilt patterns, triggering the GPS module to retrieve the rider's real-time location. This information is then transmitted instantly to predefined emergency contacts through a Telegram Bot using Wi-Fi connectivity, ensuring rapid response and assistance. The system design ensures seamless communication between hardware components and cloud-based platforms, enabling quick and reliable data transfer without delays. Emphasis is placed on developing a cost-effective and scalable solution by utilizing open-source tools and widely available components, making the system practical for real-world implementation. Overall, the methodology provides a comprehensive safety framework by combining accident detection, rider behavior monitoring, and automated alert mechanisms, thereby offering an effective and proactive approach to improving road safety using IoT technology.

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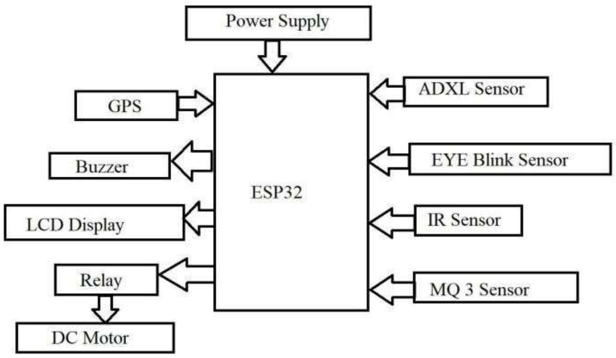

Figure 1: Block diagram of the proposed IoT Based Intelligent Helmet.

The block diagram of the proposed IoT-Based Intelligent Helmet system illustrates the interaction between sensors, the processing unit, and communication modules to ensure rider safety through real-time monitoring and automated decision-making. At the core of the system is the ESP32 microcontroller, which acts as the central control unit responsible for collecting, processing, and transmitting data. Multiple input sensors are interfaced with the ESP32, including the IR sensor for detecting proper helmet usage, the MQ-3 alcohol sensor for identifying intoxication, the eye blink sensor for monitoring rider drowsiness, and the ADXL345 accelerometer for detecting sudden motion or impact during accidents. These sensors continuously provide real-time data, which is analyzed by the ESP32 based on predefined safety conditions to determine whether it is safe to operate the vehicle. If all parameters are satisfied—such as the helmet being worn, no alcohol detected, and the rider being alert—the ESP32 activates a relay module to enable the bike ignition system; otherwise, the ignition is blocked to prevent unsafe operation. In addition to preventive measures, the system incorporates accident detection using the accelerometer, which identifies abnormal motion or impact and triggers an emergency response. In such cases, the ESP32 retrieves the rider's real-time location using the GPS module and sends an alert message to predefined emergency contacts via IoT connectivity using Wi-Fi. This ensures rapid assistance and reduces response time during critical situations. Overall, the block diagram represents a seamless flow of data from sensors to the microcontroller, followed by intelligent decision-making, control actions, and real-time communication, forming an integrated and automated safety system for improving two-wheeler rider safety.

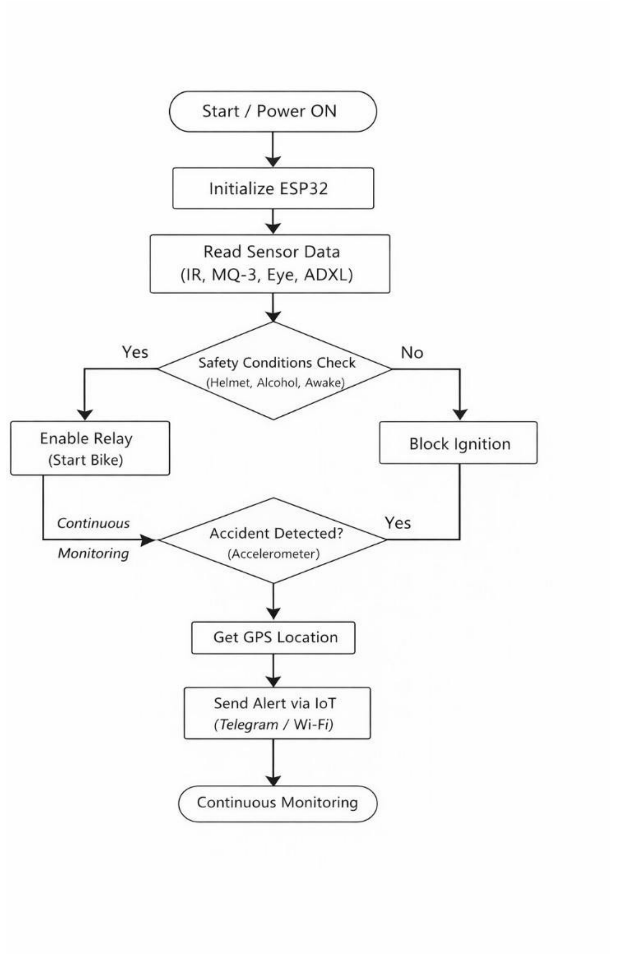

Figure 2: Methodology of the proposed IoT Based Intelligent Helmet.

The proposed methodology is designed to enhance rider safety through continuous monitoring, intelligent decision-making, and automated response using IoT technology. The process begins with system initialization, where the ESP32 microcontroller powers on and configures all connected sensors and modules for operation. Once initialized, the system continuously acquires real-time data from multiple sensors integrated into the helmet, including the IR sensor for detecting proper helmet usage, the MQ-3 alcohol sensor for identifying alcohol consumption, the eye blink sensor for monitoring rider drowsiness, and the ADXL345 accelerometer for detecting sudden motion or impact. The ESP32 processes this data and evaluates predefined safety conditions such as helmet status, alcohol presence, and rider alertness. If all conditions are satisfied, the system activates a relay module to enable the bike ignition, allowing normal operation; however, if any unsafe condition is detected, the ignition is blocked to prevent unsafe riding. In parallel, the system continuously monitors for accidents using the accelerometer, and if abnormal motion or impact is detected, it identifies a potential accident and immediately retrieves the rider's real-time location using the GPS module. This information is then transmitted to predefined emergency contacts via IoT connectivity using Wi-Fi, ensuring rapid response and assistance. The entire process operates in a continuous loop, enabling real-time monitoring, quick decision-making, and immediate action, thereby providing an effective and reliable solution for accident prevention and emergency response in two-wheeler safety systems.

2. RESULTS AND DISCUSSION

The proposed IoT-based intelligent helmet system was successfully implemented and evaluated under various conditions to assess its performance in real-time safety monitoring and accident prevention. The system demonstrated stable and reliable operation, with the ESP32 microcontroller efficiently collecting, processing, and responding to sensor data. During testing, the IR sensor accurately detected helmet usage, ensuring that the ignition system remained disabled when the helmet was not properly worn, thereby enforcing safety compliance. The MQ-3 alcohol sensor effectively identified the presence of alcohol in the rider's breath, and the system successfully prevented the vehicle from starting when alcohol levels exceeded the predefined threshold, reducing the risk of accidents caused by intoxicated driving. The eye blink detection sensor continuously monitored the rider's alertness and generated timely alerts in cases of drowsiness, contributing to the prevention of fatigue-related accidents. The ADXL345 accelerometer performed effectively in detecting sudden impacts and abnormal motion, enabling accurate accident detection in real-time scenarios. Upon detecting such events, the GPS module successfully retrieved the rider's location, and alert messages were transmitted to predefined emergency contacts via IoT connectivity using Wi-Fi and a Telegram bot with minimal delay, ensuring rapid response. The overall integration of sensors, control logic, and communication modules resulted in efficient and seamless system performance. The findings indicate that the proposed system offers a comprehensive and proactive safety solution by combining accident prevention mechanisms with emergency response features in a single wearable device. Although minor challenges such as sensor calibration, environmental interference, and reliance on internet connectivity were observed, these limitations can be addressed through future improvements. Overall, the system proves to be a cost-effective, scalable, and reliable solution for enhancing road safety among two-wheeler riders.

3. CONCLUSION

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REFERENCES

[1] I. Campero-Jurado, S. Márquez-Sánchez, J. Quintanar-Gómez, S. Rodríguez, and J. M. Corchado, "Smart Helmet 5.0 for Industrial Internet of Things Using Artificial Intelligence," *Sensors*, vol. 20, no. 21, p. 6241, 2020.

[2] Y. Choi and Y. Kim, "Applications of Smart Helmet in Applied Sciences: A Systematic Review," *Applied Sciences*, vol. 11, no. 11, p. 5039, 2021.

[3] G. Sireesha, K. B. S. Jahnavi, A. N., and A. Baburay, "Smart Helmet using IoT," *International Journal of Engineering Research & Technology (IJERT)*, 2020.

[4] R. Pawar, V. Shete, and S. Kulkarni, “Internet of Things Enabled Smart Helmet,” *International Journal of Engineering Research & Technology (IJERT)*, vol. 8, no. 7, 2019.

[5] S. A. Khan, T. Abbasi, Y. Engr, and M. Bilal, “Development of Smart Helmet using Internet of Things (IoT),” *Journal of Xi’an Shiyou University*, vol. 20, no. 6, 2024

[6] P. Lee, H. Kim, M. S. Zitouni, A. Khandoker, H. F. Jelinek, and L. Hadjileontiadis, “Trends in Smart Helmets With Multimodal Sensing for Health and Safety: Scoping Review,” *JMIR mHealth and uHealth*, vol. 10, no. 11, 2022.

[7] P. Kuhar, K. Sharma, Y. Hooda, and N. K. Verma, “Internet of Things (IoT) based Smart Helmet for Construction,” *Journal of Physics: Conference Series*, vol. 1950, 2021.

[8] B. Kartik and P. Manimaran, “IoT Based Smart Helmet for Hazard Detection in Mining Industry,” *arXiv preprint arXiv:2304.10156*, 2023.

[9] E. Soltanikazemi, A. Dhakal, B. K. Hatuwal, I. E. Toubal, A. Aboah, and K. Palaniappan, “Real-Time Helmet Violation Detection Using YOLOv5,” *arXiv preprint arXiv:2304.09248*, 2023.

[10] Y. Saleem, N. Crespi, M. H. Rehmani, and R. Copeland, “Internet of Things-Aided Systems: Architectures and Applications,” *IEEE Communications Surveys & Tutorials*, 2017.

[11] M. Anuradha, V. Siva Nagaraju, and M. Charitha, “IoT-Based Intelligent Helmet for Rider Safety,” *International Journal of Engineering Research*, 2024.

[12] K. Mohanavalli, D. Varalakshmi, A. Manasa, and K. Santhosh, “Intelligent Helmet with Accident Detection and Alert System,” *International Journal of Emerging Research*, 2025.

[13] R. Kamdi, R. Vaidya, D. Borakhade, P. Thakre, and V. Panchbhai, “Smart Helmet for Bike Riders Using IoT and Embedded Systems,” *International Journal of Intelligent Systems*, 2024.

[14] B. Shahare, S. Chawde, and R. Gudafwar, “IoT Based Smart Motorcycle Helmet,” *Journal of Electronics and Informatics*, vol. 3, no. 1, 2021.

[15] A. Teja, B. Sridivya, G. S. K. Reddy, and B. Kedarnath, “Design and Analysis of IoT-Based Smart Helmet System,” *International Journal of Scientific Development and Research*, 2020.