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IoT-Based Smart Helmet for Accident Detection and Rider Safety

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***Abstract*—Road accidents remain a major cause of injuries and fatalities, often due to delayed emergency response and rider fatigue. This paper presents an IoT-based Smart Helmet system designed to improve rider safety through automatic accident detection, drowsiness monitoring, and real-time emergency alerts. The proposed system employs an MPU-6050 accelerometer and gyroscope to detect sudden impacts and abnormal orientation, while a vibration sensor provides secondary confirmation to reduce false alerts. To enhance preventive safety, the system integrates drowsiness detection using an eye blink sensor and an MQ-3 alcohol sensor to ensure the rider is sober before enabling vehicle ignition. A pulse sensor optionally monitors the rider's vital signs after an accident. Upon detecting a crash or critical condition, the system retrieves real-time location data using a NEO-6M GPS module and transmits emergency alerts via a SIM800L GSM module. By combining multi-sensor data and IoT-based communication, the proposed Smart Helmet significantly reduces emergency response time and promotes safer riding practices.**

I. Introduction

The Internet of Things (IoT) has significantly enhanced safety solutions in transportation, especially for motorcycle riders who are highly vulnerable to severe injuries. The rising number of two-wheeler accidents highlights the need for intelligent systems that extend beyond traditional protective gear.

An IoT-based smart helmet integrates sensors, communication modules, and control units to detect accidents, monitor rider conditions, and automatically send emergency alerts with location details. This rapid detection and response mechanism helps reduce rescue time and improves rider safety.

II. System Components

A. Battery

The battery supplies power to all sensors and modules. A rechargeable Li-ion battery ensures portability and long operating duration.

Fig. 1. Rechargeable Li-ion Battery

B. Arduino Nano

The Arduino Nano is a compact microcontroller based on the ATmega328P, suitable for embedded IoT applications.

Fig. 2. Arduino Nano

C. IR Sensor

The IR sensor detects helmet usage by sensing infrared reflection, ensuring rider compliance before vehicle ignition. The IR sensor detects helmet usage by measuring infrared reflection from the rider's head, ensuring compliance before vehicle ignition. The sensor provides fast and reliable detection under varying lighting conditions.

Fig. 3. IR Sensor.

D. Eye Blink Sensor

The eye blink sensor monitors rider drowsiness by detecting eyelid movement using infrared reflection. Prolonged eye closure indicates fatigue and triggers alerts.

Fig. 4. Eye Blink Sensor

III. Literature Survey

This section presents a review of selected research works related to smart helmets, accident detection systems, sensor fusion techniques, IoT-based safety solutions, and machine learning-based impact classification. A total of ten representative papers were studied to understand existing methodologies, findings, limitations, and validation approaches in the domain of intelligent rider safety systems.

Several studies have proposed IoT-based smart helmet systems for accident prevention using multiple sensors to detect impact and rider behavior. These approaches emphasize early alert generation to reduce emergency response time and enhance rider safety through technology integration.

Embedded smart helmet systems for accident detection have also been developed using real-time sensor data processing and GSM-based alert mechanisms. These systems highlight the importance of automated emergency notifications in saving lives during critical situations.

A number of review-based studies have analyzed head-impact measurement devices used in helmets, comparing various helmet-mounted sensors, impact evaluation techniques, and injury prevention methodologies. These works contribute to improving helmet safety standards and understanding impact dynamics.

IoT-based rider safety prototypes integrating IMU sensors and alcohol detection mechanisms have been proposed to prevent riding under intoxication and ensure timely emergency alerts. The integration of multiple safety features significantly improves overall rider protection.

Several researchers have introduced accelerometer and vibration-based accident detection systems that focus on impact analysis and automatic alert transmission to emergency contacts, thereby enhancing post-accident response effectiveness.

Advanced approaches have explored sensor fusion and machine learning techniques for helmet impact detection. By combining data from multiple IMU sensors, these systems demonstrate improved classification accuracy and more reliable impact analysis.

Innovative designs such as smart textile-based impact sensors integrated into helmets enable flexible and distributed impact detection, offering enhanced rider protection and improved helmet ergonomics.

Comprehensive reviews of IoT-based smart helmet architectures have discussed hardware and software design considerations, emphasizing system reliability, scalability, and practical deployment challenges.

Machine learning-based analysis of multi-sensor IMU data has shown superior performance compared to traditional threshold-based detection methods, particularly in real-world riding scenarios.

Kinematic studies analyzing six-degree-of-freedom helmet motion have provided valuable insights into head impact dynamics, supporting the development of safer helmet designs and improved injury prevention strategies.

Laboratory-based validation methodologies have also been proposed to ensure the reliability and standardization of helmet safety systems through controlled testing environments.

Overall, the literature indicates that while existing systems contribute significantly to rider safety, limitations such as false alerts, sensor dependency, and lack of autonomous operation highlight the need for an integrated, multi-sensor, and IoT-enabled smart helmet solution.

IV. Existing System

Existing accident detection systems mainly use threshold-based accelerometer data to identify crash events. Although effective in detecting sudden impacts, these systems frequently produce false positives during normal riding conditions such as abrupt braking or road irregularities. Many approaches rely on single-sensor architectures, lacking sensor fusion, which limits their ability to distinguish real accidents from non-critical events.

Several solutions depend on smartphone-based applications connected via Bluetooth to transmit emergency alerts. However, these systems are unreliable due to Bluetooth disconnections, mobile device dependency, high battery consumption, and the requirement for the phone to be active and within range at the time of the accident. Additionally, limited GSM/GPS coverage and power constraints reduce system effectiveness, particularly in remote areas.

Other systems that rely solely on vibration sensors or gyroscopes fail to accurately differentiate between actual crashes and sudden stops. These limitations highlight the need for an autonomous, multi-sensor, and communication-independent accident detection system.

Some research-oriented solutions attempt to overcome these challenges by using smartphone-based mobile applications connected via Bluetooth to detect crashes and send alerts. However, these systems are highly dependent on the rider's mobile device being powered on, paired, and within communication range at the time of the accident. Bluetooth disconnections, application crashes, and excessive battery consumption significantly compromise their reliability.

Other existing approaches rely solely on vibration sensors or gyroscopes, which are insufficient to accurately distinguish between genuine accidents and sudden stops or external disturbances. As a result, these systems fail to provide consistent and dependable accident detection, highlighting the need for an integrated, autonomous, and multi-sensor-based safety solution.

V. Proposed System

The proposed IoT-based Smart Helmet system is designed to address the shortcomings of conventional accident detection approaches by integrating multi-sensor fusion, real-time communication, and intelligent monitoring. The primary objective of the system is to enhance rider safety by ensuring accurate accident detection, rapid emergency response, and continuous rider condition monitoring using IoT and embedded technologies.

An ESP32 or Arduino Nano microcontroller serves as the central processing unit, acquiring and processing data from multiple sensors in real time. The MPU-6050 accelerometer and gyroscope continuously monitor helmet orientation and sudden impact events, while an SW-420 vibration sensor provides secondary confirmation to minimize false alarms. Preventive safety is enhanced through an MQ-3 alcohol sensor, which detects intoxication and can disable vehicle ignition if alcohol is present.

Illustrates the block diagram of the proposed system architecture, showing the integration of sensors, communication modules, and the control unit.

The system supports IoT integration using MQTT or HTTP protocols, enabling real-time data monitoring and storage on cloud platforms such as Firebase or MySQL for future analysis of accident patterns and rider behavior. Powered by a rechargeable Li-ion battery with a TP4056 charging circuit, the helmet ensures reliable operation while maintaining low power consumption. Optional machine learning techniques can further improve accident detection accuracy over time.

For emergency response, a NEO-6M GPS module enables accurate real-time location tracking, and a SIM800L GSM module ensures autonomous transmission of alert messages to pre-registered contacts or nearby emergency services. Upon detecting an accident, the system automatically gathers impact data, determines the rider's location, and sends an SMS or cloud-based notification without requiring rider intervention.

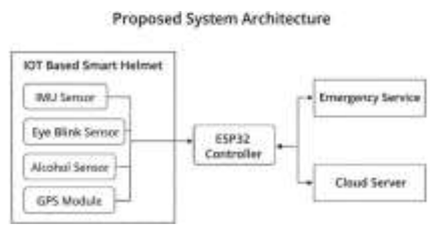

Fig. 5. Block Diagram of IoT-Based Smart Helmet System

VI. Applications

The proposed IoT-Based Smart Helmet Accident Detection System has a wide range of real-world applications aimed at improving road safety and emergency response efficiency. The major applications of the system are listed below:

- **Two-Wheeler Rider Safety Systems**: The smart helmet can be used by motorcycle and scooter riders to automatically detect accidents, monitor rider condition, and send emergency alerts with precise location details.
- **Emergency Medical Response Systems**: By transmitting real-time accident location and rider status to emergency contacts and medical services, the system significantly reduces response time and improves survival rates.
- **Smart Transportation and Intelligent Traffic Systems**: Integration with IoT platforms and cloud databases enables authorities to analyze accident patterns, identify high-risk zones, and study rider behavior for improved traffic management.
- **Fleet and Delivery Vehicle Safety**: The system can be deployed in delivery and logistics fleets to monitor rider safety, detect crashes instantly, and ensure responsible driving practices.

Fig. 6. Smart Helmet

- **Accident Data Analytics and Research**: Sensor telemetry data stored on cloud platforms can be used for accident analysis, machine learning model training, and the development of advanced road safety solutions.
- **Preventive Safety and Law Enforcement Support**: Features such as alcohol detection, drowsiness monitoring, and helmet-wearing validation help enforce traffic safety regulations and promote disciplined riding behavior.

VII. Results

The proposed IoT-based smart helmet system was tested under various real-time riding conditions to evaluate its performance and reliability. The system was validated for helmet detection, alcohol detection, drowsiness monitoring, ignition control, and accident detection.

A. Helmet Detection

The system accurately detects whether the rider is wearing a helmet. If the helmet is not worn, the bike ignition remains disabled, ensuring compliance with safety regulations.

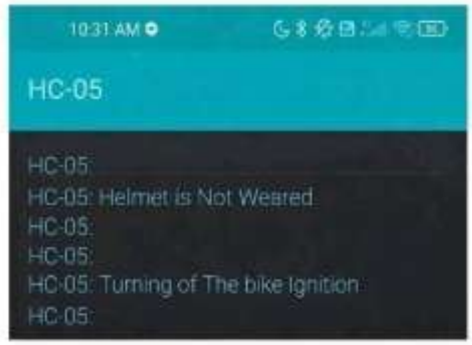

Fig. 7. Helmet Not Worn

B. Alcohol Detection

The alcohol sensor successfully detects the presence of alcohol in the rider's breath. When alcohol is detected, the system immediately turns off the bike ignition to prevent unsafe riding.

Fig. 8. Alcohol Detected

C. Drowsiness Detection

The drowsiness detection module continuously monitors the rider's alertness during vehicle operation. When signs of fatigue are detected, the system generates a drowsiness warning and automatically turns OFF the bike ignition to prevent potential accidents. This feature enhances preventive safety by ensuring that the rider operates the vehicle only in an alert state.

Fig. 9. Drowsiness Detected

D. Alcohol Not Detected

When no alcohol is present in the rider's breath, the alcohol sensor confirms a safe condition and displays the status as *Alcohol Not Detected*. Under this condition, the system allows the bike ignition to turn ON and enables normal vehicle operation.

Fig. 10. Alcohol Not Detected

E. Accident Detection

Accidents are detected using a vibration sensor and an MPU-6050 accelerometer that continuously monitor sudden impacts and abnormal motion patterns. When an accident occurs, the system accurately identifies the event and immediately triggers the emergency response mechanism. The rider's location is obtained using the GPS module, and an emergency alert is sent to predefined contacts through the GSM module to ensure timely assistance.

Fig. 11. Accident Detection

F. Drowsiness Not Detected

If the rider is alert and no signs of fatigue are detected, the system displays the status as *Drowsiness Not Detected*. The bike ignition remains ON, allowing the rider to continue driving safely without interruption.

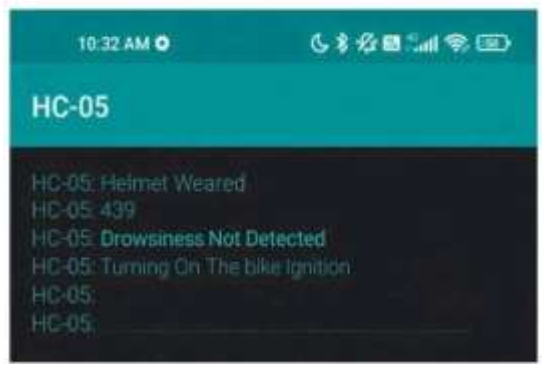

Fig. 12. Drowsiness Not Detected

VIII. Conclusion

This project presents an IoT-based smart helmet system designed to enhance two-wheeler rider safety through automatic accident detection, real-time emergency alerting, and continuous rider monitoring. By integrating multiple sensors such as an MPU-6050 accelerometer and gyroscope, vibration sensor, alcohol sensor, and an optional pulse sensor, the system achieves accurate accident detection while minimizing false alerts. The use of GPS and GSM modules enables autonomous location tracking and emergency communication without relying on smartphones.

The proposed system not only responds to accidents but also emphasizes preventive safety by ensuring helmet usage, detecting alcohol consumption, and monitoring rider alertness. Powered by a rechargeable Li-ion battery, the system is portable, reliable, and energy efficient.

Overall, the smart helmet provides a cost-effective and scalable safety solution that can significantly reduce emergency response time and help save lives. Future enhancements may include improved drowsiness detection techniques and large-scale real-world deployment.

REFERENCES

[1] P. Vivekanandan *et al.*, "Accident prevention using IoT-based smart helmet," *Nanosistemi, Nanomateriali, Nanotechnologii*, vol. 22, no. 3, pp. 577–590, 2024.
[2] D. Nagaraju *et al.*, "Embedded based smart helmet for accident detection," *IJSREM*, vol. 9, no. 4, 2025.
[3] K. L. O'Connor *et al.*, "A systematic review of head-impact measurement devices," 2017.
[4] A. D. T. Alcantara *et al.*, "IoT-based prototype using IMU and GSM," *Sensors*, 2023.
[5] M. K. Kumar *et al.*, "Accelerometer and vibration-based IoT system," 2023.
[6] A. Strandberg, "Sensor fusion and ML classifier," M.S. thesis, 2022.
[7] M. J. Saikia *et al.*, "Smart textile-based impact sensors," *Sensors*, 2024.
[8] H. T. Chethana *et al.*, "Smart helmet IoT designs," 2023.
[9] B. Emsley *et al.*, "Machine learning on multi-sensor IMU data," 2025.
[10] A. Bracali *et al.*, "6-DOF helmet kinematics," 2022.
[11] L. Gabler *et al.*, "Helmet validation protocols," 2022.
[12] D. P. Srinivas Kumar, "Smart Helmet Management System Using IoT," *IJIRSET*, vol. 11, no. 5, pp. 5930–5936, 2022.