International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 04, ICTEM 2.0 (2026)

Ultra Smart Helmet: An Integrated Safety System for Motorcyclists

Atufa javed[1], Archi Rastogi[2], Devang Chaudhary[3], Mohammad Faris[4] ,Deepti Gupta[5]

*[1,2,3,4]**Graduate student**

*[5]**Assistant Professor**

Department of Computer Science & Engineering

Moradabad Institute of Technology, Moradabad

Email: atufajaved31@gmail.com[1] , archirastogi2004@gmail.com[2], deepchaudhary48366@gmail.com[3] , farismalik0786@gmail.com[4], deepti.kumar@gmail.com[5]

Abstract: This research paper proposes an IoT-enabled Ultra Smart Helmet designed to enhance the safety of two-wheeler riders. It employs real-time monitoring and automated response capabilities to achieve this objective. The system integrates diverse sensors to detect helmet wear, alcohol consumption, sudden accidents, and unsafe driving conditions. Should the rider fail to wear a helmet or be under the influence of alcohol, the system automatically prevents the vehicle from starting using an ignition-control mechanism. In the event of an accident, the helmet promptly transmits an emergency alert along with the rider's location to registered contacts, facilitating timely assistance. Motorcyclists encounter substantial challenges, including the absence of enforcement of safe driving practices, delayed emergency response, and a heightened risk of fatal injuries during road accidents. This Ultra Smart Helmet presents an intelligent, cost-effective, and user-friendly solution to address these challenges. By reducing road accidents, promoting responsible driving, and ensuring expedited rescue, it underscores the potential of IoT-based safety technologies to significantly enhance rider protection and road safety.

Keywords: Ultra Smart Helmet, Motorcycle Safety, Alcohol Detection, Crash Detection, Helmet Compliance, IoT-Integrated Safety System.

1. Introduction

Two-wheeled riders encounter numerous safety challenges on the road, particularly in high-traffic or unfamiliar areas. Routine tasks such as maintaining balance, avoiding obstacles, and responding to sudden hazards become arduous and potentially hazardous. Global road safety reports indicate that over 1.3 million individuals lose their lives annually due to road accidents, with a substantial proportion of these fatalities involving two-wheeled riders [8].
Several risk factors impact rider safety and augment the likelihood of severe injuries, including:

- Riding without a helmet
- Alcohol consumption while driving
- Excessive speed or sudden impacts
- Delayed medical assistance following an accident

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 04, ICTEM 2.0 (2026)

- Slippery or irregular road surfaces

Traditional helmets primarily provide head protection but lack the ability to detect unsafe riding conditions. They do not measure alcohol levels, cannot notify families in case of an emergency, and offer no information regarding accidents. Alternative solutions, such as advanced riding gear or AI-powered smart helmets, exist, but they are frequently prohibitively expensive or not widely accessible to the general public [1,2].

With advancements in contemporary technology, the Internet of Things (IoT) and smart sensors are enhancing the intelligence and accessibility of safety devices. These technologies enable real-time monitoring of helmet usage, alcohol detection, accident identification, and emergency communication, thereby ensuring the safety and responsibility of two-wheeled riders.

The objective of this study is to develop an IoT-enabled Ultra Smart Helmet that safeguards riders by detecting helmet wear status, identifying alcohol consumption, monitoring accidents using sensors, and transmitting emergency alerts with location information. This system aims to mitigate road accidents and provide a practical and cost-effective safety solution for everyday motorcycle users.

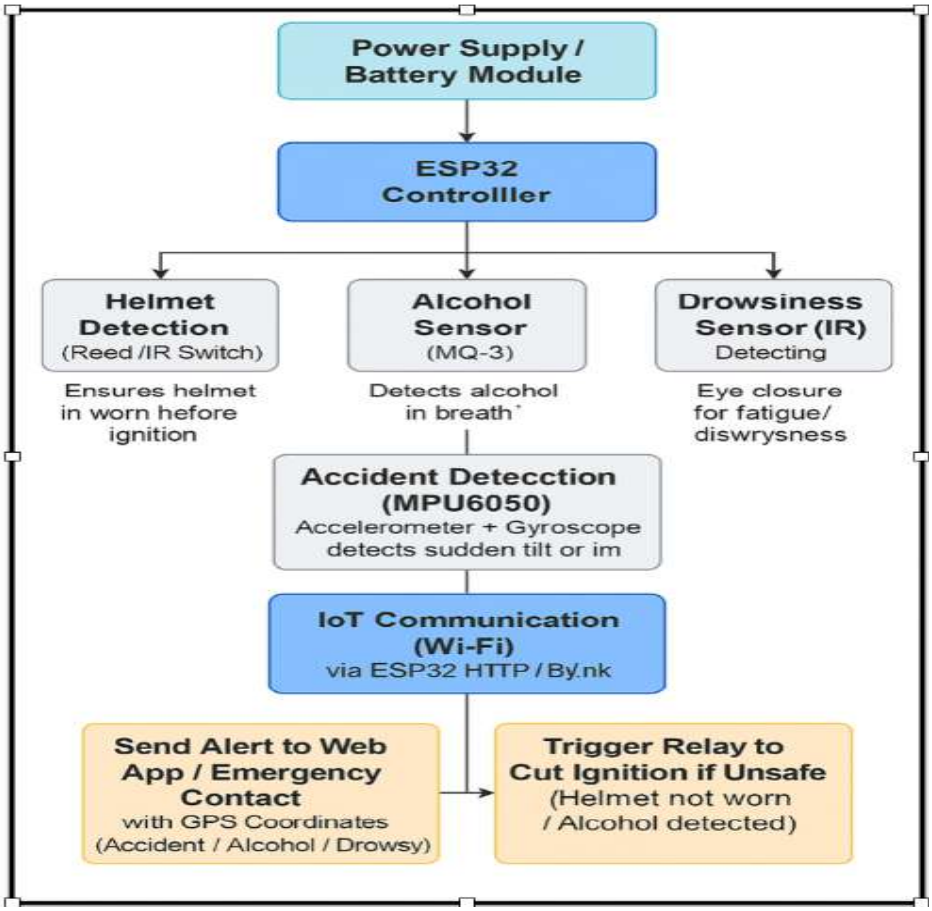

Fig 1: Flowchart of Smart helmet

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 04, ICTEM 2.0 (2026)

2. Literature Review

Several technologies have been developed to enhance the safety of two-wheeler riders, ranging from conventional helmets to advanced electronic safety systems; however, significant limitations persist. Traditional helmets provide only basic head protection and lack features such as accident detection, alcohol sensing, helmet-wear verification, and emergency communication, thereby limiting their effectiveness in ensuring comprehensive rider safety [7,8]. Although certain alcohol-detection and ignition control systems have been proposed for vehicles, they are often costly and not specifically optimized for two-wheelers [4]. Basic accident-detection devices may suffer from accuracy issues and fail to transmit real-time location alerts during emergencies [5]. Standalone tools such as breath alcohol sensors, crash sensors, and mobile emergency applications address isolated safety concerns but do not provide an integrated mechanism that combines ignition control, automated emergency alerts, and real-time monitoring [2,3,7].

The integration of IoT technology into wearable safety devices has significantly advanced rider protection by incorporating sensors such as alcohol sensors (MQ-3), accelerometers (MPU6050), RF modules, and GPS systems to enable real-time monitoring, accident detection, and automated emergency notifications [1,3,5,6]. Research studies have demonstrated smart helmet prototypes capable of detecting alcohol consumption, controlling vehicle ignition, identifying crashes, and transmitting location data to emergency contacts [1,2,3]. However, these systems continue to face limitations, including false alarms due to road vibrations, environmental sensitivity of sensors to temperature and humidity, GPS inaccuracy in indoor or underground environments, high implementation costs, and processing and power constraints that restrict long-term usability [4,5].

Overall, while existing research and technological advancements contribute significantly to rider safety, most solutions focus on individual functionalities rather than delivering a unified, cost-effective, and fully integrated system. This research gap emphasizes the necessity for an IoT-enabled Ultra Smart Helmet capable of combining helmet detection, alcohol identification, accident monitoring, real-time location tracking, and automated emergency alerts into a single comprehensive safety solution [1,6,8,9].

3. System Architecture and Design

The Ultra Smart Helmet is engineered to augment rider safety by integrating accident detection, alcohol detection, and emergency alert functionalities through the Internet of Things (IoT). The system seamlessly integrates hardware and software components to monitor rider conduct, identify accidents, mitigate drunk driving, and promptly notify emergency contacts. The proposed framework comprises three distinct components: hardware design, software architecture, and communication/data processing.

3.1 Hardware Components

3.1.1. Microcontroller

- The ESP32 microcontroller is utilised for interfacing with diverse sensors and modules.
- It regulates data transfer between components and processes sensor data in real-time.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 04, ICTEM 2.0 (2026)

Fig 2: ESP32

3.1.2. Sensors

- **Accelerometer & Gyroscope (MPU6050):** Detects sudden impacts or falls and triggers accident alerts.

Fig 3: MPU6050

- **Alcohol Sensor (MQ-3):** Detects alcohol levels and prevents ignition if the rider is impaired [3][4].

Fig 4: MQ-3 sensor

- **IR Sensor:** Ensures bike ignition only when helmet worn

Fig 5: IR Sensor

- **Eye Blink Sensor (Drowsiness Sensor):** Detects rider drowsiness by monitoring blink rate. Activates buzzer and sends warning signals if the rider becomes sleepy.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 04, ICTEM 2.0 (2026)

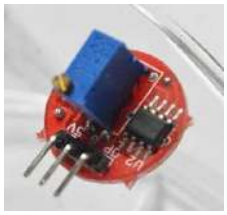

Fig 6: Eye Blink Sensor

3.1.3. Feedback Mechanisms

- **Buzzer:** The buzzer serves as an alert device for the rider, promptly informing them of potential hazards such as alcohol detection, drowsiness, or system warnings. In the event of an accident detection, it emits loud audible alarms to ensure immediate attention.
- **LED Indicators:** The LED indicators provide visual status updates, indicating whether the system is operational, alcohol has been detected, an emergency alert has been triggered, or drowsiness detection has been activated.
- **Relay Module:** The relay module exercises control over the ignition system, automatically deactivating it in the presence of alcohol detection or when helmet safety conditions are not met.

3.1.4 Location and Emergency Modules

- **GPS Module:** Captures the precise real-time coordinates of the rider, enabling the sending of timely location information to emergency contacts during accidents or instances of drowsiness.

- **GSM Module:** Utilises SMS messaging to transmit accident status and GPS coordinates to predefined contacts, ensuring emergency communication even in scenarios where internet access is unavailable.

Fig 7: GPS Module

3.1.5 Power Supply

- **Rechargeable Lithium Battery:** Powers all sensors and modules.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 04, ICTEM 2.0 (2026)

- **Power Management Circuit:** Ensures stable voltage and protects against overcharging.

Fig 8: Battery

3.2. Software Components:

3.2.1 IoT-Based Alert & Monitoring System

The device continuously monitors sensor data from the MPU6050, MQ-3, IR, and Eye Blink sensors.

Predefined thresholds are employed to detect:

- Accidents
- Alcohol consumption
- Drowsiness
- Unsafe conditions

Upon triggering, the system initiates the following actions:

- Sends an emergency SMS with the GPS location via GSM
- Activates the buzzer and LED
- Interrupts the ignition through a relay

The collected data is subsequently logged for analysis and safety enhancement purposes.

3.2.2 Mobile application for caregivers

A lightweight IoT-based web application is developed to continuously monitor the rider's safety status in real time. The web application receives live data from all sensors and presents it in a user-friendly dashboard for family members or supervisors.

```
‹/› Code

Connecting to WiFi...
.....
Connected!
192.168.1.45   (example IP)
Web server started!
```

Fig 9: IP of web server

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 04, ICTEM 2.0 (2026)

Key Functionalities:

- Real-time Sensor Updates: The web application presents live data from the infrared sensor (helmet wear detection), MQ-3 alcohol sensor, MPU6050 accident sensor, GPS location, and system status (relay, buzzer, LED).
- Emergency Alerts: In the event of an accident or unsafe condition, the system automatically dispatches an SMS alert via the GSM module, including the user's precise GPS coordinates.
- Helmet Detection: The web application indicates whether the helmet is securely fastened.
- Accident Detection: Impact or fall detection from the MPU6050 triggers warnings on the dashboard and activates the buzzer and SMS alerts.

4. Proposed work

This project aims to design an IoT-enabled Ultra Smart Helmet that enhances rider safety through real-time monitoring, accident detection, alcohol detection, and emergency alert systems. The helmet incorporates multiple sensors, including an infrared sensor (IR), a MQ3 alcohol sensor, an MPU6050 microcontroller, an eye-blink sensor, a GPS module, and a GSM module. These sensors collaborate with the ESP32 microcontroller to provide continuous safety feedback to the user and caregivers.
The IR sensor ensures that the rider is wearing the helmet before ignition. The MQ3 alcohol sensor detects the presence of alcohol in the rider's breath and blocks the engine through a relay if the alcohol level is unsafe. The MPU6050 handles accident detection by identifying sudden impacts or unusual tilt patterns. The eye-blink sensor monitors drowsiness and alerts the rider with a buzzer and LED indicators if abnormal blinking is detected. GPS and GSM modules transmit the rider's live coordinates and emergency SMS alerts to pre-saved contacts whenever an accident or unsafe condition is detected. These features collectively contribute to reducing road accidents and ensuring prompt emergency response for maximum rider safety.

Module 1 – Helmet Wearing Detection: This module is designed to ensure that riders always wear their helmets before starting the vehicle, thereby enforcing basic safety compliance and reducing the risk of head injuries in case of accidents. The system uses an Infrared (IR) sensor strategically placed inside the helmet holder or vehicle handle. The IR sensor works on the principle of detecting the presence or absence of an object in this case, the rider's head or helmet.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 04, ICTEM 2.0 (2026)

Fig 10: Helmet status

Module 2 – Alcohol Detection: This module is designed to prevent riders from operating a vehicle under the influence of alcohol, enhancing road safety and reducing accident risks. It uses the MQ-3 alcohol sensor, a widely used sensor that can detect alcohol vapours in the rider's breath.

Fig 11: Alcohol detection

Module 3 – Accident Detection: This module is designed to provide real-time detection of accidents by monitoring the helmet's motion using an MPU6050 sensor, which combines both an accelerometer and a gyroscope. These sensors measure linear acceleration and rotational motion along multiple axes, enabling the system to detect sudden impacts or abnormal movement patterns indicative of an accident.

Fig 12: Accident detection

Module 4 – Drowsiness/Sleep Detection: This module is designed to monitor rider fatigue and detect signs of drowsiness to prevent accidents caused by sleep or inattentiveness while

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 04, ICTEM 2.0 (2026)

riding. It employs an eye-blink or eyelid movement sensor integrated into the helmet, which tracks the rider's eye activity in real-time.

Module 5 – GPS Tracking: This module is designed to monitor and track the real-time location of the rider, enhancing safety by enabling immediate response from guardians or emergency services in case of accidents. It uses a GPS module integrated with the helmet's microcontroller to continuously capture the rider's geographical coordinates.

Module 6 – Ignition Control: This module acts as a safety enforcement layer by controlling the bike's engine power through a relay or electronic switch. Its main purpose is to ensure that the vehicle operates only under safe conditions, integrating inputs from other smart helmet modules such as Helmet Wearing Detection, Alcohol Detection, and Accident Detection.

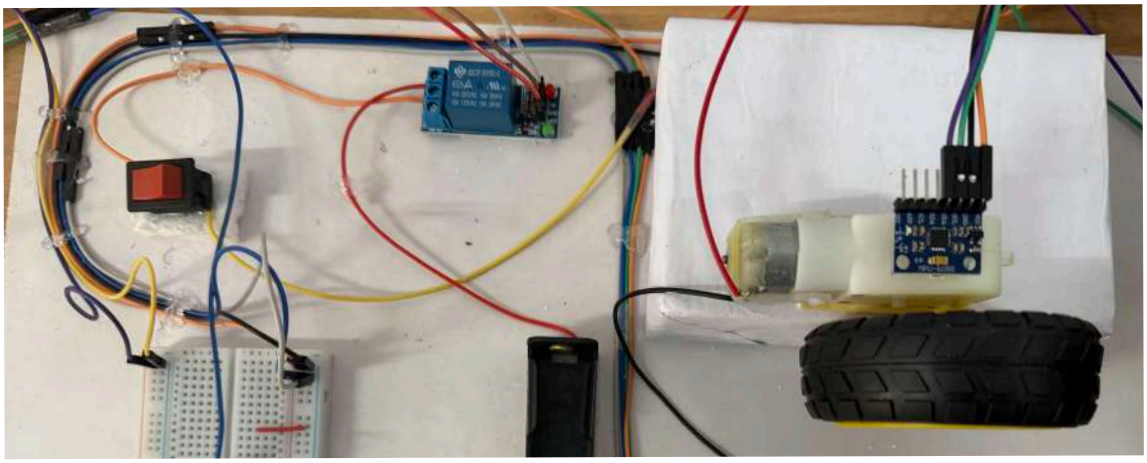

Fig 13: Accident detection

Module 7 - Web Dashboard & Cloud Integration: This module serves as the central monitoring and data management system for the Smart Helmet, enabling real-time tracking, alert generation, and historical analysis. It connects all helmet sensors to a cloud platform (e.g., Firebase) and presents the data through a user-friendly web dashboard.

5. Implementation and Testing

5.1 Experimental Setup:

The system undergoes initial testing in a controlled environment, comprising an open area and designated paths, to validate the fundamental functionality of sensors, ignition control, and alert mechanisms.
Following successful validation, real-world testing is conducted on roads, traffic intersections, and uneven surfaces to ascertain the system's stability and reliability in diverse operational scenarios.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 04, ICTEM 2.0 (2026)

5.2 Testing in Different Conditions:

The helmet undergoes rigorous testing in diverse lighting conditions, including bright sunlight, evening, and low light, as well as various environments such as open roads and narrow streets.
Furthermore, real riding conditions are simulated, including bumps, sharp turns, and sudden stops, to assess the sensor's stability.

5.3 Performance Assessment:

- **Accident Detection Accuracy:** The MPU6050 is subjected to controlled falls, abrupt tilts, and impact simulations to verify its accuracy in recognising accidents without generating false alarms.

- **Ignition Control & Safety Response Time:** We assess the system's promptness in responding to the following scenarios:
  - Helmet removal
  - Alcohol detection
  - Accidents or falls

The relay response time and the time taken to send emergency SMS messages are meticulously recorded to guarantee swift action during emergencies.

- **Navigation & Alert Response:** Notifications such as drowsiness alerts, accident detection alerts, and alcohol warnings are scrutinised for their timely activation of buzzers or LEDs.

5.4 Battery Life and Power Usage

Power consumption is monitored continuously by running the helmet with sensors, GSM alerts, GPS tracking, and buzzer usage. Battery endurance is tested to ensure a long operational duration without frequent recharging.

6. Advantages of the Proposed System

6.1 Enhanced Rider Safety:

Combines multiple safety modules such as helmet wearing detection, alcohol detection, accident detection, and drowsiness monitoring to proactively prevent accidents.

6.2 Real-Time Monitoring:

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 04, ICTEM 2.0 (2026)

Continuous tracking of helmet status, alcohol levels, and rider condition ensures that unsafe situations are detected immediately. Alerts and notifications are sent in real-time, enabling prompt corrective action.

6.3 Accident Response and Emergency Support:

GPS tracking and cloud integration allow guardians or emergency services to locate the rider instantly in case of an accident. Automated alerts reduce response time and can potentially save lives.

6.4 Prevention-Oriented System:

Ignition control ensures the vehicle cannot be started if the helmet is not worn or if alcohol is detected, promoting safe riding habits.Drowsiness detection warns the rider before fatigue leads to an accident.

6.5 User-Friendly Interface:

Web dashboard provides clear visualisation of helmet status, accident detection, GPS location, and alerts. Easy access for both riders and guardians on any device with an internet connection.

7. Conclusion

This study investigated the development of an Ultra Smart Helmet equipped with critical safety features such as accident detection, alcohol sensing, helmet-wear monitoring, and emergency alert systems. The project also explored enhancement possibilities, including AI-based object recognition and emergency safety balloons. During implementation, several challenges were identified, including sensor accuracy issues, connectivity limitations, environmental disturbances, and cost constraints.

To enhance system reliability and accessibility, practical solutions were proposed, such as using hybrid sensor modules, improving indoor/outdoor detection accuracy, enabling cloud connectivity, and integrating automatic safety mechanisms. The Ultra Smart Helmet aims to ensure safer riding by preventing drunk driving, reducing accident impact, and providing immediate emergency signalling. This will ultimately boost rider confidence and self-reliance on busy roads.

Future research directions include integrating wearable devices (e.g., smartwatches) to monitor rider stress, fatigue, or abnormal health patterns, advanced voice-assistance features enabling commands like “Report accident,” “Find nearest hospital,” or “Call emergency contact,” and energy-harvesting technologies (solar or kinetic) to increase battery life and reduce charging dependency. Additionally, compact and reusable emergency balloon systems for impact protection and AI and machine-learning-based obstacle prediction for safer navigation will be explored.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 04, ICTEM 2.0 (2026)

8. Future Scope

The proposed IoT-enabled Smart Helmet system provides a strong foundation for enhancing rider safety; however, significant advancements can be incorporated in the future to further improve its effectiveness. With the integration of Artificial Intelligence (AI) and computer vision technologies, the helmet can be upgraded to detect nearby vehicles, pedestrians, and road obstacles in real time, thereby shifting from reactive accident detection to predictive accident prevention. By building upon existing IoT-based helmet systems that focus on alcohol detection, accident monitoring, and ignition control [1,2,3,6], the future smart helmet can analyze traffic conditions and provide proactive alerts to reduce collision risks. Additionally, an innovative emergency safety balloon (airbag helmet mechanism) can be integrated, which would automatically deploy upon detecting a severe impact using motion sensors such as MPU6050 [5], offering enhanced protection to the head and neck during high-impact accidents and improving upon traditional helmet protection systems [7].

Further advancements may include biometric health monitoring features such as heart rate, oxygen level, and body temperature tracking, enabling real-time health assessment and emergency alerts in critical situations. Cloud-based AI analytics can also be implemented to analyze historical riding data, identify unsafe behavioral patterns, and suggest preventive measures, thereby extending current web dashboard and IoT capabilities [2,6]. Moreover, integration with 5G networks and Vehicle-to-Everything (V2X) communication systems could allow the helmet to communicate with nearby vehicles and smart traffic infrastructure, contributing to broader road safety initiatives aligned with global safety recommendations [8]. Thus, while the present system integrates helmet detection, alcohol sensing, accident detection, GPS tracking, and ignition control [1–7], future enhancements can transform it into a fully intelligent, predictive, and life-saving smart safety ecosystem.

References

[1] R. S. Reddy, P. Prasad, and S. Kumar, “Smart Helmet for Accident Detection and Alcohol Detection Using IoT,” *IJIRT*, vol. 8, no. 5, 2021.

[2] S. Sharma and A. Verma, “IoT-Based Smart Helmet with Accident Detection and Location Tracking,” *IEEE Conference on Intelligent Transportation*, 2023.

[3] M. R. Shaikh and K. Patil, “Helmet Detection and Ignition Control System Using RF and Alcohol Sensor,” *IJERT*, vol. 9, 2020.

[4] A. Shinde and P. Bhosale, “Alcohol Detection and Vehicle Ignition Control Using Arduino and MQ-3 Sensor,” *IJSREM*, 2022.

[5] V. Choudhary et al., “Accident Detection and Emergency Alert System Using MPU6050 and GPS,” *IEEE Sensors Applications Symposium*, 2022.

[6] J. Karthik and R. Rajendra, “Smart Helmet Using IoT for Rider Safety and Accident Prevention,” *ICIES*, 2021.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 04, ICTEM 2.0 (2026)

[7] A. Chauhan and R. Singh, "A Review on Intelligent Helmet Systems with Alcohol Detection," *IJCA*, vol. 177, no. 32, 2020.

[8] World Health Organization (WHO), *Global Status Report on Road Safety*, 2023.

[9] *Banzi and M. Shiloh, Getting Started with Arduino: The Open-Source Electronics Prototyping Platform, 3rd ed. Sebastopol, CA, USA: Maker Media, 2014*