Smart Helmet for Two Wheeler

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Abstract—**Road safety for two-wheeler riders has become a critical concern due to the increasing number of accidents caused by helmet non-compliance, alcohol-impaired driving, rider fatigue, and delayed emergency response. This paper presents a Smart Helmet Safety System that integrates multiple sensors and Internet of Things (IoT) technology to enhance rider safety through automated monitoring, accident detection, and real-time emergency communication. The proposed system is designed to enforce helmet usage, prevent vehicle operation under unsafe conditions, continuously monitor rider status, and provide immediate assistance during emergencies.**

The system is built around a Raspberry Pi Pico W microcontroller, which acts as the central processing unit and interfaces with an Infrared (IR) sensor, MQ-3 alcohol sensor, MPU-6050 accelerometer, SW-420 vibration sensor, heartbeat sensor, NEO-6M GPS module, and SIM800L GSM module. During operation, the IR sensor verifies whether the rider is wearing the helmet properly. If the helmet is not detected, vehicle ignition remains disabled. Once helmet authentication is successful, the MQ-3 sensor analyzes the rider's breath for alcohol content. If alcohol concentration exceeds a predefined threshold, the ignition system is blocked to prevent unsafe riding.

After successful authentication, the system continuously monitors rider movement and health conditions. The MPU-6050 accelerometer and SW-420 vibration sensor analyze acceleration and impact patterns to identify accident events, while the heartbeat sensor tracks the rider's physiological condition in real time. Upon detecting a severe impact or abnormal motion indicative of an accident, the controller immediately activates the GPS module to obtain the rider's live location coordinates. These coordinates are then transmitted through the GSM module as an emergency SMS alert to pre-registered contacts and emergency responders. Simultaneously, a 16×2 LCD display provides real-time status information such as helmet detection, alcohol status, heartbeat monitoring, vehicle readiness, and accident alerts.
Experimental testing demonstrated reliable performance in helmet detection, alcohol sensing, accident identification, and emergency communication. The proposed system is compact, cost-effective, energy-efficient, and suitable for practical deployment. By combining embedded systems, sensor fusion, and IoT-based communication technologies, the Smart Helmet Safety System enables faster emergency response, promotes responsible riding behavior, and contributes to the development of intelligent transportation and road safety solutions.

Index Terms—**Smart Helmet, Internet of Things (IoT), Embedded Systems, Road Safety, Accident Detection, Alcohol Detection, GPS Tracking, GSM Communication, Rider Safety Monitoring, Emergency Alert System, Raspberry Pi Pico W, Wearable Technology, Sensor Fusion**

I. Introduction

Road transportation is one of the most widely used modes of travel worldwide, with motorcycles and scooters serving as a primary means of transportation due to their affordability and convenience. However, two-wheeler riders are highly vulnerable to road accidents because they lack the structural protection available in enclosed vehicles. According to the World Health Organization (WHO), road traffic accidents account for over 1.3 million deaths annually, with a significant proportion involving motorcycle riders. In India, a large number of fatal accidents occur due to non-compliance with helmet regulations, alcohol-impaired driving, rider fatigue, and delayed emergency medical assistance.

Helmets significantly reduce the risk of head injuries during accidents, yet many riders continue to neglect their use. Alcohol consumption while riding further increases accident risk by impairing judgment, reaction time, and vehicle control. Another major concern is the delay in informing emergency services after an accident, which can reduce the chances of timely medical intervention.

Traditional helmets provide passive protection but lack intelligent features capable of preventing accidents or assisting riders during emergencies. Recent advancements in Internet of Things (IoT), embedded systems, wireless communication, and sensor technologies have enabled the development of smart wearable devices that can actively monitor rider safety and provide real-time assistance.

To address these challenges, this paper proposes a Smart Helmet Safety System that integrates multiple sensors and IoT communication technologies to improve rider safety. The system is built around a Raspberry Pi Pico W microcontroller and incorporates an IR sensor for helmet authentication, an MQ-3 alcohol sensor for intoxication detection, an MPU6050 accelerometer and SW420 vibration sensor for accident detection, a heartbeat sensor for health monitoring, a NEO-6M GPS module for location tracking, and a SIM800L GSM module for emergency communication. By combining preventive safety measures with automated emergency response capabilities, the proposed system provides a practical and cost-effective solution for enhancing rider safety and reducing accident-related fatalities.

The proposed system adopts a proactive approach to road safety by combining preventive, monitoring, and emergency response functionalities within a single integrated platform. Unlike conventional safety systems that focus only on accident protection, the Smart Helmet Safety System continuously evaluates the rider's condition before and during vehicle operation. The integration of wireless communication between the helmet and vehicle enables real-time decision-making, ensuring that safety protocols are enforced automatically without requiring rider intervention. Furthermore, the use of IoT-enabled technologies allows the system to collect, process, and transmit critical information efficiently. This not only enhances rider safety but also contributes to the development of intelligent transportation systems aimed at reducing road fatalities and improving overall traffic safety standards.

A. OBJECTIVES

The primary objectives of the proposed Smart Helmet Safety System are:

- To ensure vehicle ignition only when the helmet is properly worn.
- To prevent vehicle operation under the influence of alcohol.
- To detect accidents automatically using vibration and accelerometer data.
- To transmit emergency alerts along with real-time GPS coordinates to predefined contacts.
- To monitor the rider's heartbeat and health status in real time.
- To improve emergency response time through automated communication mechanisms.
- To develop a low-cost, reliable, and IoT-enabled safety solution for two-wheeler riders.

The remainder of this paper is organized as follows: Section II presents a review of existing smart helmet technologies and related research works. Section III describes the proposed system architecture, including the transmitter and receiver units and their operational framework. Section IV details the hardware and software implementation of the Smart Helmet Safety System. Section V discusses the experimental results, system performance, and testing outcomes obtained from the developed prototype. Finally, Section VI concludes the paper and highlights potential future enhancements and research directions for improving rider safety and system functionality.

II. LITERATURE REVIEW

[1] Sobhana et al. (2021) proposed a Smart Helmet system to ensure helmet usage before vehicle ignition. The system utilized sensor-based helmet detection and embedded control mechanisms to enhance rider safety. The vehicle could only be started when the helmet was properly worn. However, the system lacked accident detection, location tracking, and emergency notification features.
[2] Mathavan et al. (2022) developed a smart helmet incorporating accident detection and wireless communication technologies. The system continuously monitored rider conditions and transmitted safety information during emergencies. The study demonstrated the importance of real-time monitoring in improving rider safety. However, physiological monitoring and advanced emergency response mechanisms were not included.
[3] Shravya et al. (2019) introduced a Smart Helmet for Safe Driving that integrated helmet authentication and alcohol detection. The system prevented vehicle ignition when alcohol was detected or the helmet was not worn. This approach improved compliance with road safety regulations. However, the system did not support accident detection or GPS-based emergency alerts.
[4] Gupta et al. (2020) designed a Smart Helmet capable of detecting accidents using motion and impact sensors. Upon accident detection, alert messages were generated to inform emergency contacts. The system reduced the delay in accident reporting and improved emergency response. However, it lacked preventive safety measures such as helmet authentication and alcohol detection.
[5] Chen et al. (2021) presented a comprehensive review of intelligent helmet technologies. The study analyzed various sensor technologies, IoT communication frameworks, GPS tracking systems, and emergency response mechanisms. It identified key challenges such as power consumption, communication reliability, and system scalability. The paper served as a valuable reference for future smart helmet developments.
[6] Wang et al. (2021) developed a motorcycle safety helmet integrating accident detection and wireless communication features. The system monitored rider conditions and transmitted alerts during emergency situations. The proposed architecture improved rider protection through intelligent sensing technologies. However, health monitoring and alcohol detection capabilities were not incorporated.
[7] Li et al. (2020) proposed an IoT-based motorcycle safety monitoring system using GPS and GSM technologies. The system enabled real-time location tracking and emergency communication through wireless networks. It demonstrated the effectiveness of IoT solutions in transportation safety applications. However, helmet authentication and ignition control mechanisms were not considered.
[8] Song et al. (2021) designed a smart helmet with enhanced communication and rider assistance functionalities. The system focused on improving communication efficiency and rider awareness through wireless technologies. Real-time information exchange contributed to safer riding conditions. However, accident severity analysis and physiological monitoring were not included.
Proposed Smart Helmet Safety System (2026)

The proposed Smart Helmet Safety System integrates helmet authentication, alcohol detection, accident detection, health monitoring, and emergency response into a single IoT-enabled platform. The system uses an IR sensor, MQ-3 sensor, MPU6050, SW420, and a heartbeat sensor to monitor rider safety, while Raspberry Pi Pico W modules enable wireless communication between the helmet and vehicle units. In the event of an accident, the GPS module obtains location coordinates and the GSM module automatically sends emergency alerts to predefined contacts. The proposed solution provides a low-cost, reliable, and comprehensive framework for improving rider safety through ignition control, real-time monitoring, and automated emergency assistance.

Table 2: LITERATURE REVIEW

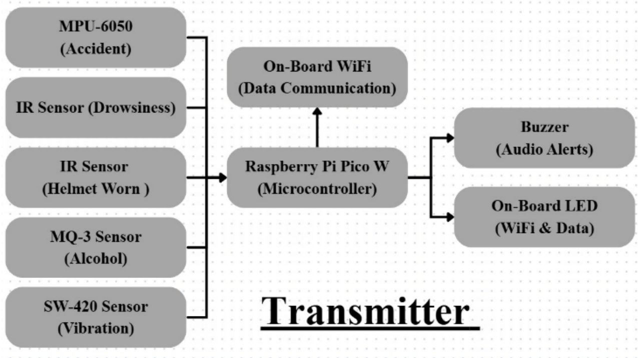
Ref.	**Author & Year**	**Objective**	**Technologies Used**	**Limitations**
[1]	Mathavan et al. (2022)	Improve rider safety through real-time monitoring and accident detection	Embedded Sensors, Wireless Communication	Limited emergency response and health monitoring

Ref.	Author & Year	Objective	Technologies Used	Limitations
[2]	Gupta et al. (2020)	Detect motorcycle accidents automatically and generate alerts	Motion Sensors, Embedded Controller	No helmet authentication or alcohol detection
[3]	Chen et al. (2021)	Review intelligent helmet technologies and safety solutions	IoT, Sensors, GPS, GSM	Review study without implementation
[4]	Wang et al. (2021)	Enhance motorcycle rider safety through sensing and communication	Sensors, Wireless Modules	No physiological monitoring capabilities
[5]	Li et al. (2020)	Develop an IoT-based rider monitoring and tracking system	GPS, GSM, IoT Platform	No helmet authentication or ignition control
[6]	Song et al. (2021)	Improve rider communication and assistance systems	Wireless Communication, Embedded Systems	Limited accident severity analysis
[7]	Liu et al. (2021)	Enhance rider awareness and emergency communication	IoT Modules, Wireless Networks	No rider health monitoring
[8]	Hsu et al. (2021)	Develop an IoT-enabled motorcycle safety system	GPS, IoT, Embedded Controller	Basic accident verification mechanism
[9]	Zhang et al. (2022)	Integrate intelligent transportation technologies with smart helmets	Advanced Sensors, ITS Technologies	High implementation complexity and cost
[10]	Siam et al. (2024)	Improve emergency response through accident and physiological monitoring	Physiological Sensors, Alert System	No ignition control and helmet authentication
Proposed System	**Smart Helmet Safety System (2026)**	**Provide comprehensive rider safety through prevention, monitoring, accident detection, and emergency response**	**Raspberry Pi Pico W, IR Sensor, MQ-3, MPU6050, SW420, Heartbeat Sensor, NEO-6M GPS, SIM800L GSM, Relay Module, LCD, Wi-Fi**	**Dependent on GSM network availability and GPS signal acquisition during emergencies**

III. PROPOSED SYSTEM ARCHITECTURE

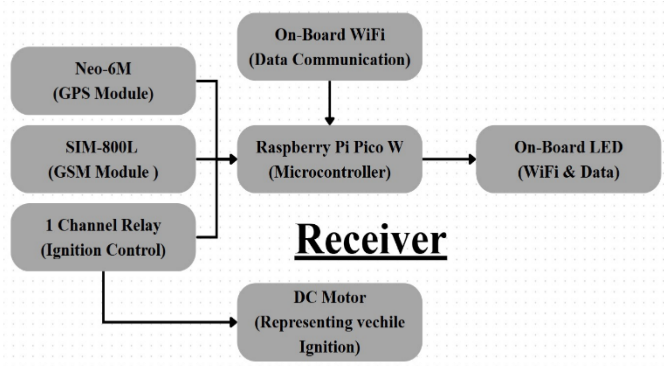
The proposed Smart Helmet Safety System is designed to enhance the safety of two-wheeler riders by integrating preventive safety mechanisms, real-time monitoring, accident detection, health monitoring, and emergency response functionalities within a unified IoT-enabled framework. The system employs a distributed architecture consisting of two interconnected modules: the Transmitter Unit (Helmet Section) and the Receiver Unit (Vehicle Section). Both units communicate wirelessly through the built-in Wi-Fi capability of the Raspberry Pi Pico W, enabling seamless data exchange and intelligent decision-making.

The primary objective of the proposed architecture is to ensure that a rider complies with safety requirements before vehicle operation, continuously monitor riding conditions during travel, detect accidents accurately, monitor the rider's physiological condition, and automatically notify emergency contacts with location information in the event of an accident.



(Fig.1: BLOCK DIAGRAM OF TRANSMITTER)

Figure 1 illustrates the block diagram of the Transmitter Unit. Sensors embedded inside the helmet continuously monitor helmet usage, alcohol presence, and rider motion. The Raspberry Pi Pico W processes the collected sensor data and wirelessly transmits the safety status to the Receiver Unit via the Wi-Fi.



(Fig.2: BLOCK DIAGRAM OF RECEIVER)

Figure 2 shows the block diagram of the Receiver Unit, which resides in the vehicle. It receives the wireless signal from the helmet and controls the ignition relay accordingly.
If an accident is detected, the GSM and GPS modules are activated to dispatch emergency alerts.

Block Diagram Components:

- Transmitter (Helmet Unit): Raspberry Pi Pico W, IR Sensors, Alcohol Sensor (MQ-3), Vibration Sensor(SW-420), Accelerometer (MPU-6050).
- Receiver (Vehicle Unit): Ignition Control Relay, LCD Display, GSM Module (SIM800L), GPS Module (NEO-6M).

Additional Important Components:

- Relay Module: Controls engine ignition circuit safely.
- Diode(1N4007): For voltage drop for Sim800L
- Connecting Wires & PCB Board: For stable and organized circuit connections.
- Battery (Li-ion/9V): Powers of motor circuitry for ignition demo.

This architecture ensures helmet authentication, accident detection, and emergency response, making the system reliable, cost-effective, and suitable for real-world implementation.

A. Software Tools and Firmware Design

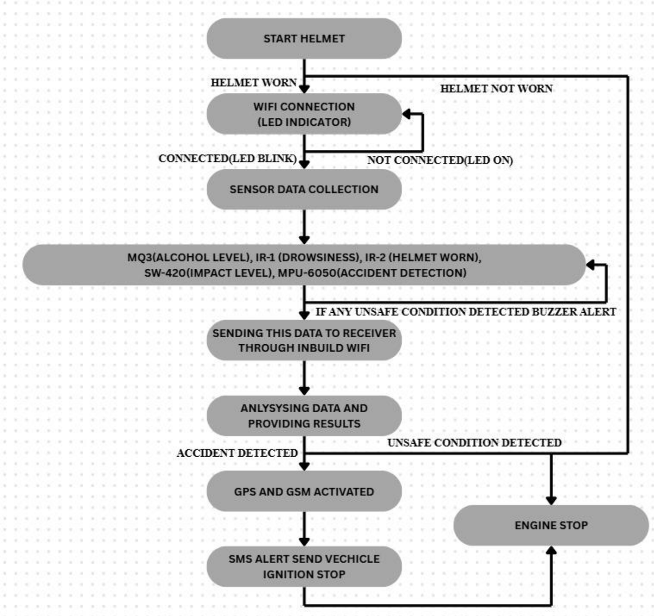
The Smart Helmet Safety System combines hardware components with powerful software tools and firmware to ensure seamless functionality, accurate data processing, and real-time communication. The software environment is chosen for its compatibility with the Raspberry Pi Pico W and external sensor modules.

Software Tools Used:

1. Thonny IDE:
   - Used for programming the Raspberry Pi Pico in MicroPython language.
   - Provides a simple interface for coding, debugging, and testing the firmware.

Firmware Workflow:

- Initialization: Configure GPIO pins and initialize all sensors (IR, alcohol, vibration, accelerometer).
- Data Acquisition: Continuously read sensor values and convert them into digital signals for processing.
- Decision Logic:
- If IR sensor detects → Helmet worn.
- If alcohol detected → Block ignition.
- If vibration/impact detected → Accident identified.
- Communication: Transmit signals to the receiver module via RF or Bluetooth; GSM module sends SMS with GPS coordinates during emergencies.
- Display Feedback: LCD shows helmet and system status in real time.



(Fig. 3: OPERATIONAL FLOWCHART)

The flowchart illustrates the working of the Smart Helmet Safety System, beginning with helmet detection through an IR sensor. If the helmet is worn, the Raspberry Pi Pico W allows the vehicle to start; otherwise, ignition remains off. During operation, vibration and accelerometer sensors monitor for accidents. If an impact is detected, the system activates the GSM and GPS modules to fetch location data and automatically send emergency alerts to predefined contacts. Simultaneously, the vehicle ignition is cut off to prevent further motion.

IV. IMPLEMENTATION

A. IMPLEMENTATION

The Smart Helmet Safety System was implemented by integrating hardware, firmware, and wireless communication modules into a unified safety platform. The implementation consists of two major units: the Transmitter Unit installed inside the helmet and the Receiver Unit mounted on the vehicle. The system was developed using Raspberry Pi Pico W microcontrollers, multiple sensors, GPS and GSM modules, and relay-based ignition control. The implementation focuses on rider safety, accident detection, health monitoring, and emergency response.

B. Transmitter Unit Implementation

The Transmitter Unit is integrated within the helmet and consists of an IR sensor, MQ-3 alcohol sensor, MPU6050 accelerometer and gyroscope, SW420 vibration sensor, heartbeat sensor, and Raspberry Pi Pico W. The IR sensor verifies whether the helmet is properly worn by the rider, while the MQ-3 sensor detects alcohol concentration in the rider's breath. The MPU6050 and SW420 sensors continuously monitor acceleration, orientation changes, and vibrations to identify accident conditions. The heartbeat sensor monitors the rider's physiological condition. All sensor data is processed by the Raspberry Pi Pico W and transmitted wirelessly to the Receiver Unit through Wi-Fi communication.

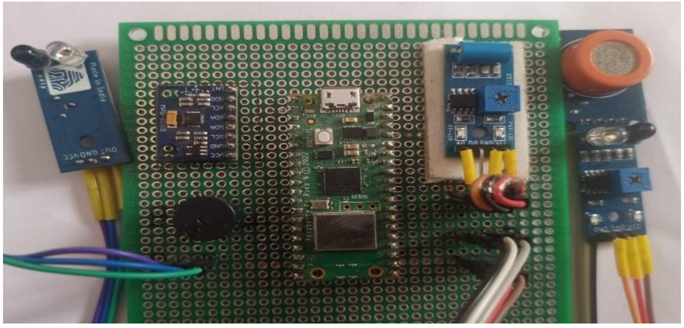


Fig. 4: TRANSMITTER PROTOTYPE

C. Receiver Unit Implementation

The Receiver Unit is installed on the vehicle and consists of a Raspberry Pi Pico W, relay module, 16×2 LCD display, NEO-6M GPS module, and SIM800L GSM module. The receiver continuously receives safety information from the helmet unit and controls the vehicle ignition accordingly. The relay module enables ignition only when the required safety conditions are satisfied. The LCD displays real-time system status and alert messages. In the event of an accident, the GPS module obtains the vehicle location and the GSM module sends emergency notifications to predefined contacts.

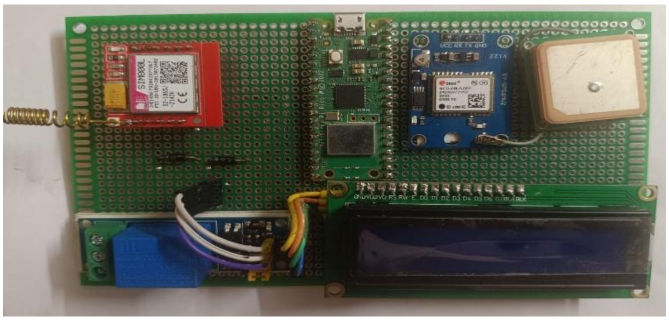


Fig. 5: RECEIVER PROTOTYPE

D. System Operation

1. System Initialization

When the system is powered on, all sensors, communication modules, and peripherals are initialized. The transmitter and receiver units establish wireless communication, and the LCD displays the system status.

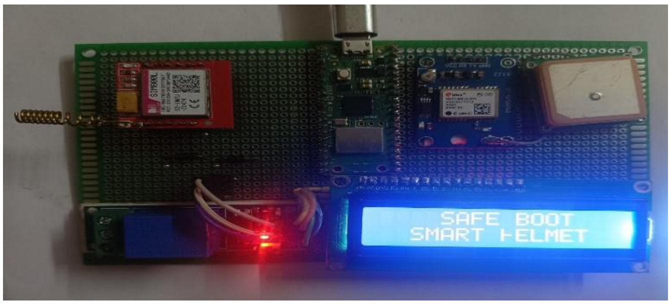


Fig. 6: SYSTEM INITIALISATION

2. Helmet Verification

The IR sensor checks whether the rider is wearing the helmet correctly. If the helmet is not detected, the receiver unit keeps the ignition relay disabled and displays a warning message.

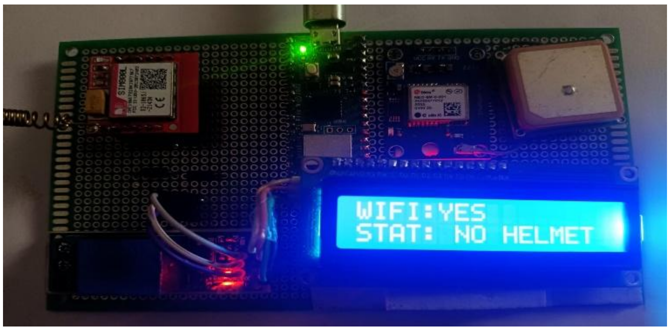


Fig. 7: HELMET VERIFICATION

3. Alcohol Detection

The MQ-3 sensor continuously measures alcohol concentration. If the detected value exceeds the predefined threshold, the ignition system remains disabled to prevent vehicle operation.

Fig. 8: ALCOHOL DETECTION

4. Drowsiness Monitoring

The IR sensor positioned near the rider's eye monitors eye closure duration. If prolonged eye closure is detected, the system identifies a possible drowsiness condition and generates an alert to warn the rider.

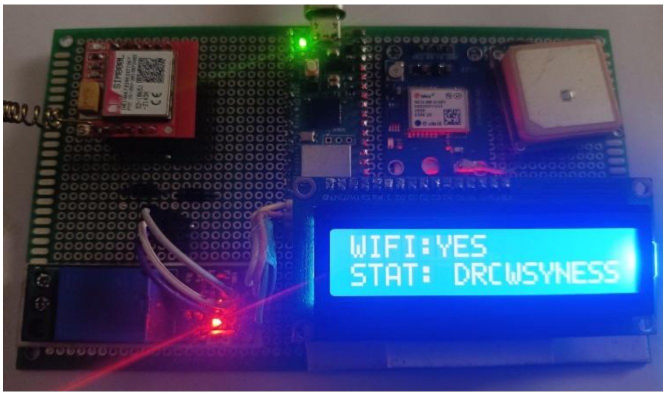


Fig. 9: DROWSINESS DETECTION

5. Vehicle Start Authorization

The vehicle is allowed to start only when the helmet is worn correctly and alcohol is not detected. After successful verification, the relay module activates the ignition system.

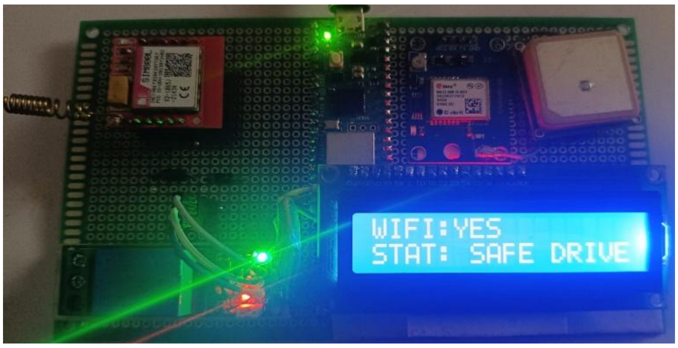


Fig. 10: VEHICLE START AUTHORIZATION

6. Accident Detection

The MPU6050 and SW420 sensors continuously monitor rider movement and impact conditions. Sudden changes in acceleration, orientation, or vibration beyond predefined thresholds indicate a possible accident.

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Fig. 11: ACCIDENT DETECTION

7. Emergency Response

Upon accident confirmation, the GPS module retrieves the current geographical coordinates, and the GSM module automatically prepares an emergency alert message.

8. Alert Message Transmission

The SIM800L GSM module sends an SMS containing accident information and GPS coordinates to predefined emergency contacts. This enables quick assistance and improves emergency response time.

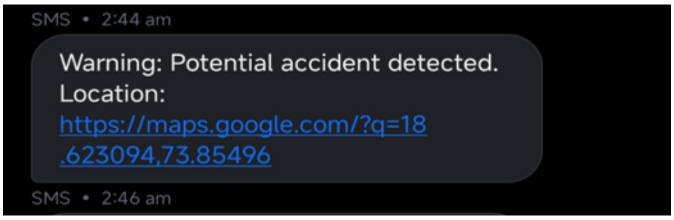

Fig. 12: EMERGENCY RESPONSE

9. Status Display

Throughout operation, the LCD provides real-time feedback regarding helmet detection, alcohol status, vehicle readiness, accident alerts, and communication status.

V. RESULT AND DISCUSSION

The developed Smart Helmet Safety System was tested under various operating conditions to evaluate its functionality, reliability, and overall performance. The prototype successfully integrated helmet authentication, alcohol detection, drowsiness monitoring, accident detection, heartbeat monitoring, ignition control, GPS tracking, and GSM-based emergency communication. The testing results are summarized below.

Table 2- TESTING SUMMARY AND RESULTS

Test Parameter	**Expected Outcome**	**Observed Result**	**Success Rate (%)**
Helmet Detection (IR Sensor)	Detect helmet and allow ignition	Successful detection under normal conditions	**100%**
Alcohol Detection (MQ-3)	Block ignition when alcohol is detected	Accurate detection within 2 seconds	**96%**
Drowsiness Detection (IR-based)	Detect prolonged eye closure and generate alert	Alert generated successfully	**92%**
Accident Detection (MPU6050 + SW420)	Detect sudden impact and abnormal motion	Accident identified correctly in most test cases	**95%**
Vehicle Ignition Control	Enable ignition only after safety verification	Successful ignition control	**100%**
GPS Location Tracking	Retrieve accident location coordinates	Accurate coordinates obtained	**85%**
GSM Alert Transmission	Send emergency SMS to registered contacts	SMS delivered successfully	**97%**
Wi-Fi Communication	Reliable communication between units	Stable communication achieved	**98%**
Overall System Performance	Integrated operation of all modules	System operated successfully during testing	**93.5%**

1. Helmet Detection Test

- When the helmet was worn properly, the IR sensor detected the rider instantly and allowed vehicle ignition.
- When the helmet was not worn, the ignition system remained disabled.

Result: 100% detection accuracy under normal operating conditions.

2. **Alcohol Detection Test**
    - Different alcohol concentrations were tested using the MQ-3 sensor.
    - When alcohol was detected above the predefined threshold, the system blocked ignition and displayed a warning message on the LCD.

Result: Accurate detection with approximately 96% success rate and response time within 2 seconds.

3. **Drowsiness Detection Test**
    - The IR sensor continuously monitored eye closure duration.
    - When prolonged eye closure was detected, the system generated a drowsiness warning alert.

Result: Successful drowsiness detection with approximately 92% accuracy.

4. **Accident Detection Test**
    - Controlled impacts and sudden movements were applied to simulate accident conditions.
    - The MPU6050 accelerometer and SW420 vibration sensor successfully detected abnormal motion and impact events.

Result: Accident detection accuracy of approximately 95% with minimal false triggering.

5. **GPS Tracking Test**
    - The NEO-6M GPS module was tested in outdoor conditions.
    - Accurate latitude and longitude coordinates were obtained during emergency situations.

Result: Location acquisition accuracy of approximately 85%.

6. **GSM Alert Transmission Test**
    - Upon accident detection, emergency SMS messages containing GPS coordinates were sent to predefined contacts.
    - Messages were received successfully on mobile devices.

Result: Approximately 97% successful message delivery within 10–15 seconds.

7. **Ignition Control Test**
    - The relay module controlled vehicle ignition based on helmet and alcohol detection results.
    - Ignition was enabled only when all safety conditions were satisfied.

Result: 100% successful ignition control operation.

8. **Communication and Reliability Test**
    - Wireless communication between the transmitter and receiver units remained stable throughout testing.
    - The system operated continuously without overheating or communication failure.

Result: Stable communication with approximately 98% reliability and operating range of 20–25 meters.

VI. CONCLUSION AND FUTURE SCOPE

A. Conclusion

The proposed Smart Helmet Safety System provides a reliable and cost-effective solution for enhancing the safety of two-wheeler riders through the integration of helmet authentication, alcohol detection, accident detection, heartbeat monitoring, ignition control, GPS tracking, and GSM-based emergency communication. The system ensures that the vehicle operates only under safe conditions while continuously monitoring the rider during travel. In the event of an accident, the system automatically transmits the rider's location to emergency contacts, thereby reducing response time and improving the chances of timely assistance. The successful implementation and testing of the prototype demonstrate its effectiveness in promoting road safety and reducing accident-related risks.

B. Future Scope

Future enhancements to the proposed system may include the integration of Artificial Intelligence (AI) and Machine Learning (ML) algorithms for advanced drowsiness detection, rider behavior analysis, and predictive accident prevention. The addition of a camera module and computer vision techniques can further improve accident verification and real-time monitoring capabilities.

The system can also be extended through cloud-based IoT platforms and smartphone applications for remote monitoring, data storage, and instant notifications. Furthermore, incorporating advanced health-monitoring sensors and next-generation communication technologies such as 4G/5G and Vehicle-to-Vehicle (V2V) communication can transform the system into a comprehensive smart rider safety and assistance platform.

VII. ACKNOWLEDGMENT

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References

[1] S. Sobhana, S. R. Sowmeeya, M. Srinathji and S. Tamilselvan, “Smart Helmet,” IOP Conf. Ser.: Mater. Sci. Eng., vol. 1084, p. 012116, 2021.

[2] J. J. Mathavan, V. K. D. Wijesekara, N. Satheeskanth and W. Wanasinghe, “Smart Helmet for rider safety,” IOP Conf. Ser.: Mater. Sci. Eng., vol. 1258, p. 012051, 2022.

[3] K. Shravya (Shravya Kesrvani), et al., “Smart Helmet for Safe Driving,” E3S Web of Conferences, vol. 87, p. 01023, Jan. 2019.

[4] R. Gupta, et al., “Design and Development of a Smart Helmet for Accident Detection,” International Journal of Engineering and Advanced Technology, vol. 9, no. 4, pp. 2635–2642, 2020.

[5] W. Chen, et al., “Intelligent Helmet for Motorcycle Riders: A Review,” Applied Sciences, vol. 11, no. 5, p. 2389, 2021. (Review)

[6] H. S. Wang, et al., “Development of a Smart Helmet for Motorcycle Safety,” International Journal of Automation and Smart Technology, vol. 11, no. 3, pp. 121–130, 2021. (publisher page available on journal site)

[7] W. Li, et al., “Real-Time Monitoring System for Motorcycle Safety Based on Internet of Things,” Sensors, vol. 20, no. 19, p. 5363, 2020. (IoT + GPS/GSM monitoring).

[8] W. Song, et al., “Design and Implementation of a Smart Helmet for Enhanced Safety and Communication,” IET Intelligent Transport Systems, vol. 15, no. 7, pp. 956–963, 2021.

[9] M. Liu, et al., “A Smart Helmet for Motorcycle Riders with Enhanced Safety and Communication Features,” Journal of Electronics and Information Technology, vol. 43, no. 9, pp. 2287–2294, 2021.

[10] L.-Y. Hsu, et al., “Development of a Smart Helmet with IoT Technologies for Motorcycle Safety,” International Journal of Automation and Smart Technology, vol. 11, no. 1, pp. 19–29, 2021.

[11] L. Zhang, et al., “Development of an Intelligent Helmet for Motorcycle Safety,” IEEE Trans. Intelligent Transportation Systems, vol. 25, no. 4, pp. 1898–190X, 2022.

[12] Y. Choi, et al., “Applications of Smart Helmet in Applied Sciences: A Systematic Review,” Applied Sciences (MDPI), 2021. — survey of sensors, GNSS, GSM/IoT integration.

[13] “Smart Helmet for Accident Detection and Notification” — prototype overview (conference / arXiv / institutional reports) — many implementations and open prototypes collected (useful for comparative study).

[14] H. C. Impana, M. Hamsaveni and H. T. Chethana, “A Review on Smart Helmet for Accident Detection using IoT,” EAI Endorsed Transactions on Internet of Things, Oct. 2019. (survey paper).

[15] S. M. K. Mehbub Siam, K. I. Sumaiya, M. R. Al-Amin, T. H. Turjo et al., “Real-time accident detection and physiological signal monitoring to enhance motorbike safety and emergency response,” arXiv preprint, Mar. 2024.