

AI-Based Smart Helmet 2.0 – Rider Safety & Health Monitoring System Using IOT

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Abstract— Road accidents involving two-wheelers are frequently caused by helmet negligence, alcohol consumption, irresponsible riding, and delayed emergency assistance. To address these safety challenges, this project proposes a Smart Helmet for Accident Prevention Using IoT that combines sensing, vehicle control, and wireless communication technologies. The system uses an IR sensor to detect whether the rider is wearing the helmet and an MQ-3 alcohol sensor to monitor alcohol presence in the rider's breath. An Arduino controller processes the sensor signals and controls the vehicle ignition through a relay or motor driver. The vehicle is permitted to operate only when the helmet is worn and alcohol remains below the predefined threshold. An emergency switch is also provided, allowing the rider to manually request assistance during an emergency. In addition, accident or emergency conditions can trigger IoT-based alerts containing the rider's location through GPS and wireless communication. LCD and buzzer units provide immediate visual and audible warnings. The proposed system aims to improve safety compliance, prevent unsafe riding, support rapid emergency response, and provide a practical, cost-effective solution for intelligent two-wheeler transportation.

Keywords— Smart Helmet, Internet of Things (IoT), Alcohol Detection, Accident Prevention, Emergency Alert System.

I. INTRODUCTION

Road safety is an important concern worldwide, particularly for two-wheeler riders who are more exposed to injuries during road accidents. Motorcycles and scooters are widely used because they are economical, convenient, and suitable for congested traffic conditions. However, the absence of protective vehicle structures makes riders highly vulnerable to serious injuries. Major factors contributing to two-wheeler accidents include failure to wear helmets, alcohol consumption, excessive speed, careless riding, and delayed emergency assistance. Among these factors, helmet negligence and drunk driving are particularly important because they can often be prevented through proper safety measures and intelligent monitoring systems.

A conventional helmet provides passive protection by reducing the severity of head injuries during an accident. However, it cannot determine whether the rider is actually wearing it before starting the vehicle. Similarly, conventional

vehicles do not normally have a mechanism to identify whether the rider is under the influence of alcohol. Traffic authorities generally depend on manual helmet checking, breath analyzers, and roadside inspections. Although these methods are useful, they cannot continuously monitor rider behavior and may not prevent unsafe riding in every situation. Therefore, an automated safety system capable of monitoring essential rider conditions is required.

The development of the Internet of Things (IoT) has created new opportunities for improving transportation and personal safety. IoT technology allows sensors, controllers, communication modules, and remote monitoring platforms to exchange information in real time. By integrating IoT with a helmet, several safety functions can be combined into a single intelligent system. The proposed Smart Helmet for Accident Prevention Using IoT is designed to provide active safety rather than relying only on conventional protective equipment.

The proposed system incorporates an IR sensor to detect whether the rider is wearing the helmet. An MQ-3 alcohol sensor is used to identify the presence of alcohol in the rider's breath. These sensor signals are processed by an Arduino controller, which acts as the central decision-making unit. The vehicle ignition is connected to the control system so that the vehicle can operate only when the required safety conditions are satisfied. If the helmet is not worn or alcohol is detected above the predefined threshold, the controller prevents vehicle operation and activates an alert.

The system also includes an emergency switch, which provides an additional safety facility for the rider. If the rider experiences an accident, medical emergency, or dangerous situation, the switch can be pressed manually to request assistance. The IoT communication module can transmit an emergency notification to predefined contacts, while GPS can provide the rider's location. A buzzer and LCD display provide immediate audible and visual indications of system conditions.

The overall objective of the project is to integrate helmet detection, alcohol monitoring, ignition control, emergency assistance, and IoT communication into a compact and practical safety system. The proposed Smart Helmet can encourage responsible riding, reduce preventable accidents, improve safety compliance, and support faster emergency response. Thus, the system represents a useful step toward

intelligent transportation, connected vehicle safety, and IoT-enabled road safety applications.

II. PROBLEM IDENTIFICATION

- **Balance Difficulty:** Conventional two-wheeled cycles require continuous rider control to maintain equilibrium, particularly during starting, stopping, low-speed movement, and sudden disturbances.
- **Stability Challenges:** A cycle with only two ground-contact wheels can easily become unstable when its center of gravity shifts due to acceleration, braking, uneven surfaces, or external forces.
- **Gyroscopic Integration:** Existing self-balancing platforms often use complex robotic structures. Integrating a high-speed gyroscope into a compact cycle-style aluminum frame requires careful consideration of weight, mounting position, rotational speed, and available space.
- **Power Management:** The system requires coordinated operation of wheel motors, gyroscope motor, controller, and motor drivers while operating from a limited-capacity lithium battery.
- **System Integration:** Mechanical components and electrical units must be properly assembled to achieve reliable operation, efficient power distribution, and safe movement.
- **Prototype Performance:** Practical testing is required to evaluate stability, movement, response, power consumption, and reliability under different operating conditions.

A. Existing System

The existing two-wheeler safety system mainly depends on conventional helmets, traffic regulations, manual inspections, and roadside alcohol testing. Traditional helmets provide passive protection against head injuries but do not verify whether the rider is wearing them before starting the vehicle. Alcohol detection is generally performed manually using breath analyzers by traffic authorities. Some existing electronic systems provide individual functions such as helmet detection, accident detection, GPS tracking, or GSM-based alerts. However, these features are often implemented separately rather than as a single integrated safety platform. Emergency assistance generally depends on the rider or bystanders reporting the accident. Therefore, existing systems provide limited continuous monitoring and automated prevention.

B. Drawbacks

- **Passive Protection:** Conventional helmets protect the head but cannot actively prevent unsafe riding.
- **Manual Enforcement:** Helmet compliance and alcohol detection depend heavily on traffic police and periodic inspections.
- **No Continuous Monitoring:** Existing systems may not continuously verify helmet usage while the vehicle is moving.
- **Limited Ignition Control:** Many systems lack reliable integration between safety sensors and vehicle ignition.
- **Delayed Emergency Response:** Accident victims may be unable to contact emergency services themselves.

- **Limited Manual Assistance:** Riders may not have an emergency switch to request help during dangerous situations.
- **Poor Integration:** Helmet detection, alcohol monitoring, GPS, and emergency communication are often separate systems.

III. LITERATURE REVIEWS

A) Literature Survey:

Gunjan Chhabra, Keshav Kaushik, Pardeep Singh, Gourav Bathla, Ahmad Almogren, Salil Bharany, Ayman Altameem, Ateeq Ur Rehman (2024), The authors developed an IoT and machine-learning-based framework for improving two-wheeler rider safety. The proposed system monitors multiple parameters including alcohol consumption, helmet usage, vehicle speed, location, and rider physiological conditions. EEG signals were analyzed to classify alcoholic and non-alcoholic conditions using machine-learning algorithms such as multilayer perceptron, support vector machine, k-nearest neighbors, and Naïve Bayes. The system also supports real-time ignition control and helmet detection. Experimental evaluation under indoor and outdoor environments demonstrated approximately 95% accuracy. The study shows that combining IoT, wearable sensing, and intelligent classification can provide proactive safety rather than relying only on post-accident response.

Sreenivasulu Kyathari Neelakanteshwaralu, Rashmi Gadenahalli Puttaswamy, Sunil Thimmaiah, Rohith Shivashankar, Yashas Ponnasamudra Thippeswamy (2024), The authors presented an IoT-based smart helmet developed around an Arduino microcontroller. The research demonstrates the feasibility of integrating embedded electronics into a helmet to improve rider safety and support accident-related monitoring. The Arduino-based architecture provides a low-cost platform for processing sensor information and controlling connected safety functions. The work is relevant to practical smart-helmet development because Arduino provides flexible interfacing with sensors, communication modules, and warning devices. The study emphasizes the development of an accessible prototype rather than a complex high-cost system. It provides a useful foundation for integrating additional functions such as alcohol detection, emergency switches, GPS tracking, and IoT-based accident notification in future implementations.

Varshini P. A. (2025), developed a smart helmet combining accident detection, alcohol sensing, GPS tracking, and emergency communication. The system uses an Arduino Uno, MQ-3 alcohol sensor, GPS, and GSM modules. Alcohol detection is performed before vehicle operation, and ignition is disabled when alcohol is detected. During an accident, the system detects impact, obtains the rider's location through GPS, and sends an emergency notification to predefined contacts using GSM communication. Prototype testing demonstrated accident detection, emergency alert transmission, and ignition blocking during alcohol detection. The study highlights the importance of combining preventive safety measures with post-accident emergency communication. Its low-cost architecture also makes the proposed approach suitable for wider adoption among two-wheeler riders.

Adya Utsahi, Mona Tibrewal, Navin Patidar, Sapan Parikh (2025), The authors proposed an IoT-based smart helmet as an active road-safety solution for motorcycle riders. The research addresses major safety concerns including helmet compliance and delayed medical assistance following accidents. The proposed architecture integrates sensing and communication technologies to identify unsafe riding conditions and support emergency response. Unlike conventional helmets that provide only passive protection, the system focuses on active monitoring and rapid communication. The study emphasizes that smart helmets can transform rider safety by combining sensors, embedded controllers, and IoT connectivity. The work is particularly relevant to the present project because it supports the concept of integrating preventive safety mechanisms with automatic emergency notification rather than depending entirely on manual intervention.

S. A. A. Shah, M. Faheem, A. Raza (2021), developed an IoT-based smart helmet intended to detect motorcycle accidents and automatically notify emergency contacts. The system combines helmet-based sensing with accident identification and location communication. Its primary contribution is reducing dependence on the rider or bystanders for reporting an accident. When an accident occurs, the system can identify the event and communicate relevant information to facilitate emergency assistance. The study demonstrates the usefulness of IoT connectivity in reducing delays after motorcycle accidents. It also establishes a foundation for integrating additional functions such as alcohol detection, helmet-wearing verification, emergency switches, and vehicle ignition control into a comprehensive rider-safety system.

T. Durkka Parameswari, S. Padmashankari, M. Vaishnavi, S. Sindhana (2024), The researchers investigated smart helmet technology using IoT and embedded sensing for improving rider protection. The proposed system incorporates an Arduino-based controller together with physiological and location-monitoring technologies. GPS and GSM communication are used to support location-based emergency notifications. The study demonstrates that wearable electronics can transform a conventional helmet into an intelligent safety device capable of monitoring rider conditions and communicating emergency information. The integration of multiple modules provides a foundation for real-time safety monitoring. The research is significant for the present project because it demonstrates how IoT communication can complement conventional helmet protection and provide emergency assistance when a rider is unable to communicate independently.

Onkar M. Mudegaonkar, Aditi Baliram Raipure, Shruti Ketan Chavan, Prerana Dhanraj Malule (2026), The authors developed an integrated smart helmet combining IR-based helmet detection, alcohol sensing, accelerometer-based accident detection, GPS tracking, and ESP32-based IoT communication. The system allows vehicle operation only when the helmet is worn and alcohol is not detected. During an accident, the accelerometer identifies abnormal impact conditions and the controller obtains the rider's location through GPS before transmitting emergency notifications. The study also considers sustainable operation through solar-powered energy. Prototype testing demonstrated successful operation of the major safety functions and emergency communication. The research is highly relevant because it

integrates preventive controls and emergency response within a single platform.

A. JS, U. Zaid, S. BN, S. Kumar Yadav, S. Noor Ahamed (2025), The authors developed a smart helmet system using IoT and multiple sensors for monitoring rider safety. The architecture uses an ESP32 controller with IR, MQ-3, and accelerometer sensors. The IR sensor supports helmet detection, while the MQ-3 sensor identifies alcohol presence and the accelerometer supports accident detection. Emergency notifications are transmitted using an IoT communication mechanism, with Telegram-based notification highlighted in the reported implementation. The study demonstrates how multiple low-cost sensors can be combined within a wearable platform to provide continuous safety monitoring. Its architecture supports the development of integrated systems that can detect unsafe conditions and provide immediate warnings or emergency notifications.

Sharmin Akter, Md. Abu Yousuf, K. M. Rafiqul Alam, Md. Sahidullah et al. (2024), The researchers proposed a cost-effective IoT-enabled smart helmet incorporating multiple sensors for rider safety and accident detection. The system combines helmet-related sensing with alcohol, vibration, ultrasonic, and GPS technologies. This multi-sensor approach allows the helmet to monitor different hazardous conditions rather than depending on a single parameter. The main contribution is the development of an affordable safety platform that can support accident detection and location-based emergency response. The study is important for developing countries because cost is a significant factor in large-scale adoption of smart safety equipment. It demonstrates that several safety functions can be integrated while maintaining a relatively accessible prototype architecture.

Muhammad Irfan Minhas et al. (2026), This research presents a low-cost smart helmet designed to provide both accident detection and emergency response. The architecture includes an integrated GPS-GSM system capable of transmitting the rider's geographical location without requiring smartphone connectivity. The prototype was evaluated through 150 experimental tests involving laboratory and real-world riding conditions. Reported results achieved 93.7% accident-detection accuracy, a 2.6% false-positive rate, and an average emergency-alert latency of 2.8 seconds. Finite Element Analysis also confirmed structural integrity under ECE 22.05 impact conditions with a safety factor of 1.38. The findings demonstrate the potential of combining physical helmet protection with intelligent sensing and rapid emergency communication.

B) Literature Summary

Recent studies on IoT-based smart helmets demonstrate the integration of Arduino/ESP32 controllers, IR sensors, alcohol sensors, accelerometers, GPS, GSM, and wireless communication technologies for two-wheeler safety. Researchers have focused on helmet-wearing verification, alcohol detection, accident identification, vehicle ignition control, and emergency location sharing. Several systems successfully provide automatic alerts to predefined contacts, reducing dependence on manual accident reporting. Advanced studies also incorporate machine learning, cloud platforms, physiological monitoring, and multi-sensor

architectures. Overall, the literature confirms that IoT-enabled helmets can provide proactive safety, continuous monitoring, and faster emergency response. However, most reported systems remain prototype-oriented and require further practical validation.

C) Research Gap

Existing smart helmet research still has several limitations. Many systems address helmet detection, alcohol sensing, or accident notification individually rather than integrating all functions into one reliable platform. Continuous helmet monitoring and automatic vehicle control during riding are insufficiently explored. Emergency communication often depends on GSM or internet availability, while advanced cloud-based monitoring remains limited. Sensor calibration, false detection, environmental effects, battery life, and long-term reliability are not adequately evaluated. Rider comfort and practical usability are also frequently overlooked. Therefore, there is a need for a cost-effective and integrated smart helmet combining helmet detection, alcohol monitoring, ignition control, emergency switching, GPS location, and IoT-based alerts.

IV. RESEARCH METHODOLOGY

A) Proposed System

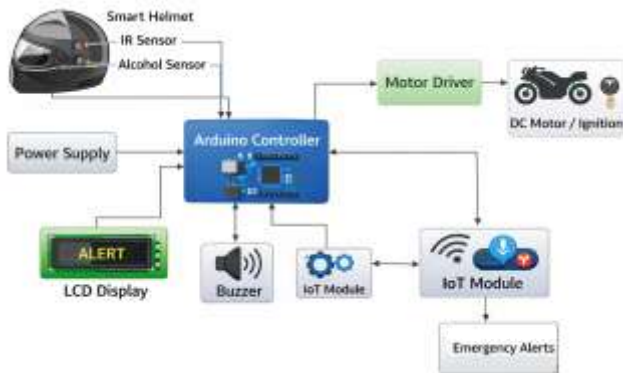


Figure 2. Block Diagram

- **System Activation:** The Smart Helmet system is powered using a regulated power supply. Arduino initializes the sensors, display, buzzer, IoT module, and vehicle-control circuit.
- **Helmet Detection:** An IR sensor installed inside the helmet detects whether the rider is wearing it properly. The sensor sends the helmet-status signal to the Arduino controller.
- **Alcohol Detection:** The MQ-3 alcohol sensor continuously checks the rider's breath. The Arduino compares the sensor output with a predefined threshold value.
- **Safety Decision:** If the helmet is worn and alcohol is below the specified threshold, the controller considers the riding condition safe and permits vehicle operation.
- **Ignition Control:** A relay/motor-driver circuit receives the Arduino command and enables the vehicle ignition or DC motor only when all required safety conditions are satisfied.
- **Unsafe Condition:** If the helmet is not worn or alcohol is detected above the threshold, the Arduino disables ignition and activates the buzzer and LCD to warn the rider.
- **Continuous Monitoring:** During riding, the helmet sensor continues monitoring helmet status. If the rider removes the helmet, the controller detects the change and activates an appropriate warning/control response.
- **Emergency Switch:** The rider can press the emergency switch during an accident, medical problem, dangerous

situation, or other emergency to manually request assistance.

- **IoT Alert:** The IoT module transmits the emergency or accident notification to predefined contacts. When GPS is integrated, the rider's current location is included.
- **Emergency Response:** The received alert allows family members or emergency personnel to identify the rider's condition and location, supporting faster assistance and improving overall road safety.

B) Hardware Used

- **Arduino UNO:** Acts as the main controller, processing signals from sensors and controlling the ignition, buzzer, LCD, and IoT module.
- **IR Sensor:** Detects whether the rider is wearing the helmet and provides helmet-status information to the Arduino.
- **MQ-3 Alcohol Sensor:** Detects alcohol vapors in the rider's breath and helps prevent vehicle operation when the preset threshold is exceeded.
- **Emergency Switch:** Allows the rider to manually activate an emergency request during an accident, medical problem, or dangerous situation.
- **GPS Module:** Determines the geographical location of the rider and provides coordinates for emergency alerts.
- **ESP8266 IoT Module:** Provides wireless connectivity for transmitting safety information and emergency notifications.
- **LCD Display:** Displays messages such as helmet status, alcohol detection, system condition, and emergency activation.
- **Buzzer:** Produces audible warnings during unsafe conditions such as alcohol detection or helmet removal.
- **Relay/Motor Driver:** Controls the vehicle ignition or DC motor according to Arduino commands.
- **DC Motor:** Represents vehicle movement in the prototype model.
- **Power Supply:** Provides regulated electrical power to the controller, sensors, communication module, and output devices.



Figure 2. Project Model

V. CALCULATION

1. Total Power Consumption

Component	Voltage	Current	Power
Arduino UNO	5 V	50 mA	0.25 W
IR Sensor	5 V	20 mA	0.10 W
MQ-3 Alcohol Sensor	5 V	150 mA	0.75 W
LCD	5 V	20 mA	0.10 W
ESP8266 IoT	5 V	80 mA	0.40 W

Module			
GPS Module	5 V	50 mA	0.25 W
Buzzer	5 V	30 mA	0.15 W

Total Power:

$$P_{total} = 0.25 + 0.10 + 0.75 + 0.10 + 0.40 + 0.25 + 0.15$$

$$= 2.00 \text{ w}$$

2. Total Current Requirement

For a 5 V supply:

$$I = \frac{P}{V}$$

$$I = \frac{2}{5} = 0.4 \text{ A}$$

$$I_{total} = 400 \text{ mA}$$

Hence, a 5 V, 1 A regulated supply is suitable for the electronics.

3. Battery Backup Calculation

Assume a 12 V, 2 Ah battery:

$$E = V \times Ah = 24 \text{ Wh}$$

For a system consumption of approximately 2 W:

$$T = \frac{24}{2} = 12 \text{ hrs}$$

Considering approximately 80% practical efficiency:

$$T = 12 \times 0.8 = 9.6 \text{ hrs}$$

4. Emergency Alert Response Calculation

If the sensor processing takes 0.5 s, IoT processing takes 0.8 s, and network transmission takes 1.2 s:

$$T_{alert} = 0.5 + 0.8 + 1.2$$

$$= 2.5 \text{ s}$$

5. Sensor Decision Logic

The vehicle is permitted to operate only when:

Helmet=1
and

Alcohol<Threshold

Therefore:

Ignition=ON, if Helmet=1 and Alcohol<Threshold

Otherwise:

Ignition=OFF

The emergency switch independently triggers the emergency-alert routine when pressed.

VI. ADVANTAGES AND APPLICATIONS

A) Advantages

- Ensures helmet compliance before vehicle operation.
- Detects alcohol consumption and prevents drunk riding.
- Provides automatic ignition control during unsafe conditions.

- Emergency switch enables immediate manual help requests.
- IoT provides real-time alerts and location sharing.
- Improves rider safety, awareness, and emergency response.

B) Applications

- Used in motorcycles and scooters for enhanced rider safety.
- Suitable for delivery and logistics riders.
- Applicable in college, industrial, and corporate campuses.
- Useful for fleet safety monitoring and management.
- Supports smart-city transportation systems.
- Suitable for emergency assistance, accident reporting, and location-tracking applications.

VII. CONCLUSION

The proposed Smart Helmet for Accident Prevention Using IoT provides an effective approach for improving two-wheeler rider safety by combining helmet detection, alcohol monitoring, vehicle control, emergency assistance, and wireless communication. The system uses an IR sensor to verify helmet usage and an MQ-3 alcohol sensor to identify alcohol consumption before vehicle operation. The Arduino controller processes these inputs and controls the ignition through a relay or motor driver, ensuring that the vehicle operates only when the predefined safety conditions are satisfied. The emergency switch provides an additional manual safety feature, allowing the rider to request help whenever an accident, medical emergency, or dangerous situation occurs. The IoT module can transmit emergency notifications and location information to predefined contacts, supporting faster assistance. LCD and buzzer outputs provide immediate visual and audible warnings to the rider. The proposed prototype demonstrates how embedded systems and IoT technology can transform a conventional helmet into an intelligent safety device. Overall, the system can reduce unsafe riding practices, encourage helmet compliance, discourage drunk driving, and improve emergency response. With further development and real-world testing, the proposed smart helmet can become a practical and cost-effective solution for enhancing road safety.

VIII. FUTURE SCOPE

- Enhanced Safety: Add drowsiness detection, overspeed monitoring, obstacle detection, heart-rate monitoring, and advanced accident sensors to provide comprehensive rider protection.
- Smart Integration: Develop compact, lightweight electronics and connect the helmet with smart-city infrastructure and intelligent traffic management systems.

REFERENCES

- [1] G. Chhabra, K. Kaushik, P. Singh, G. Bathla, A. Almogren, S. Bharany, A. Altameem, and A. U. Rehman, "Internet of things based smart framework for the safe driving experience of two wheelers," *Scientific Reports*, vol. 14, Art. no. 21830, 2024, doi: 10.1038/s41598-024-72357-4.
- [2] A. Dubey, D. Bisen, and N. Venu, "IoT-enabled smart helmet for motorcycle safety: Integrated alcohol detection, fatigue monitoring, and emergency response system," in *Proc. 2025 IEEE 3rd Int. Symp. on Sustainable Energy, Signal Processing and Cybersecurity (iSSSC)*, 2025, doi: 10.1109/iSSSC66652.2025.11389095.

- [3] S. D. Dhere, S. Aher, R. Agalme, and M. Kachake, "Smart helmet for accident detection and prevention using IoT," *International Journal of Science and Research Archive*, vol. 15, no. 1, pp. 1537–1543, 2025, doi: 10.30574/ijstra.2025.15.1.1214.
- [4] R. E. P. De Leon, S. N. A. Sanone, C. G. Juarizo, C. C. Sison, and E. A. Garcia, "Internet of Things-based smart helmet with accident identification and logistics monitoring for delivery riders," *Engineering Proceedings*, vol. 58, no. 1, Art. no. 129, 2023.
- [5] T. D. Parameswari, S. Padmashankari, M. Vaishnavi, and S. Sindhana, "Smart helmet technology: Integrating IoT for enhanced user safety," *Journal of Propulsion Technology*, 2024.
- [6] A. Jadhav, "Alcohol and accident detection with sharing of mobile notification along location using smart helmet system," *Research & Reviews: Journal of Embedded System & Applications*, 2024.
- [7] P. De, S. Kumar, and L. Singh, "IoT-enabled smart helmet for safety and accident detection," in *Proc. IEEE International Conference on Intelligent Computing and Communication Systems (ICICNIS)*, 2024.
- [8] S. Akter, M. A. Yousuf, K. M. R. Alam, and M. Sahidullah *et al.*, "A cost-effective smart helmet for human safety and road accident detection using IoT," in *Proc. International Conference on Recent Progresses in Science and Technology (ICRPSET)*, 2024.
- [9] P. A. Parjane, P. B. Mahale, P. G. Dhavane, S. A. Chetke, and I. T. Mukharjee, "Smart helmet to avoid road hazards using IoT," *Iconic Research and Engineering Journals*, 2025.
- [10] A. JS, U. Zaid, S. BN, S. K. Yadav, and S. Noor Ahamed, "Smart helmet system: Enhancing rider safety through IoT and sensor integration," *Journal of Big Data Analytics and Business Intelligence*, 2025.
- [11] S. Sripad, T. Mehta, A. Srivastava, and V. Viswanathan, "The future of vehicle electrification in India may ride on two wheels," *ACS Energy Letters*, vol. 4, no. 11, pp. 2691–2694, 2019.
- [12] D. Mahata, P. K. Narzary, and D. Govil, "Spatiotemporal analysis of road traffic accidents in large Indian cities," *Clinical Epidemiology and Global Health*, vol. 7, no. 4, pp. 586–591, 2019.
- [13] D. Yadav, R. Goyal, and V. S. Yadav, "Automotive evaporative emissions and refueling losses from Indian two-wheelers," *Materials Today: Proceedings*, vol. 63, pp. 680–684, 2022.
- [14] S. Gopakumar and M. Gumma, "Design & optimization for vehicle dynamic events of electric 2-wheeler using genetic algorithm approach," SAE Technical Paper, 2024, doi: 10.4271/2024-26-0260.
- [15] World Health Organization, *Global Status Report on Road Safety 2023*. Geneva, Switzerland: World Health Organization, 2023.
- [16] M. A. Khan and S. Gupta, "IoT-based accident detection and emergency notification system," *IEEE Access*, 2019.
- [17] R. S. Chauhan and A. Verma, "Smart helmet using GSM and GPS technology for accident detection," *International Journal of Computer Applications*, 2017.
- [18] K. N. Prasad, V. R. Kumar, and S. Teja, "Accident detection and alert system using IoT and smart helmet," *International Journal of Recent Technology and Engineering*, 2019.
- [19] S. T. Jadhav and R. R. Patil, "Real-time accident detection and reporting system using IoT," *International Journal of Computer Science and Mobile Computing*, 2019.
- [20] N. K. Verma and P. Singh, "Embedded system based smart helmet for safe driving," *International Journal of Engineering and Advanced Technology*, 2019.