Design a Smart Helmet for Accident Detection and Location Tracking

Amol N. Godase[1], Kishor T. Narale[2], Ayan I. Devale[3], Pravin V. Kamble[4]
[1]*Department of Electrical Engineering, SKN Sinhgad College of Engineering,* Korti, Pandharpur, Maharashtra-413304
[2]*Department of Electrical Engineering, SKN Sinhgad College of Engineering,* Korti, Pandharpur, Maharashtra-413304
[3]*Department of Electrical Engineering, SKN Sinhgad College of Engineering,* Korti, Pandharpur, Maharashtra-413304
[4]*Department of Electrical Engineering, SKN Sinhgad College of Engineering,* Korti, Pandharpur, Maharashtra-413304
Correspondence:amolgodase999@gmail.com*

Abstract— **This study examines cutting-edge motorcycle safety systems that use crash detection and alert systems to lower accident mortality. These systems track motion dynamics and key angles to detect collisions using IMU sensors and tilt detection. Emergency alarms with accurate position data can be transmitted in real time thanks to integrated GPS and GSM devices. By preventing dangerous driving conditions, further features like alcohol detection and helmet usage enforcement improve rider safety. More precision and quicker reaction times are possible with future advancements like machine learning and real-time analytics. By increasing accident detection and emergency response effectiveness, these affordable solutions offer substantial advantages, especially in areas with extensive motorcycle usage the system consists of an ESP32 microprocessor and a multi-modal sensor package that includes MQ-3 alcohol, force-impact sensors, and an inertial measurement unit (IMU). Sensors to perform preventative safety checking. A time-windowed sensor-fusion algorithm was used to differentiate between legitimate collisions and typical riding dynamics in order to get beyond the single threshold constraint of unreliable systems. In order to minimize erroneous activations, this reasoning uses simultaneous cues of high-G inertial rotations and physical impacting features throughout a 500 ms time window. The system's architecture is entirely self-sufficient and uses an integrated GPS-GSM module to transmit the location via SMS without requiring a smartphone connection.**

Keywords — Smart helmet, accident detection, Internet of Things (IoT), GPS tracking, GSM module, ESP32, inertial measurement unit (IMU), real-time monitoring, rider safety, embedded systems, wireless communication.

I. INTRODUCTION

Riders' smart helmets have significantly improved thanks to the arrival of Internet of Things (IoT) technology into the personal safety equipment space. Because there is no physical protection for the staff, motorbike accidents continue to be a serious problem that worries people all over the world According to recent research, embedded sensor platforms are developing at a remarkably fast pace. They can detect hazardous situations, monitor rider behaviour, and enable a timely emergency reaction. The inertial measuring unit (IMU) and communication components might be incorporated into the motorcycle helmet to provide continuous safety verification, according to preliminary activities. This served as the basis for real-time crash warning systems According to preliminary research, it is feasible to attach IMU sensors and communication modules to motorcycle helmets so they can identify collisions and provide real-time emergency alerts.

In order to distinguish between typical riding behaviour and instances of accident scale, more study was conducted on how to improve detection reliability through signal-processing pipeline optimization and multi-axis motion analysis. The development of functional smart helmets was further aided by embedded systems based on energy-saving solutions, such as vibration filters, fall detection, and sudden-impact sensors.

The need for the continuous sensing and alert systems incorporated into protective gear was supported by a number of studies that looked at the behavioral analysis of riders and environmental factors. In order to improve the accuracy of crash categorization under different riding situations, low-cost IMU-based accident detection systems looked into threshold selection, calibration techniques, and High-G impact characterization. GPS-enabled, cloud-based helmet systems that may automatically send emergency signals when serious crashes were detected were suggested by complementary study.

In order to offer high-quality anomaly detection at a reasonable computing cost, machine-learned methods for lightweight anomaly detection have recently been included into embedded systems. To put it another way, helmet-based sensing was emphasised as a crucial step in reducing the emergency reaction time and responsiveness to accident information transmitted within a minute to a carer or medical service. Helmet-mounted electronics that use little energy are now feasible thanks to concurrent efforts in low-power wireless communication and micro module development

II. RELATED WORKS

A. Selecting a Template (Heading 2) IMU Sensor- Based Crash Detection

An Internet of Things (IoT)-enabled motorbike accident detection system that notifies specified contacts of emergencies is proposed in this study

[1]. When a crucial tilt degree is exceeded, the system uses a tilt sensor to track the bike's inclination and sends out GPRS and SMS alerts. It gets power straight from the motorcycle's battery because of its efficient design. An Arduino Nano for data processing, a SIM800L GSM module for wireless connection, and an MPU-6050 accelerometer for tilt measuring are essential parts. A safe tilt threshold of 40 degrees was determined after thorough testing. Future developments might include ultrasonic sensors to improve detection accuracy and GPS for accurate location monitoring The MPU-6050 Inertial Measurement Unit (IMU) is used in

this study [2] to providean accident detection system designed especially for bikes. The system takes into account the special dynamics of two- wheeled vehicles by monitoring motion metrics like roll, pitch, and yaw.

Gyroscopic drift and accelerometer inaccuracies are reduced by the MPU-6050's integrated Digital Motion Processor (DMP). Even in high-vibration conditions, the system strikes a balance between responsiveness and stability by combining data using complementing and Kalman filters. By integrating automatic alerts, this affordable system seeks to shorten emergency response times.

A smart helmet system that uses GSM for wireless communication In order to address the issue of motorcycle safety, this article develops a helmet that can communicate with GSM technology. Using sensors like vibration and sound sensors is a critical step in the development of such a system. An Arduino microcontroller receives the sensor and uses real-time data processing to identify injuries caused by an accident. All of this is beneficial for GSM technology when it comes to keeping an eye on a young smart helmet system. As previously noted, a very precise location from the GPS coupled with information to contact emergency personnel would be given following a fall and the falling detection procedure.

B. Message AlertSystem-Equipped Smart Helmet

This paper integrates into a smart helmet system to help prevent accidents and assist riders in emergency rescue. In order to stop the user from starting the scooter in unfavourable circumstances, it uses sensors to monitor helmet use and alcohol consumption. It has an accident detection system that, in the case of an accident, triggers a GSM-based alert and sends an SMS to pre-designated contacts with the GPS location. RF technology is used to communicate between the vehicle modules and the helmet interface, and a microcontroller is in charge of control functions. This is a way to lessen the number of accidents.

A Smart Helmet for Accident Detection and Reporting System Using GSM and GPS Technology In order to improve motorcycle safety by identifying collisions and quickly alerting emergency contacts, this study suggests a smart helmet that is integrated with GSM and GPS technologies. The helmet, which has vibration sensors, detects collisions and uses GPS data to convey the accident's location. In order to combat drunk driving and guarantee safety compliance, it has features like helmet usage enforcement. By addressing both accident prevention and quick reaction, this cutting-edge technology seeks to lower fatalities while showcasing its ability to save lives in dire circumstance.

III. PROBLEM STATEMENT

Due to ineffective preventative measures and delayed emergency response, motorbike accidents present a serious safety risk and frequently result in fatalities or serious injuries. The distinct dynamics of motorcycles in contrast to other vehicles are not adequately addressed by conventional safety measures. Smart safety technologies and sophisticated crash detection systems have been developed as a result.

Accurately identifying crashes in high-vibration settings, keeping an eye on rider behaviour like helmet use, and guaranteeing real-time warning delivery with precise position data are important concerns. Cost- effectiveness, adaptability to various road conditions, and efficient power management continue to be major challenges. In order to close these gaps, sensors, IoT- enabled communication modules, and data processing methods must be integrated in order to increase detection accuracy, speed up response times, and eventually lower the number of fatal accidents. The purpose of this survey is to examine recent developments in smart crash detection and alert systems, with a focus on creative ways to reduce the likelihood of motorcycle accidents and enhance rider safety.

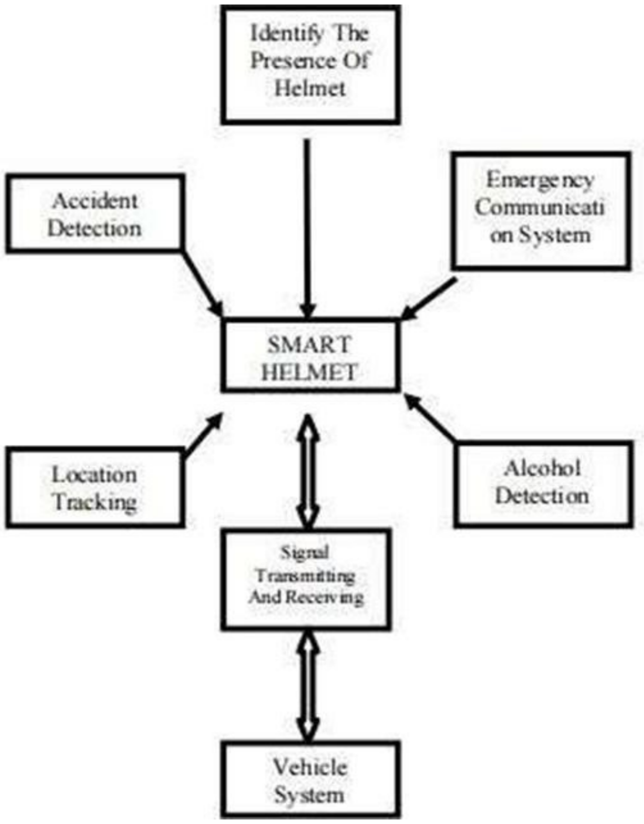

Fig. 1. Proposed System Block Diagram

IV. LIMITATIONS

Smart Helmet Limitations for Accident Recognition a Communication in Remote Locations For the transmission of emergency warnings, the system mainly depends on GSM (2G) networks through the SIM800L module. The technology might not be able to transmit GPS coordinates or SMS alerts in real time in isolated or mountainous areas with spotty cellular service, which could cause a delay in emergency response

A. Battery Life and Power Management

The helmet unit itself needs a small, light power source (such a Li-Po battery) for portability even though the system is made to interface with the motorcycle's power supply. If sophisticated sleep- mode algorithms are not used, the high-power consumption from the ESP32's Wi-Fi/Bluetooth features and the SIM800L's transmission bursts may cause the battery to run out quickly.

B. Higher Cost:

Due to integrated sensors and communication technology, smart helmets are more expensive than conventional helmets. Advanced models featuring HUD displays, AI integration, or cameras further increase costs.

C. Connectivity & Network Restrictions:

In distant or low-signal locations, emergency notifications may not be dependable due to their reliance on mobile networks, Wi-Fi, or Bluetooth. In areas with poor satellite coverage or tunnels, GPS tracking might not work properly.

D. Weight and Comfort Issues:

These helmets are larger due to the addition of sensors, batteries, and displays, which may be uncomfortable during lengthy rides.

E. Durability and Weather Resistance Issues:

Electronic components may be impacted by exposure to severe environments including rain, dust, or extremely high or low temperatures. Not every smart helmet is made to be dustproof or waterproof.

F. Privacy & Security Risks:

Concerns about the security of personal data may arise from GPS tracking and mobile app connectivity. If the system is compromised, location data may be accessed without authorization.

G. Limited Availability & Compatibility:

Certain models might not be widely available or work with every smartphone or gadget.

H. Maintenance and Repair Challenges:

Repairs can be difficult and expensive if electronic components malfunction. Smart helmets, in contrast to conventional helmets, could need regular troubleshooting and software updates.

V. KEY SYSTEM MODULE

A. MQ3 Alcohol Sensor:

The MQ3 alcohol sensor uses a semiconductor gas sensor to identify the presence of alcohol vapor in the surrounding air. When the rider breathes out, the sensor detects the level of alcohol in their breath. If the alcohol concentration surpasses a predetermined limit, usually established at 500 (though adjustable), the sensor initiates a response to halt the signal's transmission to the receiver. The activation level for the MQ3 sensor can be adjusted according to particular needs or regulatory guidelines. Setting the threshold at 500 offers flexibility without compromising the accurate detection of alcohol intoxication. However, this limit can be modified as required to match legal requirements or safety regulations. The MQ3 alcohol sensor is smoothly incorporated into the smart helmet system, usually placed near the rider's mouth to ensure precise detection. It communicates with the transmitter to relay information on alcohol levels, enabling the system to take the necessary steps to prevent the vehicle from starting.

B. GPS Module:

The GPS (Global Positioning System) module is a crucial component of the smart helmet system, offering real-time location tracking and navigation features for the rider. The GPS module relies on a satellite network to precisely identify the rider's current location, including both latitude and longitude. This information is crucial for navigation, monitoring, and emergency situations. Using GPS coordinates, the smart helmet system can offer navigation support to the rider, such as step-by-step directions and optimized routing.

C. GSM Module

GSM modules provide dependable communication features with wide reach across cellular networks. They guarantee connectivity in remote or areas with weak signal coverage, ensuring dependable communication for the smart helmet system. The GSM module enables the smart helmet system to communicate with external devices or services through standard cellular network protocols. It enables the transmission and reception of data, such as text messages, phone calls, and internet access. One of the main roles of the GSM module is to make emergency calls or send messages when accidents or urgent situations occur. It allows the smart helmet system to notify predetermined emergency contacts with important details, such as the rider's location, obtained through the GPS module.

D. Vibration Sensor:

The vibration sensor is designed to identify abrupt impacts or vibrations that go beyond a preset limit, usually configured to 700 in the software. When these vibrations happen, suggesting a possible accident or emergency, the sensor starts a process to make an emergency call. This call contains essential information, such as the rider's current latitude and longitude, which is gathered from the GPS module built into the smart helmet system. By quickly notifying emergency contacts with the rider's location information, this helps ensure a prompt response in the event of an accident or emergency. This quick reaction can be essential in offering prompt assistance to the rider, possibly lessening the seriousness of injuries or avoiding additional damage.

VI. RESULT

By incorporating standard safety features such as helmet identification, alcohol detection, and object detection, a smart helmet system can help save the life of a two-wheeler rider during an accident. By sending an SMS with the biker's location to the police station, nearby hospital, and the biker's family, the technology also helps manage the aftermath of an accident more effectively. This ensures that, in the case of an accident, victims will get the right medical care at the right time.

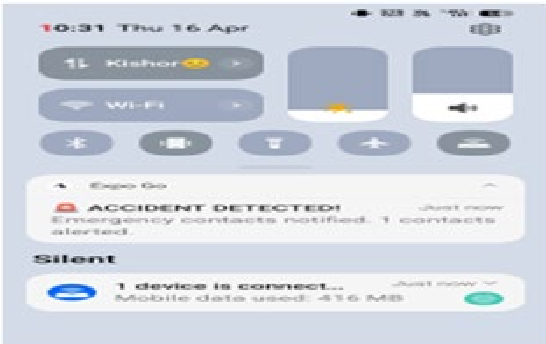

Fig. 2. Real-Time Emergency Notification.

The developed smart helmet system demonstrates effective real-time accident detection and emergency response through an integrated IoT-based monitoring and alert mechanism. The system continuously records accident events and displays them in a structured accident history interface, where details such as date, time, GPS coordinates (e.g., 17.218424, 74.970851), impact value (85.5), and status (Active/Resolved) are clearly presented. The impact value, derived from IMU and vibration sensor data, helps distinguish between normal riding conditions and actual crash scenarios. Upon detecting a high-impact event, the system instantly triggers an alert mechanism that sends notifications to predefined emergency contacts and displays a real-time mobile notification stating "Accident Detected," confirming successful alert transmission. The notification includes immediate status updates and confirms that emergency contacts have been informed without delay. Additionally, the integration of GPS enables accurate location tracking, which can be viewed on a map for quick response. The system also allows manual resolution of incidents, improving monitoring and management. Overall, the results confirm that the proposed system operates with low latency, high accuracy, and reliable communication, significantly reducing emergency response time and enhancing rider safety.

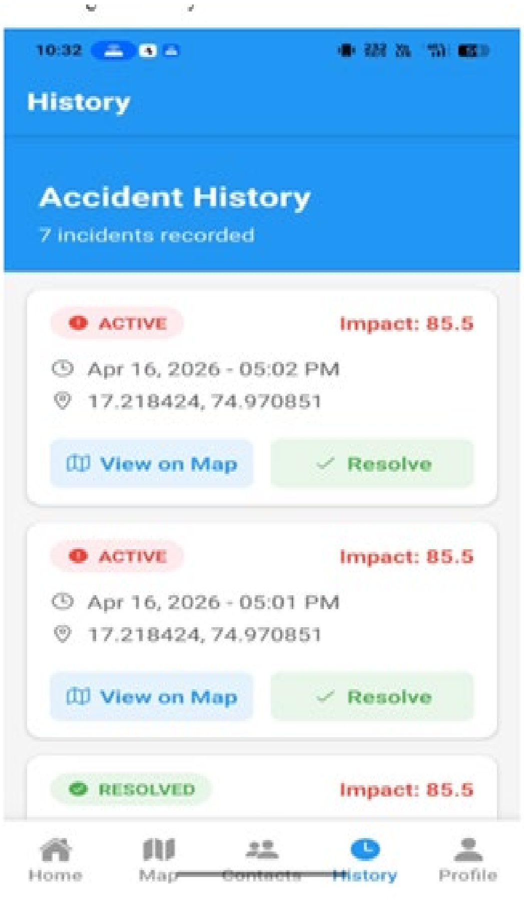

Fig. 3. Accident Detection and History Monitoring Interface.

This figure presents a mobile application interface for accident detection and monitoring. It displays a structured history of recorded incidents, including timestamps, GPS coordinates, and impact severity values. Each entry indicates the current status (Active/Resolved) and provides options to view the accident location on a map or mark the incident as resolved. This interface supports real-time tracking, efficient incident management, and quick response in smart safety systems.

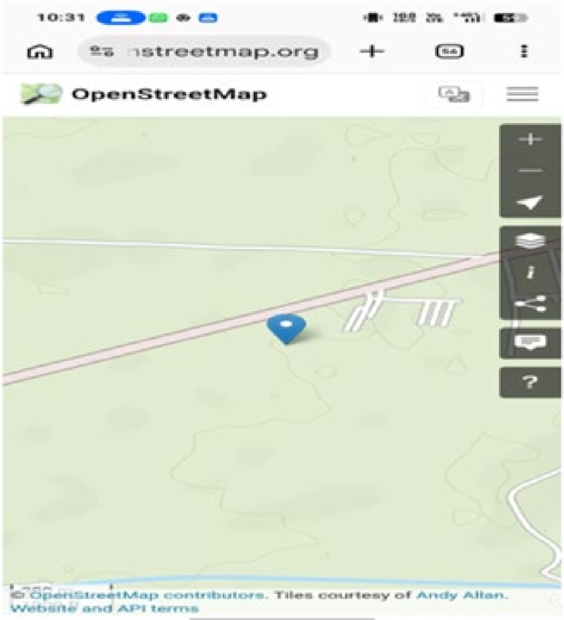

Fig. 4. Accident Location Visualization Using OpenStreetMap

This figure shows the integration of the OpenStreetMap platform within the proposed accident detection system for real-time location tracking. The map interface displays a marker indicating the exact position of the detected accident based on GPS coordinates obtained from the device. Users can interact with the map using zoom and navigation controls to better understand the surrounding area. This feature plays a crucial role in enhancing emergency response by providing accurate and accessible location details, allowing authorities or nearby contacts to quickly reach the accident site. The use of an open-source mapping service ensures cost-effectiveness and flexibility for deployment in smart transportation and safety applications.

VII. CONCLUSION

The development and use of the IoT-based Smart Helmet Monitoring System raise several important ethical issues that must be acknowledged and addressed to ensure its proper and responsible application. The primary ethical objective of the project is to enhance human safety. By integrating real-time monitoring and intelligent accident detection systems, the project seeks to reduce the risk of injury or death for riders. This aligns with the fundamental ethical principle of protecting life and improving well-being through technological progress. The system uses various sensors, such as gas, vibration, MEMS, and piezoelectric, to detect potentially dangerous situations like alcohol intoxication, falls, or collisions. These features ensure that riders are physically able to operate their vehicles and receive immediate assistance in case of an emergency. From an ethical perspective, this progressive approach encourages accountability and promotes the cultivation of safer driving behaviors. Another important ethical issue is ensuring the privacy and security of data. The system employs real- time GPS tracking and continuous sensor monitoring, resulting in the collection of sensitive personal data, such as the rider's location and activities. This information needs to be safely stored and sent using encryption and strict access controls to prevent unauthorized access or improper use. The system uses real-time GPS tracking and ongoing sensor monitoring, leading to the gathering of sensitive personal information like the rider's location and actions. This data must be stored and transmitted securely, using encryption and strict access controls, to avoid misuse or unauthorized access. Users should be made aware of the type of data being gathered and its intended use, guaranteeing transparency and proper consent. The system also promotes equity and accessibility through its compact, cost-effective, and easy-to-use design. This allows the safety benefits it provides to reach a larger portion of the population, including individuals in areas with limited resources. From a socio-technical standpoint, the system promotes a culture centered on safety and accountability. By allowing remote monitoring via mobile notifications and IoT connections, it enhances the support system for a rider, including family members, emergency services, or supervisors, particularly in high-risk jobs such as delivery or construction. Moreover, it is essential to maintain a balance between independence and oversight. Although using monitoring systems for safety reasons is ethically acceptable, users should maintain control over their personal information and have the ability to turn off monitoring features when they are not required, provided that safety rules are not affected. In summary, this project maintains ethical standards by focusing on safety, safeguarding data, fostering responsible actions, and supporting fair access. It shows how technology can be responsibly incorporated into everyday life to tackle real-life issues while respecting personal rights and freedoms.

REFERENCES

[1] S. R. Patel, M. Joshi, and N. Deshmukh, “AI-based smart helmet for real-time accident detection and prevention using IoT,” Int. J. Sci. Res. Appl., vol. 12, no. 1, pp. 45–52, 2025.

[2] N. R. Munagala, P. S. Reddy, S. S. Kumar, and M. Nithiya, “Smart helmet system for advanced rider safety using Internet of Things,” J. Eng. Sci. Res. Develop., vol. 10, no. 3, pp. 110–116, 2025.

[3] A. P. Kumar, B. K. Kumar, K. Balaji, M. L. Sai, and S. G. Babu, “IoT-based smart helmet for road accident detection,” Int. J. Res. Publ. Rev., vol. 5, no. 4, pp. 8680–8684, 2024.

[4] A. Khan, D. Patel, and K. Sharma, “Design of smart helmet for accident avoidance and alcohol detection,” Int. J. Sci. Res. Eng. Develop., vol. 7, no. 6, pp. 43–46, 2024.

[5] R. Gupta and S. Verma, “Development of smart helmet using Internet of Things for two-wheeler safety,” J. Xi’an Shiyou Univ. (Nat. Sci.), vol. 20, no. 7, pp. 220–226, 2024.

[6] P. Sharma, L. Singh, and K. Bhosale, “Sensor- based helmet for accident detection and location tracking,” in Proc. IEEE Int. Conf. Commun. Electron. Syst. (ICCES), 2023, pp. 1034–1039.

[7] D. Ramesh and S. Kumar, “Sensor fusion approach for intelligent accident detection in smart helmets,” IEEE Sensors J., vol. 23, no. 9, pp. 13247–13255,
2023.

[8] A. Gupta and R. Tiwari, “Machine learning-based accident prediction system for smart helmets,” IEEE Access, vol. 11, pp. 116320–116329, 2023.

[9] H. C. Impana, M. Hamsaveni, and H. T. Chethana, “A review on smart helmet for accident detection using IoT,” EAI Endorsed Trans. Internet Things, vol. 6, no. 21, pp. 1–8, 2022.

[10] K. Shetty, P. Fernandes, and A. Naik, “Helmet for accident prevention and real-time alert system using GSM and GPS,” Int. Res. J. Eng. Technol. (IRJET), vol. 9, no. 2, pp. 1420–1425, 2022.

[11] S. U. Rehman, S. A. Khan, A. Arif, and U. S. Khan, “IoT-based accident detection and emergency alert system for motorbikes,” 2021.

[12] A. Cismas, I. Matei, V. Ciobanu, and G. Casu, “Crash detection using IMU sensor,” in Proc. 21st Int. Conf. Control Syst. Comput. Sci. (CSCS), 2017.

[13] R. Subramaniyan, S. Kumuran, and K. J., “Smart helmet system with wireless communication through
GSM,” in Proc. IEEE Int. Conf. Artif. Intell. Internet Things (AIIoT), 2024, pp. 1–6.

[14] A. J. Amulya and S. Anusha, “Smart helmet with message alert system,” Dept. Electron. Commun. Eng., Vidyavardhaka College of Eng., Mysuru, India, 2020.

[15] M. N. Manjesh and S. Raj, “Smart helmet using GSM and GPS technology for accident detection and reporting system,” Int. J. Eng. Res. Technol. (IJERT), vol. 3, no. 4, pp. 1–6, 2014.

[16] S. U. Ahmed, R. Uddin, and M. Affan, “Intelligent gadget for accident prevention: Smart helmet,” in Proc. Int. Conf. Comput. Inf. Technol. (ICCIT), 2020, pp. 31–34.

[17] J. R. Biswas, S. Kachroo, P. Chopra, and S. Sharma, “Development of an app-enabled smart helmet for real-time detection and reporting of accidents,” in Proc. MSIT, GGSIPU, India, 2020.

[18] S. J. Swathi, S. Raj, and D. Devaraj, “Microcontroller and sensor-based smart biking system for driver’s safety,” Kalasalingam Acad. Res. Educ., India, 2020.

[19] N. Nataraja et al., “Smart helmet,” in Proc. IEEE Int. Conf. Recent Trends Electron. Inf. Commun. Technol. (RTEICT), Bengaluru, India, 2018.

[20] S. Chandran, S. Chandrasekar, and E. E. N, “Konnect: An Internet of Things (IoT)-based smart helmet for accident detection and notification,” in Proc. Int. Conf. IoT Smart Appl., 2016