Automobile Accident and Theft Prevention System †

Muhammad Abdur Rehman, Amina Asif †, Muhammad Shahbaz and Ahsan Ayaz
Department of Electrical and Computer Engineering, Air University, Islamabad 44230, Pakistan

Abstract:

In today's rapidly evolving technological world, the integration of advanced sensor technologies plays a vital role when it comes to enhancing vehicle safety and security. Our project, titled" Automobile Accident and Theft Prevention System," aims to address the concerns surrounding auto- mobile accidents and theft through integration of innovative sensors. The system comprises a diverse range of sensors, including drowsiness detection, alcohol and CO detection, Battery Theft detection sensors, and more integrated with a microcontroller. The primary focus of our system is to prevent accidents by detecting potential hazards such as driver drowsiness and intoxication. In case of detected alcohol or CO levels exceeding safe limits, proactive measures such as rolling down windows are implemented to ensure driver safety. Moreover, sensors integrated into various car components enable theft detection, notifying authorities of any unauthorized removal of essential parts like batteries or tires. Recent automotive sensor studies show that such integrations significantly improve real-time responsiveness and overall safety. Our system offers an innovative, comprehensive solution that is affordable, extremely effective, extensively evaluated in practical scenarios, and works with any car model regardless of brand or year. It includes a standalone power source that enables the system to recognize theft or collision incidents even when the vehicle is off or the internal battery has been taken out.

1. Introduction

When it comes to automotive safety and security, there is a constant threat of accidents and thefts. Our project, titled" Automobile Accident and Theft Prevention System," seeks to tackle these issues by leveraging advanced sensor technologies. By seamlessly integrating a diverse array of sensors with a microcontroller, our system aims to proactively detect and mitigate potential hazards, enhancing road safety. Additionally, our focus extends to further enhance theft detection capabilities, aiming to provide real-time alerts and precise location tracking in the event of a theft attempt. Through innovation and integration, we aim to offer a comprehensive solution for automobile safety and security. Recent studies on vehicular sensor integration [1], embedded systems [2], and economical GSM/GPS alert systems [3] indicate that these multifunctional strategies are gaining traction. Research indicates that integrating safety and theft detection systems can greatly decrease response times and enhance recovery results [4]. Our system presents a unique, all-inclusive platform that is budget-friendly, energy-saving, compatible with any vehicle type, and self-sustaining to operate even when the vehicle is off or the internal battery is taken out. This renders it perfect for ongoing monitoring, real-time event identification, and post-theft response in urban and rural environments

2. Literature Review

When it comes to improvement and development of current technologies for the safety and reliability of vehicles, it has long been a focus of research aimed toward enhancing accessibility and improving the overall safety and security of vehicles. Numerous research has explored diverse procedures to deal with the challenges faced via this demographic, with a specific emphasis on security and safety of vehicles [1], [2], [7]. Existing literature highlights the importance of modern technological solutions that offer actual-time feedback and monitoring to users, thereby enhancing the overall reliability and security of vehicles [3], [8]. Additionally, current advancements in sensor generation, microcontrollers, and connectivity alternatives have enabled the creation of extra state-of-the-art vehicle accident prevention and theft control systems [4], [9]. However, at the same time as sizable progress has been made in this field, there remains a need for similar research to refine current structures and discover new avenues for enhancing accident prevention and protection from theft and its effectiveness. As a result, many applicable systems are either limited to a single function, such as accident detection or GPS tracking, or are very expensive commercial systems unreachable by most middle-class consumers [5], [10]. Many of them operate purely on the internal power of the car; therefore, they stop functioning when the car is turned off and also if the battery is stolen. Furthermore, such systems are not very user-friendly and modular, which makes installation and maintenance very difficult for users lacking technical know-how [6], [11]. Obviously, these setbacks emphasize the necessity for an affordable, all-in-one solution that is energy efficient, self-sufficient in power supply, and fulfills the dual function of accident prevention and theft detection—in short, what our proposed system is intended to offer.

3. Problem Statement

Despite the remarkable advancements in automotive technology, the persisting prevalence of auto- mobile accidents and thefts remains a significant concern, posing threats to public safety and security. Current safety and security systems exhibit limitations in effectively addressing both accident prevention and theft detection, often leading to inadequate protection and delayed responses. Issues such as false alarms, vulnerabilities, and prolonged intervention times further underscore the shortcomings of existing systems. Consequently, there is a critical need for an integrated solution that leverages advanced sensor technologies, real-time monitoring capabilities, and intuitive user interfaces to provide comprehensive protection against accidents and thefts while minimizing false alarms and response delays. Furthermore, the escalating frequency of vehicle thefts, compounded by recent incidents highlighting the necessity for prompt intervention, emphasizes the urgency for the development of an innovative Automobile Accident and Theft Prevention System to enhance overall safety and security on roads.

4. Methodology

Firstly, we understood user needs by engaging with potential users such as drivers, fleet operators, and car owners to identify their safety and security concerns. We conducted surveys, interviews, and observations to understand their challenges and requirements regarding accident prevention and theft control systems. We reviewed existing literature, including academic research, industry reports, and technological advancements related to vehicle safety. We analyzed previous projects to gain insights into successful strategies, challenges, and emerging technologies.

Based on the findings from user needs and literature review, we designed a comprehensive system architecture with a block diagram outlining key components, sensors, and functionalities. We selected components based on reliability, accuracy, compatibility, and cost-effectiveness for tire pressure monitoring, drowsiness detection, alcohol detection, battery monitoring, and theft detection. We tested selected components for accuracy, responsiveness, and reliability, and evaluated compatibility between different modules.

We integrated components with a microcontroller and implemented software algorithms to manage sensor data, trigger alerts, and control system behavior. We tested the integrated system to verify functionality. A prototype was built with assembled hardware and programmed microcontrollers and was tested in simulated and real-world environments. We troubleshooted issues during testing and gathered feedback from drivers, experts, and regulators. Based on feedback, we refined the design and improved functionality. We finalized the system to meet safety standards, enhancing reliability, effectiveness, and ease of use.

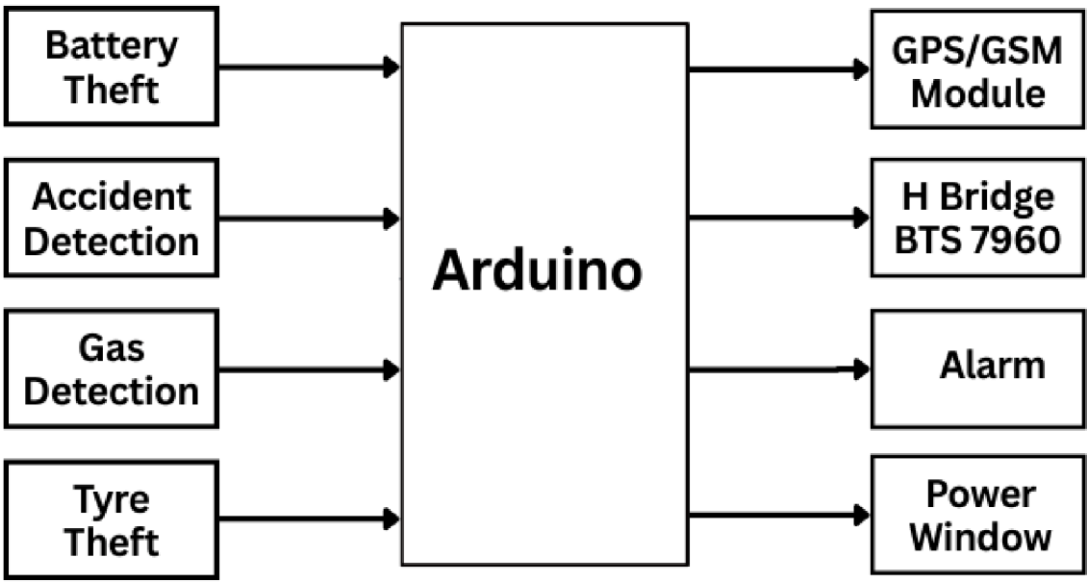


Figure 1: Block diagram of main system

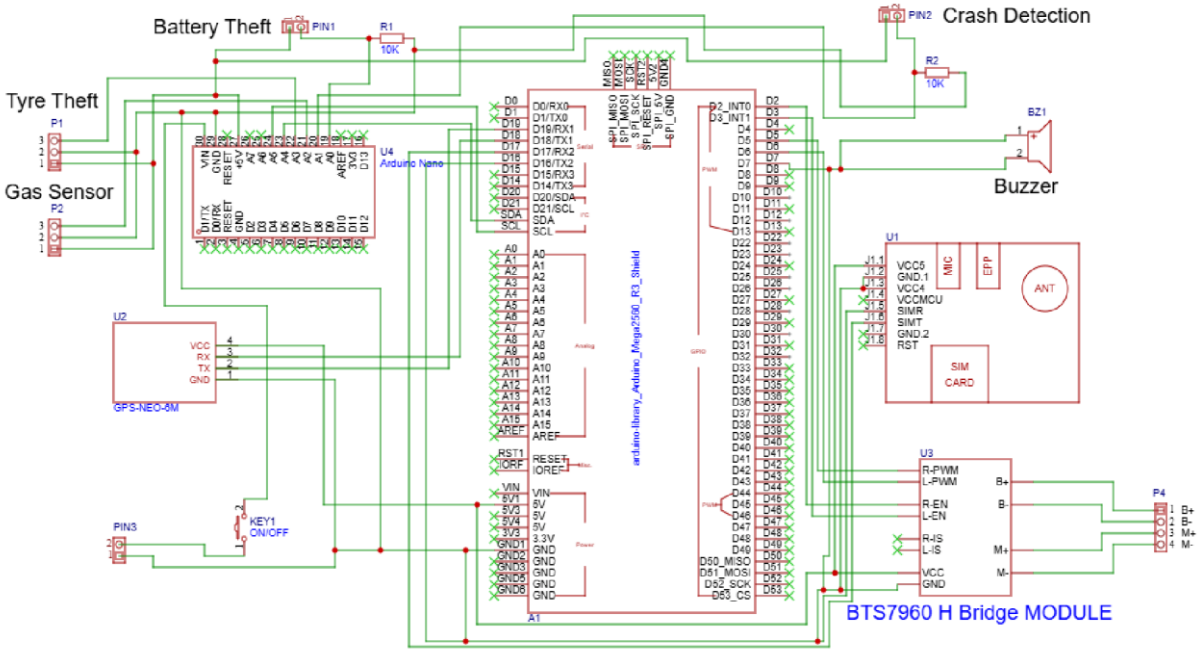


Figure 2: Software Simulation

5. Hardware Implementation

To develop a strong and dependable automobile safety and monitoring system, we used a two-microcontroller architecture with an Arduino Mega 2560 as the main controller and an Arduino Nano as a specialized sensor node. It provided better performance, hardware distribution, and easier maintenance. The Arduino Mega is powered through USB, usually from a laptop (tracking real time values). The Arduino Nano is powered by a dedicated USB power bank, keeping sensor power separate from high-load devices and preventing overcurrent problems. All GND (ground) connections are common for Mega, Nano, sensors, and modules to provide a common ground reference, necessary for correct analog readings and stable communications. The Mega oversees core system activities: communicating with the SIM900A GSM and Neo-6M GPS modules, powering the BTS7960 H-Bridge motor driver to drive the power window, reading I2C sensor data from the Nano, and triggering alerts through buzzer and SMS. The Mega is the I2C Master, sending periodic requests to the Nano (slave) for sensor data to monitor crash, smoke/gas, battery theft, and tire theft.

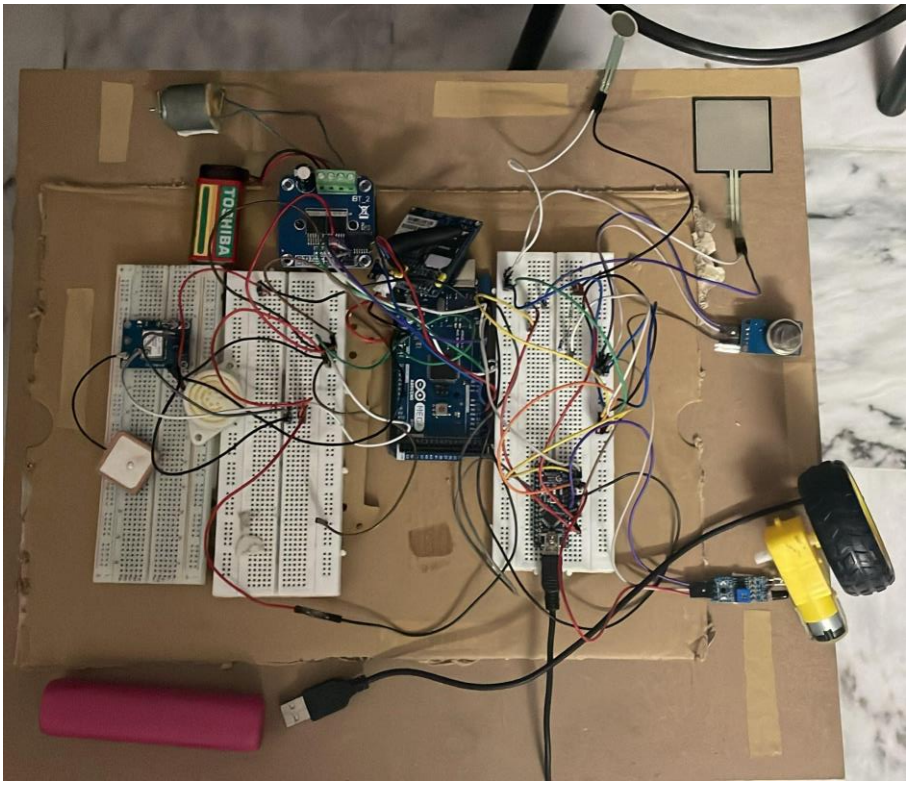


Figure 3: Automobile and theft prevention system

6. Design Calculations

6.1 Power Window Calculations

Parameter	Value
Voltage (V)	12 V (DC)
Current (A)	~5 A (avg)
Power (W)	12 × 5 = 60 W
Duration (s)	~1.5 s
Energy (J)	60 × 1.5 = 90 J
Energy (Wh)	0.025 Wh
Peak Current	Up to 15 A

Given:

- Voltage $V = 12\,\text{V}$
- Average Current $I = 5\,\text{A}$
- Time for 3-inch drop $t = 1.5\,\text{s}$

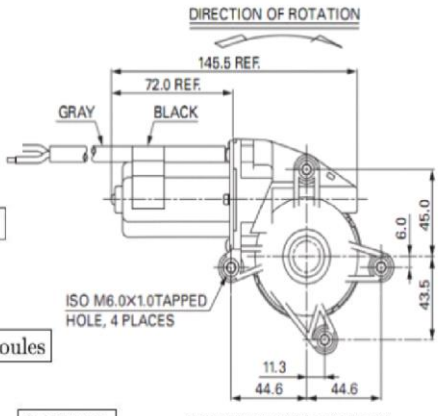
1. Power Consumption:

$$P = V \times I = 12 \times 5 = \boxed{60\,\text{W}}$$

2. Energy Used:

$$E = P \times t = 60 \times 1.5 = \boxed{90\,\text{Joules}}$$

Or in Watt-hours: $E = \dfrac{90}{3600} = \boxed{0.025\,\text{Wh}}$



Power Window Motor Design [3]

Figure 4: Power Window Calculations

6.2 Gas Sensor Calculations

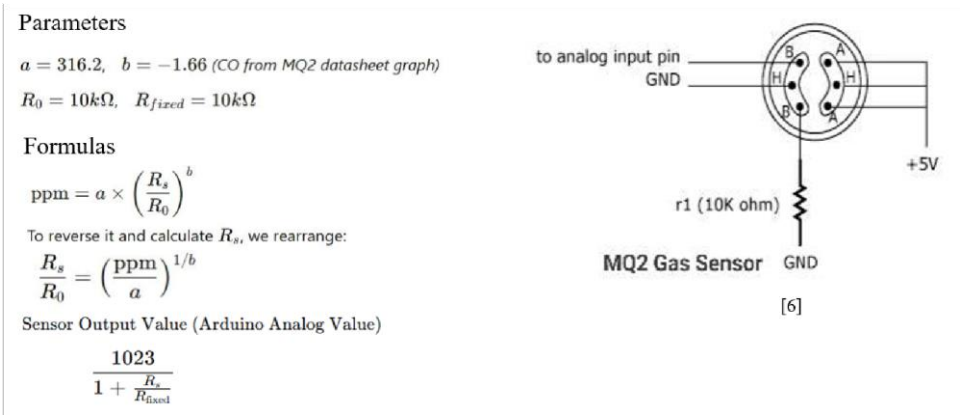


Figure 5: Gas Sensor Calculations

CO Concentration (ppm)	$\frac{R_s}{R_0}$	R_s (kΩ)	ADC Value
10	6.81	68.1	131
50	2.62	26.2	281
100	1.70	17.0	376
200	1.10	11.0	465
400	0.72	7.2	586
700	0.50	5.0	683
1000	0.39	3.9	725

Figure 6: Gas Sensor Results

7. Results and Discussions

Upon completion of the hardware integration, we tested the final module in different cars and under different conditions to see how well it worked in real life. When we removed the car battery, the system reacted exactly as planned. The alarm was triggered right away, and the user received a call, informing them that their battery had been stolen. For crash detection, the system sent a text message to the user saying a crash had happened, the alarm went off, and the live GPS location was also sent to the guardian. In the case of gas detection, the gas sensor picked up the presence of harmful gases and sent that data to the controller. This then triggered the alarm and powered the motor to roll down the window, helping with ventilation, which worked just as we intended. Tire theft was also tested using the IR sensor. When the tire was removed, the sensor detected it accurately, triggered the alarm, and sent a warning message to the user saying the tire had been stolen. Overall, all features worked well during testing. The system responded on time and gave the results we were expecting. It proved to be an efficient, low-cost (approximately USD 100), and reliable solution. Most importantly, since it doesn't depend on the car's battery, it worked even when the car was off, making it a practical all-in-one safety system that can be installed in any vehicle. However, there are some limitations. The system depends heavily on GSM signals, so alerts may be delayed or would not be received in areas with weak or no network coverage. It also doesn't have a user-friendly interface, so any changes need to be made in the code. The power bank requires occasional charging, and sensors might be affected in harsh environments if not properly protected. To improve reliability, especially for theft detection, RFID technology can be added in future versions. This would allow for more accurate results with enhanced security.

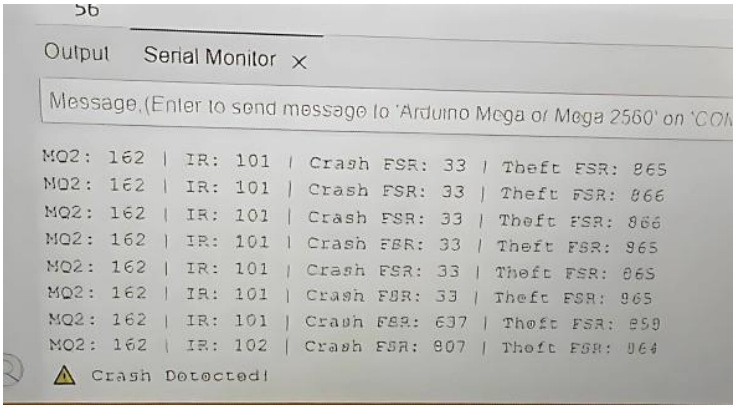


Figure 7: Serial Monitor Showing Crash Detected

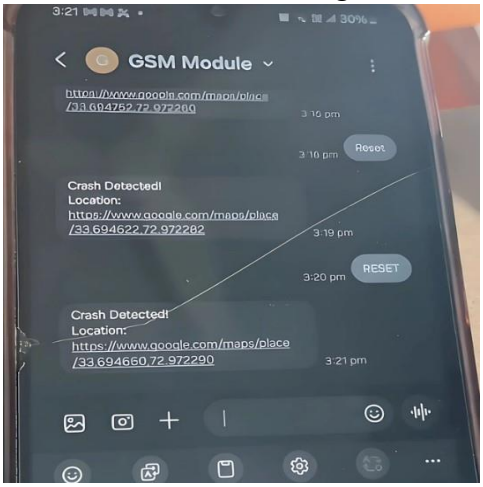


Figure 8: Message on Phone through GSM Module

Figure 9: Location of Accident Accessed

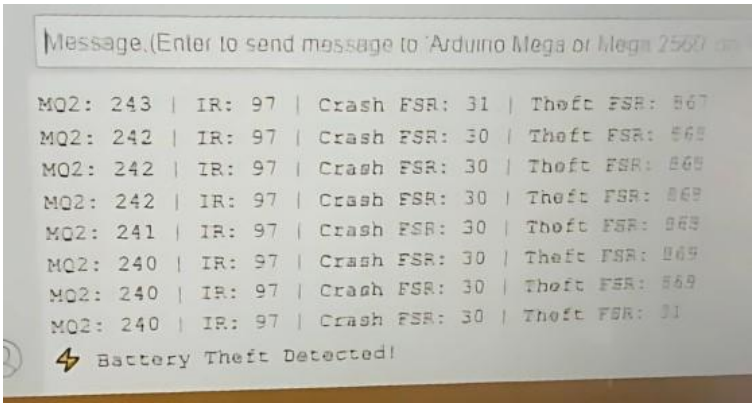


Figure 10: Serial Monitor Showing Battery Theft

Figure 11: GSM Call on Phone Indicating Battery Theft

8. Conclusions

Accident Prevention and Theft Deterrence System for Cars is the major leap on the road to making roads safer to drive and a safer vehicle for thieves to romanticize. From the challenges of driver fatigue, gas poisoning, accident detection, tyre and battery theft, the work illustrates how new engineering solutions can be applied to real life issues. Unification of these components into a single module and the implementation of the system in a real car, were of utmost importance to get the project results. Successful completion of these tasks leads to a powerful, stable, and revolutionary system which can perform life saving functions and improve vehicular security. This project not only contributes to automotive safety but also serves as a valuable learning experience, showcasing the application of engineering principles in tackling complex challenges. The resulting integrated system serves as a stepping stone for future development and commercialization, establishing a standard for the development of advanced safety and security solutions in the automotive sector.

10. Supplementary Material

A full demonstration of the project is available as a video. It includes live testing of crash detection, tire theft alerts, gas response, and battery theft simulation under real-world conditions.

Project Demonstration in an actual vehicle:
https://drive.google.com/file/d/1DB5-fi9c0I5XQnUO38gmkg8grY_YDXhG/view?usp=sharing

General Project Demonstration:
https://drive.google.com/file/d/1pbzP0wkOE5vlGbHYBZemR8nGGoIHgdbn/view?usp=sharing

Author Contributions: Conceptualization, M.A.; methodology, A.A, M.A and M.S; software, M.A; validation, A.S, M.A and A.A; formal analysis, A.S; investigation, M.S; resources, A.A, M.A and M.N; data curation, M.S, A.A, M.A and A.S; writing original draft preparation, M.A.; writing review and editing, M.A and A.A; visualization, M.S,
A.A, M.A and M.S; supervision, A.A; project administration, A.A; funding acquisition, M.A, A.A and M.S. All authors have read and agreed to the published version of the manuscript.
Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available on request from the corresponding author, M.A. The data are not publicly available due to restrictions e.g. their containing information that could compromise the privacy of research participants.
Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the result

References

[1] R. Kumar, M. Bansal, and S. Singh, "Low-Cost Embedded Safety Systems for Smart Vehicles," *IEEE Sensors Journal*, vol. 20, no. 10, pp. 5500–5508, 2020. doi: 10.1109/JSEN.2020.2971234

[2] P. S. Rao and V. Kumar, "Implementation of a low-cost accident detection and messaging system using Arduino UNO," in *Proc. 4th Int. Conf. on Computing, Communication and Automation (ICCCA)*, Greater Noida, India, 2018, pp. 1–5.

[3] M. Hossain and M. Hassan, "Design of a cost-efficient GPS-GSM based tracking system for vehicles," in *Proc. Int. Conf. on Electrical, Computer and Communication Engineering (ECCE)*, Cox's Bazar, Bangladesh, 2019, pp. 1–5.

[4] A. Jain and P. Sharma, "A review on integrated vehicle theft detection and accident alert system," *Int. J. Sci. Res. Sci. Eng. Technol.*, vol. 6, no. 2, pp. 394–398, 2020.

[5] R. Kumar, M. Bansal, and S. Singh, "Low-Cost Embedded Safety Systems for Smart Vehicles," *IEEE Sensors Journal*, vol. 20, no. 10, pp. 5500–5508, 2020. doi: 10.1109/JSEN.2020.2971234.

[6] A. Jain and P. Sharma, "A review on integrated vehicle theft detection and accident alert system," *Int. J. Sci. Res. Sci. Eng. Technol.*, vol. 6, no. 2, pp. 394–398, 2020.

[7] M. S. Islam and M. A. Rahman, "Design and development of smart vehicle accident detection system," in *Proc. 3rd Int. Conf. on Electrical Engineering and Information & Communication Technology (ICEEICT)*, Dhaka, Bangladesh, 2016, pp. 1–6.

[8] P. V. R. Venkatesh and S. R. Biradar, "Smart vehicle accident detection and alert system," *Int. J. Eng. Trends Technol.*, vol. 38, no. 7, pp. 340–344, 2016.

[9] A. R. Al-Ali, M. A. Zualkernan, and F. Aloul, "A mobile GPRS-sensors array for air pollution monitoring," *IEEE Sensors Journal*, vol. 10, no. 10, pp. 1666–1671, 2010.

[10] J. Jose and S. George, "Design and implementation of vehicle theft detection and accident notification system," in *Proc. Int. Conf. on Information Science (ICIS)*, Kochi, India, 2017, pp. 107–111.

[11] R. Patel and H. Patel, "Vehicle tracking and accident alert system using GPS and GSM," *Int. J. Eng. Dev. Res.*, vol. 5, no. 4, pp. 430–435, 2017.