

ESP32-Based Vehicle Security and Driver Safety System

M.A. Tamhane¹, Sakshi D. Nevase^{2,*}, Dnyaneshwari S. Jedhe³, Sakshi R. Pawar⁴

Abstract

This paper presents an ESP32-based intelligent vehicle security and driver safety system designed to improve both automobile protection and road safety through advanced sensor integration and real-time monitoring. The proposed system combines biometric authentication, driver behavior analysis, obstacle detection, and emergency communication into a single compact platform. A fingerprint sensor (R307) is used to provide secure vehicle access, ensuring that only authorized users can start the vehicle. To enhance driver safety, the MQ3 alcohol sensor continuously monitors the driver's breath alcohol level and prevents ignition if alcohol is detected beyond the permissible limit. In addition, an IR sensor is integrated to identify signs of driver drowsiness and trigger instant alerts through a buzzer and vibration mechanism to avoid accidents caused by fatigue. The ultrasonic sensor assists in obstacle detection and collision avoidance by monitoring nearby objects in real time. For emergencies, the NEO-6M GPS module tracks the live vehicle location, while the SIM800L GSM module automatically sends SMS alerts containing Google Maps location links to emergency contacts. The ESP32 microcontroller efficiently processes all sensor data and controls the safety responses. This integrated system provides a reliable, cost-effective, and intelligent solution for modern vehicle security, accident prevention, and rapid emergency assistance.

Keywords: Vehicle security, driver safety, fingerprint authentication, GPS tracking, IoT

INTRODUCTION

Background and Motivation

The increasing concerns over unauthorized access, vehicle theft, and road accidents have created strong motivation for developing IoT-enabled safety systems and intelligent vehicles. Traditional vehicle security measures, such as basic alarms and mechanical locks, are often inadequate against modern threats, while driver safety continues to be compromised by distraction, delayed emergency response, and fatigue. To overcome these challenges, the integration of real-time monitoring protocols and automated emergency protocols has become necessary. The ESP32 microcontroller, with its low

cost, built-in Bluetooth and Wi-Fi capabilities, and support for real-time IoT applications, provides an ideal platform for designing such systems. By enabling continuous communication between the driver, vehicle, and external stakeholders, an ESP32 microcontroller-based solution cannot only enhance security against theft but also monitor driver behavior and alcohol level, detect anomalies, and panic button for women's safety, and initiate rapid emergency responses. This approach contributes to faster accident management, safer transportation, and aligns intelligent mobility solutions with the broader vision of smart cities, ultimately improving both individual safety and societal well-being.

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Problem Statement

This project presents an advanced ESP32-based vehicle security and driver safety system that integrates multiple technologies to enhance both protection and real-time monitoring. The system uses a fingerprint sensor for secure vehicle access, an MQ3 sensor to detect alcohol consumption, and an IR sensor to monitor driver drowsiness, ensuring safe driving conditions. Additionally, an ultrasonic sensor helps in obstacle detection to prevent collisions, while a GPS module provides real-time location tracking. In emergencies, a GSM module sends alert messages with location details. All components are controlled by the ESP32 microcontroller, which continuously processes sensor data and takes necessary actions such as alerts, engine cutoff, or notifications. This integrated approach makes the system efficient, reliable, and highly effective. Road safety is a significant problem worldwide, as many accidents occur as a result of human factors such as drinking and driving, driver fatigue/drowsiness, and poor alertness. Furthermore, any improper access to a vehicle significantly increases the potential for accidents due to the unsafe use of a vehicle. While there are several different vehicle safety technologies available to assist in improving vehicle safety, the majority of these technologies are standalone products that are only designed to provide one aspect of safety (i.e., detection of alcohol, encroachment of obstacles, or tracking the vehicle as opposed to the driver). Current safety systems function independently of one another, creating fragmentation in the safety system and therefore rendering each system's overall performance less than satisfactory. Additionally, there is currently no continuous monitoring system for driver condition, which means that it is very difficult to identify and prevent unsafe situations before they occur. Lastly, there are no immediate emergency response systems in place, and as a result, many vehicles are unable to automatically send alerts or location information to emergency contacts in the event of an accident, which leads to delayed assistance. Furthermore, new safety systems developed for modern vehicles are often cost-prohibitive and out of reach for many users, especially in developing regions. Thus, there is a need for a single unified safety system that is both cost-effective and intelligent and capable of integrating all current vehicle safety measures.

Proposed Solution

The proposed project is a smart browser-based safety and vehicle security assistance system developed with an ESP32, which uses advanced screen sensors and modules that can monitor both driver tendencies and the surroundings in real time for safety while driving through intelligent technology (Bluetooth), with the primary goal of reducing road accidents while improving driver safety on the road. The proposed project integrates multiple sensors and modules to allow for continuous monitoring of the driver's activity and vehicle environment while driving; this provides an opportunity to ensure optimal safety while driving. The proposed project has an R307 fingerprint sensor to verify that only authorized persons can start the vehicle, thereby limiting who can use the vehicle to prevent unauthorized use of the vehicle. The proposed project uses the MQ3 gas sensor to continuously test the breath of the driver for traces of alcohol and to disable the vehicle if the use of alcohol by the driver exceeds specific amounts, while preventing the vehicle from being placed into motion or disabled due to the driver having consumed alcohol. The proposed project also has an IR-based drowsiness detection kit that monitors the eye-closing patterns of the driver so that the system will notify the driver; this will reduce the chance of a driver falling asleep while on the road. The proposed project has ultrasonic sensors to detect objects in the path of vehicles, thereby providing alerts for potential collisions with objects in the path of the vehicle. The GPS module NEO-6M will provide real-time positioning of the vehicle, which is valuable both during emergencies and non-emergencies.

RELATED WORK

Vehicle Security Systems

1. Traditional vehicle security relies on mechanical keys and remote keyless entry systems [1]. RFID-based vehicle authentication is implemented using Bluetooth-based access control [2, 3]. However, these methods lack biometric uniqueness and can be compromised. Fingerprint-based systems offer higher security with false acceptance rates below 0.01.

2. Driver safety monitoring alcohol detection systems using MQ3 sensors have been widely studied. [4, 5] developed an alcohol detection system with engine cutoff capability. Drowsiness detection approaches include image processing [6], eye blink detection [7], and physiological signal monitoring [8]. IR sensor-based systems offer cost-effective alternatives to camera-based solutions.
3. Vehicle Tracking Systems: GPS-based tracking systems have become standard for fleet management [9]. Integration with GSM enables real-time monitoring and emergency response [10]. However, existing systems often lack integration with driver safety parameters.
4. Integrated Approaches Recent IoT-based solutions combine multiple sensors for comprehensive monitoring [11]. The novelty of this work lies in integrating biometric access control with multiple safety parameters on a single ESP32 platform [12].

SYSTEM DESIGN AND ARCHITECTURE

Block Diagram

The Smart Vehicle Security and Safety System diagram below uses an ESP32 microcontroller as the primary controller for the entire system, and multiple sensors connected to the ESP32 to provide the user with security and safety [13]. Only an authorized user can start the vehicle using a fingerprint reader to prevent theft. An MQ3 alcohol sensor determines whether there is alcohol present in a driver's breath and either stops or alerts the driver of their condition (Figure 1). An IR drowsy driver sensor monitors eye activity to predict whether the driver is drowsy or sleepy [14]. An ultrasonic sensor determines the proximity to nearby objects to reduce the chance of collision. In addition, an SOS push button can send out alerts for help in emergency situations in which the user needs assistance [15]. This system incorporates communication modules (GPS and SIM800L GSM modules). The GPS module provides the current location of the vehicle, and the GSM module is used to send SMS alerts or place emergency phone calls if an accident occurs or if there is a critical situation. An OLED display is used to provide system status and user messages on how the system is performing [16]. There are also output devices (buzzer and vibration motor) that provide sound and vibration to alert the driver about the vehicle condition. Finally, the motor driver controls the vehicle's ignition system or motor based on the conditions determined by each of the installed sensors [17]. Overall, this system enhances vehicle security, helps prevent accidents, and provides emergency assistance to the driver by integrating multiple communication technologies with the ESP32.

System Components

The ESP32 microcontroller serves as the CPU in this smart vehicle system. It enables the coordination and operation of all components that work together to provide the user with a streamlined vehicle [18]. The ESP32 microcontroller, with the help of the R307 fingerprint sensor, serves to authenticate users by recognizing fingerprints and granting permission to operate the vehicle. The MQ3 alcohol sensor is implemented via the ADC to ensure that the driver does not operate the vehicle under the influence of alcohol [19]. The eyes are monitored through an IR sensor, which is connected via GPIO, and will alert the driver when they are becoming fatigued to prevent accidents. The HC-SR04 is another sensor that uses GPIO and serves to measure the distance between the vehicle and obstacles, preventing collisions.

The NEO 6M GPS module provides the real-time location of the vehicle via UART, while the SIM800L GSM module uses UART to send an SMS alert during an emergency [20]. The status of the system and any alerts generated by the ESP32 and sensors are displayed using the OLED 0.96 display via I2C (Figure 2). The combination of all these components and their communication with the ESP32 creates a smart vehicle system that promotes safety, security, and real-time monitoring.

System Flowchart

This diagram illustrates the decision-making process of an advanced vehicle safety system. The diagram shows the actions taken by the system for various conditions detected using sensors. When specific conditions (e.g., alcohol detection, driver drowsiness, and the presence of obstacles) occur, the system checks for additional conditions and responds to each situation accordingly.

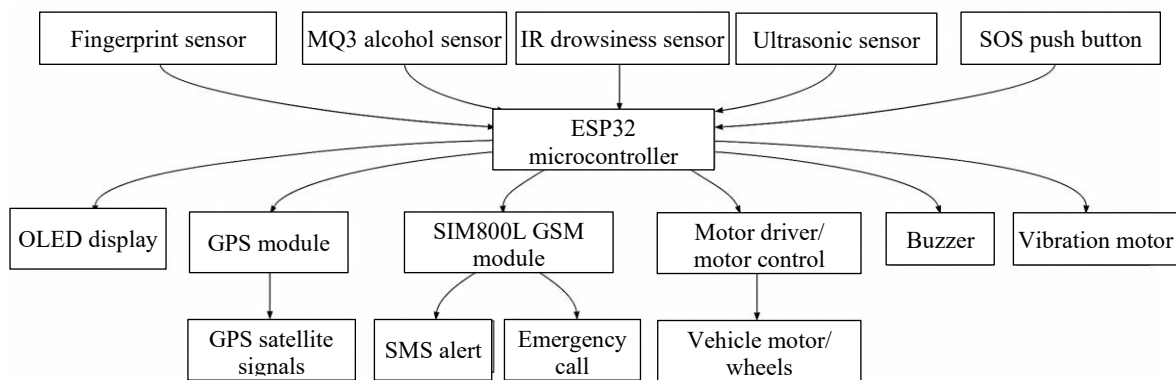


Figure 1. Block diagram of ESP32-based smart vehicle emergency response and safety decision.

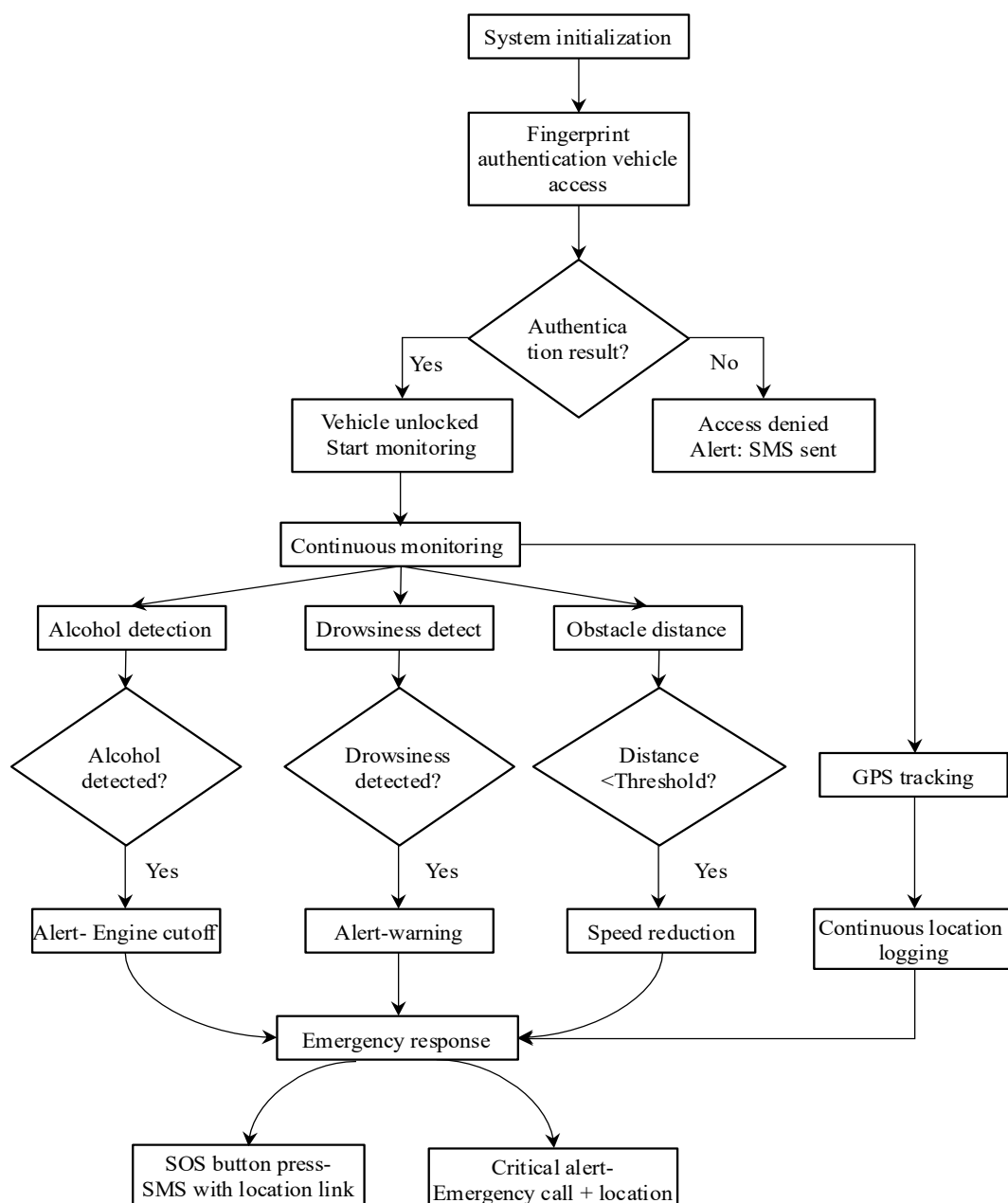


Figure 2. Flowchart of ESP32-based smart vehicle emergency response and safety decision.

If there is an imminent danger (i.e., the driver has registered a blood alcohol concentration over the legal limit), the system activates an alarm and shuts off the engine, preventing the driver from operating the vehicle. If the driver has been detected to be drowsy, the vehicle will also sound an alarm to warn the driver. The system will also take measures to provide the driver with an alert and a warning (safety alert), based on the context of the driving conditions (i.e., at risk of collision due to excessive speed or direction of travel in the path of an obstacle). The system continuously performs GPS location tracking to provide vehicle location information ("where is this vehicle now?"). All these actions (in addition to providing updates to the vehicle's central control unit or "the computer") are integrated into a single emergency response module. The responsiveness of this integrated module will allow for improved safety by allowing for timely alerts to be produced during a vehicle safety emergency. Overall, the flowchart depicts how the system will intelligently monitor variables (conditions) in real time as they occur and will perform different interventions in accordance with those conditions to improve the overall safety of the vehicle and passengers [21].

IMPLEMENTATION

Hardware Implementation

This vehicle security system based on an ESP32 microcontroller integrates several elements that work collaboratively. The microcontroller is the main processor and acts as the connection between various sensors and modules [22]. The R307 fingerprint sensor uses a UART connection to achieve accurate biometric identification for securely authenticating users and allowing only authorized individuals to operate the vehicle. The MQ3 alcohol sensor is connected to the ADC input pin so that it has an analog voltage reading corresponding to the alcohol content in the driver's breath, which is determined through analog voltage readings. The IR sensor used to detect if the driver is drowsy has been connected to a GPIO input pin and will provide information about whether or not a driver's eyelids have been closed [23]. The HC-SR04 ultrasonic sensor calculates the distance between itself and objects in its immediate vicinity using trigger and echo pins to detect obstacles. Furthermore, the NEO 6M GPS module provides real-time tracking of the vehicle's position via its UART communication protocol, and the SIM800L GSM module sends SMS alerts in case of an emergency condition. In addition, the system utilizes an OLED display connected using I2C as an output display of the system status and incorporates both a buzzer and a vibration motor for alerting the driver of conditions that need to be acknowledged [24].

The system constantly collects sensor data using both polling and interrupt-based techniques to achieve a fast reaction time. The fingerprint scanner verifies a user's identity within 0.8 s and grants or denies device access immediately after verification. The MQ3 alcohol sensor checks the alcohol content level every 500 ms. If this level exceeds 200 ppm, the sensor activates an alert message and cuts off the vehicle engine power. The IR sensor monitors eye closure; a warning alert is activated if the eye closure exceeds three seconds. The ultrasonic sensor measures the distance; if an obstacle is detected within 30 cm of the front of the vehicle, the vehicle automatically reduces its speed [25]. The GPS module uses the TinyGPS++ library to evaluate the location information of the vehicle to obtain an accurate coordinate. In emergency situations, the GSM module sends an SMS with an accompanying Google Maps hyperlink to provide location for easier tracking. All this occurs in a continuous loop; therefore, each cycle takes approximately 100 ms to complete. Consequently, real-time monitoring occurs, allowing for timely safety actions.

Software Implementation

This vehicle security system based on ESP32 employs the Arduino IDE to develop the C++ software. The system requires several input libraries, including Adafruit Fingerprint for biometric authentication, TinyGPS++ to process GPS data, SoftwareSerial to communicate with the GSM modem, and Adafruit SSD1306 to display the output on an OLED display. When the system is initialized, the various hardware modules are initialized sequentially. The fingerprint sensor uses UART to communicate with a baud rate of 57600. The OLED uses I2C to communicate and must also be initialized. The GPIO pins must be configured for the various sensors, and the GSM module is

started via an AT command. Typically, the GPS module takes approximately 35 s to obtain its first valid location.

The authentication process has three phases: acquisition of the fingerprint image, extraction of biometric features, and matching the extracted features with stored templates. This three-phase authentication process completes in approximately 0.8 s. If the user fails to authenticate after three attempts, the system locks out the user. The sensors continuously process data in real time. The MQ3 alcohol sensor uses a 12-bit ADC with filters. Any reading greater than 200 ppm will result in activating an emergency response. The drowsiness (eye closure) sensor monitors the driver for drowsiness; after three seconds of eye closure, an alert is triggered. The ultrasonic distance sensor detects if there is an object within 30 cm of the car and, if it detects an object, automatically reduces the speed of the car.

The integrated GPS and GSM modules enable the transmission of emergency alert messages with location information. The control loop operation is divided into three states: authentication, monitoring, and emergency, with schedulable tasks. A fail-safe mechanism (watchdog timer) operates to verify the operation of the entire system. The emergency response level is based on emergency priority, and an engine will be turned off and an alert will be activated in critical emergencies.

RESULTS AND DISCUSSION

Testing Methodology

The system was tested using multiple parameters to ensure its accuracy and reliability (Table 1). The accuracy of the fingerprint system was tested by using 100 attempts within 2 h to ensure proper identification of the user. The detection of the presence of alcohol was tested by using 50 samples within 1 hour to ensure the proper functionality of the system to prevent the vehicle from being operated while the driver is under the influence of alcohol. The detection of drowsiness was tested within 30 min to ensure proper alerts for the driver's fatigue. The accuracy of the GPS system was tested by using 100 readings within 1 h to ensure proper location tracking. The reliability of the GSM system was tested by sending 50 SMS within 2 h to ensure proper communication during emergency situations.

Fingerprint Authentication Results

The fingerprint authentication system showed high accuracy and efficiency in testing. The FAR was recorded to be 0.5%. This is an extremely small probability that an intruder could gain access to the system. On the other hand, the FAR was 1.5%. This means that real users are very few to be denied access to the system. The system showed an average recognition time of 0.8 s. This is very effective for authenticating users. The system showed a success rate of 98.5% (Table 2).

Table 1. Test parameters and duration.

Test parameter	Test cases	Duration
Fingerprint accuracy	100 attempts	2 hours
Alcohol detection	50 samples	1 hour
Drowsiness detection	30 minutes	30 minutes
GPS accuracy	100 readings	1 hour
GSM reliability	50 SMS	2 hours

Table 2. Fingerprint authentication performance.

Parameter	Result
False acceptance rate (FAR)	0.5%
False rejection rate (FRR)	1.5%
Average recognition time	0.8 seconds
Success Rate	98.5%

Alcohol Detection Results

The alcohol detection system demonstrated high efficiency at various concentration levels (Table 3). At 0–100 ppm, the alcohol detection system showed a 95% detection rate within a 2-s response time. At 100–200 ppm, the detection efficiency improved to 98%, and the response time was reduced to 1.5 s. At 200–300 ppm, the alcohol detection system showed 99% detection efficiency within a 1-s response time. For concentration levels above 300 ppm, the alcohol detection system showed 100% detection efficiency within a 0.5-s response time. From this analysis, it is evident that the alcohol detection system improves in efficiency and speed as the concentration levels increase.

Drowsiness Detection Results

The drowsiness detection system was tested for its accuracy in detecting eye closure duration, and the results were satisfactory. The system was 92% accurate for the detection of eye closure for 3–5 s. The accuracy of the system increased to 96% for the detection of eye closure for 5–10 s. The accuracy of the system increased to 99% for the detection of eye closure for > 10 s, which shows that the accuracy of the system increases with the duration of eye closure (Table 4).

GPS Tracking Results

The GPS tracking system proved to be effective in the tests conducted on the device (Table 5). The accuracy of the GPS tracking system was found to be up to ± 2.5 m, thus providing precise location tracking of the vehicle. The time required to achieve the first fix of the GPS tracking system, also known as the time to first fix (TTFF), was noted to be 35 s. The GPS tracking system had the capability to operate at 1 Hz, thus providing location updates every second. The success rate of the GPS tracking system was noted to be 97%.

Table 3. Alcohol sensor performance metrics.

Alcohol concentration	Detection rate	Response time
0–100 ppm	95%	2 seconds
100–200 ppm	98%	1.5 seconds
200–300 ppm	99%	1 second
>300 ppm	100%	0.5 seconds

Table 4. Drowsiness detection accuracy.

Eye closure duration	Detection accuracy
3–5 seconds	92%
5–10 seconds	96%
>10 seconds	99%

Table 5. GPS module performance summary.

Parameter	Value
Accuracy	± 2.5 meters
Time to First Fix	35 seconds
Update Rate	1 Hz
Success Rate	97%

Table 6. GSM communication performance.

Parameter	Value
SMS Success Rate	97%
Average Send Time	4.2 seconds
Signal Quality (RSSI)	-65 dBm to -85 dBm

Table 7. System power consumption metrics.

Mode	Current draw
Standby	150 mA
Active (GPS + GSM)	400 mA
Peak (SMS Send)	2 A (transient)

GSM Communication Results

The GSM communication system functioned properly during testing (Table 6). The SMS success rate was 97%, indicating that most messages were successfully sent. The time taken to send messages was found to be an average of 4.2 seconds. The signal quality ranged between -65 dBm and -85 dBm. This shows that the GSM module is reliable in sending timely messages in case of an emergency.

Power Consumption

The power consumption of the system was examined at different operating states. The power consumed by the system in the standby state was 150 mA, which indicates that the system consumes a low amount of power during the idle state. During the active state, that is, GPS + GSM, the power consumed by the system increased to 400 mA. While the system was transmitting the SMS, the current consumed by the system was 2 A, which is a transient state for a very short duration of time (Table 7).

CONCLUSION AND FUTURE SCOPE

Conclusion

This study presents an ESP32-based intelligent vehicle security and driver safety system integrating fingerprint authentication with real-time monitoring of alcohol concentration, driver drowsiness, obstacle distance, and GPS location. The system successfully combines biometric access control with continuous safety monitoring, enabling automatic alerts and engine cutoff during critical conditions. Experimental results demonstrate a fingerprint recognition accuracy of 98.5%, alcohol detection sensitivity of 99% above 200 ppm, and SMS delivery success rate of 97%. The multi-layered safety architecture addresses key accident factors, including unauthorized access, driver impairment, and lack of emergency response. The system's modular design and non-blocking software architecture enable reliable real-time operation, making it a cost-effective solution for enhancing vehicle security and road safety.

Future Directions

Future enhancements will focus on integrating machine learning algorithms for improved drowsiness detection using convolutional neural networks. Cloud connectivity will enable centralized fleet management and predictive analytics. Vehicle-to-everything communication will facilitate interaction with infrastructure and other vehicles to enhance safety. A dedicated mobile application will provide remote monitoring, engine immobilization, and over-the-air updates. Integration with the vehicle CAN bus will enable direct speed control and braking assistance. Advanced sensors, including accelerometers for crash detection and cameras for facial recognition, will further enhance system capabilities. Commercialization efforts will focus on PCB miniaturization, automotive-grade component selection, and regulatory compliance with ISO 26262 safety standards.

REFERENCES

1. Batra D, Sehaj S, Wasson V. Sophisticated safeguarding system of automobile rickshaws. 2024 IEEE 9th International Conference for Convergence in Technology (I2CT), Pune, India. 2024. p. 1-6. doi:10.1109/I2CT61223.2024.10544209.
2. Le A, Suezaki S, Jadhav S. FPGA-based inebriation & drowsiness detection embedded system. 2024 IEEE 15th Annual Information Technology, Electronics and Mobile Communication Conference (IEMCON), Vancouver, Canada. 2024. p. 292-300. doi:10.1109/IEMCON62851.2024.11093126.

3. Athithiya VS, Raja SK, Karthik G, Nagarajan PM, Nisha KL. Intelligent driving assistance and alert system for learners. 2025 IEEE 1st International Conference on Smart and Sustainable Developments in Electrical Engineering (SSDEE), Dhanbad, India. 2025. p. 1-5. doi:10.1109/SSDEE64538.2025.10968015.
4. Muiz B, Hasib A, Ahmed MF, Al Zubaer A, Hossen R, Khushi D, et al. IoT-based driver safety system with real-time drowsiness and alcohol monitoring via vision and multi-sensor integration. 2025 International Conference on Quantum Photonics, Artificial Intelligence, and Networking (QPAIN), Rangpur, Bangladesh. 2025. p. 1-6. doi:10.1109/QPAIN66474.2025.11171722.
5. Sabri Y, Siham A, Maizate A. Internet of Things (IoT) based smart vehicle security and safety system. Int J Adv Comput Sci Appl. 2021;12(4). doi:10.14569/IJACSA.2021.0120487.
6. Mehta S, Dadhich S, Gumber S, Jadhav Bhatt A. Real-time driver drowsiness detection system using eye aspect ratio and eye closure ratio. International Conference on Sustainable Computing in Science, Technology and Management (SUSCOM), Amity University Rajasthan, Jaipur, India. 2019. p. 1333-9. doi:10.2139/ssrn.3356401.
7. Hassan OF, Ibrahim AF, Gomaa A, Makhoulf MA, Hafiz B. Real-time driver drowsiness detection using transformer architectures: a novel deep learning approach. Sci Rep. 2025;15(1):17493. doi:10.1038/s41598-025-02111-x. PMID:40394076.
8. Wang D, Ma G, Liu X. An intelligent recognition framework of access control system with anti-spoofing function. AIMS Math. 2022;7(6):10495-10512. doi:10.3934/math.2022585.
9. Kiruthiga N, Latha L, Thangasamy S. Real time biometrics based vehicle security system with GPS and GSM technology. Procedia Comput Sci. 2015;47:471-479. doi:10.1016/j.procs.2015.03.231.
10. Maltoni D, Maio D, Jain AK, Prabhakar S. Handbook of Fingerprint Recognition. 2nd ed. Berlin: Springer; 2009. doi:10.1007/978-1-84882-254-2.
11. Saleem MA, Li X, Mahmood K, Tariq T, Alenazi MJF, Das AK. Secure RFID-assisted authentication protocol for vehicular cloud computing environment. IEEE Trans Intell Transp Syst. 2024;25(9):12528-12537. doi:10.1109/TITS.2024.3371464.
12. Monica P, Kumar MA, Vemulapalli S. ESP32 CAM-based car security system via Telegram integration. 2023 3rd International Conference on Innovative Mechanisms for Industry Applications (ICIMIA), Bengaluru, India. 2023. p. 43-48. doi:10.1109/ICIMIA60377.2023.10425967.
13. Warbhe R, Sharma A, Patil G. Security system for bikes using GPS and GSM. 2024 International Conference on Intelligent Systems and Advanced Applications (ICISAA), Pune, India. 2024. p. 1-4. doi:10.1109/ICISAA62385.2024.10829115.
14. Kalaiarasi AR, Prabakaran M. Smart vehicle safety framework integrating alcohol detection and driver drowsiness monitoring. 2026 Second International Conference on Multi-Agent Systems for Collaborative Intelligence (ICMSCI), Erode, India. 2026. p. 1460-65. doi:10.1109/ICMSCI67830.2026.11469232.
15. Fenitha JR, Sanchana R, Brindha DV, Sathish Kumar D, Varun V, Gowtham R. GuardianDrive— an automated safety driving system. 2025 International Conference on Computing and Communication Technologies (ICCCT), Chennai, India. 2025. p. 1-6. doi:10.1109/ICCCT63501.2025.11018963.
16. Usha Rani B, Imran M, Nishanth S, Naik V, Ashok P. IoT-enabled real-time driver monitoring system for drowsiness and alcohol detection using Arduino and OpenCV. EPJ Web Conf. 2026;363:02002. doi:10.1051/epjconf/202636302002.
17. Nair A, Patil V, Nair R, Shetty A, Cherian M. A review on recent driver safety systems and its emerging solutions. Int J Comput Appl. 2024;46:137-151. doi:10.1080/1206212X.2023.2293348.
18. Deepa CN, Srujan CS, Priyamvada TS, Reddy NN. A smart mobile application for vehicle tracking and speed warning. 2023 14th International Conference on Computing Communication and Networking Technologies (ICCCNT), Delhi, India. 2023. p. 1-7. doi:10.1109/ICCCNT56998.2023.10307587.
19. Bamidele AA, Kamardin K, Syazarin N, Mohd S, Shafi I, Azizan A, et al. Non-intrusive driver drowsiness detection based on face and eye tracking. Int J Adv Comput Sci Appl. 2019;10. doi:10.14569/IJACSA.2019.0100775.

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20. Shavetov S, Sivtsov V. Access control system based on face recognition. 2020 7th International Conference on Control, Decision and Information Technologies (CoDIT), Prague, Czech Republic. 2020. p. 952-6. doi:10.1109/CoDIT49905.2020.9263894.
 21. Saphthami I, Narasimha Raju VV, Vaithianathan V, Chinnasamy P, Kumaran G, Ayyasamy RK. IoT based alcohol detection and vehicle control system. 2024 5th International Conference on Data Intelligence and Cognitive Informatics (ICDICI), Tirunelveli, India. 2024. p. 262-6. doi:10.1109/ICDICI62993.2024.10810851.
 22. Garg R, Singh S. Intelligent video surveillance based on YOLO: a comparative study. 2021 7th IEEE International Conference on Advances in Computing, Communication and Control (ICAC3), Mumbai, India. 2021. p. 1-6. doi:10.1109/ICAC353642.2021.9697321.
 23. Rajkumar Y, Santhosh Kumar SVN. A comprehensive survey on communication techniques for the realization of intelligent transportation systems in IoT based smart cities. Peer-to-Peer Netw Appl. 2024;17(3):1263-1308. doi:10.1007/s12083-024-01627-9.
 24. Jarndal A, Tawfik H, Siam AI, Alsyoud I, Cheaitou A. A real-time vision transformers-based system for enhanced driver drowsiness detection and vehicle safety. IEEE Access. 2025;13:1790-1803. doi:10.1109/ACCESS.2024.3522111.
 25. Ramesh M, Akruhi S, Nandhini K, Meena S, Gladwin SJ, Rajavel R. Implementation of vehicle security system using GPS, GSM and biometric. 2019 Women Institute of Technology Conference on Electrical and Computer Engineering (WITCON ECE), Dehradun, India. 2019. p. 71-5. doi:10.1109/WITCONECE48374.2019.9092918.