

IoT-Enabled Driver Fatigue Alcohol Detection and Accident Prevention System for Next Generation Electric Vehicles

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Abstract

The rapid growth of electric vehicles (EVs) and smart transportation systems has significantly increased the demand for intelligent driver assistance technologies, with the global EV market expected to exceed 350 million vehicles by 2030 and road accidents accounting for approximately 1.3 million deaths annually worldwide. These applications require systems capable of detecting driver fatigue, intoxication, and accidents while providing immediate alerts and remote accessibility. Traditional vehicles lack intelligent monitoring systems, relying heavily on manual observation and delayed response mechanisms, which increases the risk of accidents and reduces the effectiveness of emergency interventions. Furthermore, conventional systems do not provide integrated communication, real-time tracking, or cloud-based data analysis, limiting their ability to support proactive safety measures. To address these challenges, the proposed Smart EV driver assistance system integrates Global System for Mobile (GSM), Global Position System (GPS), and IoT technologies with advanced sensor modules, including eye blink detection, MQ-3 alcohol sensing, and accident detection mechanisms. The system continuously monitors driver behavior and vehicle conditions, and upon detecting abnormalities such as drowsiness, alcohol influence, or collisions, it automatically transmits alert messages with precise GPS coordinates to predefined emergency contacts via GSM networks. The Internet of Things (IoT) connectivity enables real-time data visualization and remote monitoring through web or mobile dashboards, allowing users to track vehicle movement and system status efficiently. This intelligent integration enhances driver safety, ensures rapid emergency response, and supports the development of connected, smart, and reliable electric vehicle ecosystems.

Keywords: Accident Detection, Driver Monitoring, Electric Vehicles, Eye Blink Sensor, GPS Tracking, GSM Communication, Internet of Things, MQ-3 Sensor, Remote Monitoring, Smart Transportation

1. Introduction

The rapid expansion of electric vehicles (EVs) and smart transportation systems has significantly accelerated the demand for intelligent driver assistance technologies. The global EV market is projected to exceed 350 million vehicles by 2030 [1], driven by environmental concerns, government policies, and advancements in battery technologies. At the same time, road safety remains a critical global issue, with approximately 1.3 million

deaths reported annually due to road accidents [2], according to international transportation studies. These alarming statistics highlight the urgent need for advanced safety mechanisms in modern vehicles [3]. In real-world scenarios, intelligent systems are required to continuously monitor driver behavior, detect fatigue and intoxication, identify accidents, and ensure immediate emergency response through real-time communication and remote accessibility.

Problem Statement: Traditional vehicles primarily depend on manual driving and basic safety features, offering minimal support for proactive monitoring of driver conditions. Conventional systems lack embedded intelligence to assess driver alertness or detect risky behaviors such as drowsiness and alcohol consumption [4]. Additionally, emergency response in traditional vehicles often relies on external intervention or delayed reporting, which can significantly impact survival rates during critical situations. These systems also do not incorporate integrated communication technologies such as GSM, GPS, or IoT platforms, thereby limiting real-time tracking, automated alerts, and centralized data analysis capabilities.

Research Motivation: In real-time conditions, these limitations lead to several serious challenges that compromise both driver and passenger safety. Fatigue and alcohol impairment often go undetected, increasing the likelihood of accidents, especially during long-distance or nighttime driving. The absence of automatic accident detection and instant alert mechanisms delays emergency assistance, which can be life-threatening [5]. Furthermore, lack of real-time monitoring and cloud-based analysis prevents authorities or family members from tracking vehicle status and responding proactively. These issues underline the necessity for an intelligent, integrated system capable of continuously monitoring driver behavior, detecting anomalies, and providing immediate alerts with precise location details. Such a system ensures enhanced safety, faster emergency response, and contributes to the development of a reliable and connected smart EV ecosystem.

2. Literature Survey

More et al. [6] proposed an Artificial Intelligence (AI) and Internet of Things (IoT)-based road accident detection and reporting system that utilized sensors and cloud

communication for automatic incident detection. Bandaru et al. [7] proposed an IoT-based automatic vehicle accident detection and rescue system that incorporated sensors and communication modules for immediate accident identification and response.

Gupta et al. [8] proposed a driver drowsiness detection system using Convolutional Neural Network (CNN) for facial expression analysis to identify fatigue conditions. Azharudin et al. [9] proposed a drowsy driver detection system that combined facial recognition techniques with driving behavior data for comprehensive fatigue analysis.

Sanap et al. [10] proposed an Arduino-based vehicle accident alert system that utilized GPS, GSM, distance sensors, and force sensors to detect collisions and notify emergency contacts. Jadhav et al. [11] proposed a smart car accident detection and emergency alert system that integrated GPS and GSM modules for real-time accident notification and location tracking.

Sinha et al. [12] proposed an IoT-based system using an ESP32 microcontroller for real-time safety applications that enabled sensor data acquisition and wireless communication. Sharma et al. [13] proposed a women safety device that integrated IoT and GPS modules to provide location tracking and emergency alert features.

Patil et al. [14] proposed an IoT-based smart security system for women using ESP32 and GSM communication to send emergency alerts and location information.

Chatterjee et al. [15] proposed a smart safety device for women that utilized ESP32 with GPS and GSM modules for continuous tracking and alert generation. Swathi et al. [16] proposed a women safety alert system using ESP32 microcontroller and IoT cloud for real-time monitoring and emergency communication.

Khan et al. [17] proposed a smart women safety device with location tracking and alarm system that provided real-time alerts during emergency situations. Sharma et al. [18] proposed an IoT-enabled smart emergency alert device for women safety that integrated sensors and communication modules for immediate alert generation.

Rao et al. [19] proposed a real-time safety monitoring system using ESP32 and GSM communication for continuous tracking and alert generation. Deshmukh et al. [20] proposed an IoT-based women safety and security system that incorporated multiple sensors and communication modules for emergency detection and alerting.

3. Proposed System

The Smart EV Driver Assistance as presented in Figure 1 with GSM, GPS, and IoT Integration system is built around an ESP32 microcontroller, which acts as the central control unit. It interfaces with several sensors, modules, and communication devices to monitor, process, and transmit information.

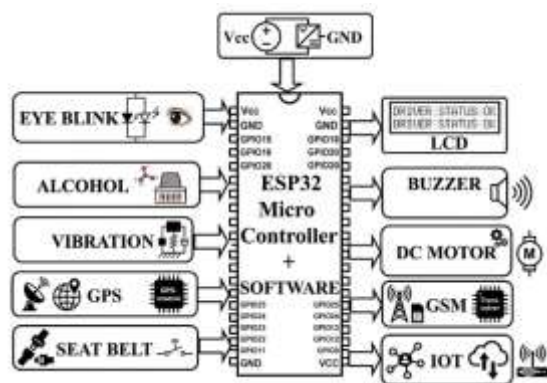


Figure 1. Proposed System Architecture.

The circuit diagram as shown in Figure 2 of this system consists of the following major components:

ESP32 Microcontroller: The ESP32 serves as the brain of the entire system. It collects data from all sensors, processes the inputs, and decides the appropriate actions. The ESP32 is preferred because it supports Wi-Fi and

Bluetooth, which make it highly compatible for IoT-based monitoring. It also has sufficient GPIO pins to connect multiple sensors simultaneously.

Power Supply Unit: A regulated 5V DC power supply is used to drive all the modules and sensors. A voltage regulator (like LM7805) ensures stable voltage output. The ESP32, being a 3.3V device, uses an onboard regulator for internal operation.

Sensors Section: The proposed work contains the following sensors

- **Alcohol Sensor (MQ-3):** Detects the presence of alcohol in the driver's breath. If alcohol content exceeds the threshold, the system alerts the driver and disables vehicle ignition.
- **Eye Blink Sensor:** Monitors eye movement to detect drowsiness or sleep. If the driver's eyes remain closed for a specific time, a buzzer sounds to wake the driver.
- **Vibration/Accelerometer Sensor:** Detects sudden shocks or accidents. When abnormal vibration is detected, it triggers an automatic alert message.
- **Temperature/Humidity Sensor (DHT11):** Monitors the vehicle's environment for safety and system health.

GPS Module: The GPS module (NEO-6M) continuously receives satellite signals and determines the current latitude and longitude of the vehicle. This data is processed by the ESP32 and transmitted via GSM or IoT platforms for tracking purposes.

Figure 3. Proposed Flowchart

3.1 Working Procedure

The Smart EV Driver Assistance System operates flowchart as shown in Figure 3 is based on continuous monitoring, detection, communication, and response. When the EV is powered ON, the ESP32 initializes all peripherals such as sensors, GPS, GSM, and display. The LCD shows the title “Smart EV Driver Assistance” along with system status.

Through Wi-Fi, the ESP32 uploads all sensor readings and alerts to the IoT cloud platform. The vehicle owner or monitoring authority can view all parameters — such as alcohol level, driver status, GPS location, and temperature — through a mobile app or web interface.

Whenever abnormal conditions are detected (e.g., intoxication, drowsiness, or accident), the system activates:

- Buzzer → Audio alert
- LED Indicators → Visual alert
- SMS & IoT Update → Remote alert

These immediate responses help in quick awareness and faster emergency assistance. All sensor data is logged on the cloud, enabling long-term analysis of driver behavior and vehicle conditions. This helps improve safety, reliability, and maintenance of EVs.

4. Results and Discussion

Figure 4 shows the developed hardware setup of the Smart EV Driver Assistance system integrated with ESP32, GSM module, GPS module, sensors, and power supply circuits. The system collects driver status and vehicle information and processes it for safety monitoring and emergency alert generation.

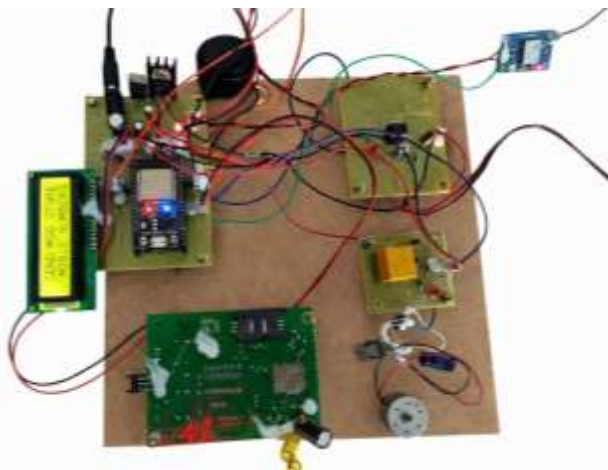


Figure 4. Hardware Prototype of Smart EV Driver Assistance System.



Figure 5. LCD Display Showing Real-Time System Information.

Figure 5 illustrates the LCD interface displaying real-time system information such as GPS coordinates, driver condition, and system alerts. The display allows immediate local monitoring of the vehicle status and assists in detecting abnormal conditions during operation.

Figure 6 presents the IoT-based web monitoring platform used to visualize and store vehicle data remotely. The dashboard displays parameters such as belt status, alcohol detection, eye blink monitoring, vibration/accident detection, location information, and timestamped records for remote supervision.

S.No	Belt	Alcohol	Eye	Vib Status	Location	Date
1	No	Beer	Open	---	Location	Location
2	Beer	---	Eye-Closed	---	Location	Location
3	Beer	---	Eye-Closed	Vib/Accident	Location	Location
4	Beer	---	Eye-Closed	---	Location	Location
5	Beer	---	Open	---	Location	Location
6	Beer	---	Open	---	Location	Location
7	Beer	---	Open	Vib/Accident	Location	Location
8	Beer	---	Eye-Closed	---	Location	Location
9	Beer	---	Eye-Closed	---	Location	Location
10	Beer	Alc-Detected	Open	---	Location	Location
11	Beer	Alc-Detected	Eye-Closed	---	Location	Location
12	Beer	---	Eye-Closed	---	Location	Location
13	Beer	---	Eye-Closed	Vib/Accident	Location	Location
14	Beer	---	Eye-Closed	---	Location	Location
15	Beer	---	Eye-Closed	---	Location	Location
16	Beer	---	Eye-Closed	---	Location	Location
17	Beer	---	Eye-Closed	---	Location	Location
18	Beer	---	Eye-Closed	---	Location	Location
19	Beer	---	Eye-Closed	---	Location	Location
20	Beer	---	Eye-Closed	---	Location	Location

Figure 6. IoT Web Dashboard for Remote Vehicle Monitoring

5. Conclusion

The proposed Smart EV Driver Assistance system presents an effective and intelligent solution to enhance road safety by integrating GSM, GPS, and IoT technologies with advanced sensing mechanisms for real-time driver and vehicle monitoring. By continuously analyzing driver behavior through eye blink detection, alcohol sensing, and accident detection modules, the system ensures early identification of critical conditions such as fatigue, intoxication, and collisions. The automatic

transmission of alerts along with precise GPS coordinates enables rapid emergency response, significantly reducing the impact of road accidents. Additionally, IoT-based remote monitoring and data visualization provide users with real-time insights and improved control over vehicle status and movement. This comprehensive integration overcomes the limitations of traditional systems by enabling proactive safety measures, efficient communication, and intelligent decision-making. Finally, the system contributes to the development of safer, smarter, and more reliable electric vehicle ecosystems, aligning with the growing demands of modern transportation and reducing risks associated with human error.

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