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Intelligent In-Vehicle Health Monitoring and Emergency Control System using IoT and Predictive Analytics

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ABSTRACT: The rising incidence of in-vehicle health emergencies and accidental confinement has necessitated the development of intelligent safety systems capable of real-time monitoring and intervention. This work presents an Intelligent In-Vehicle Health Monitoring and Emergency Control System that integrates Internet of Things (IoT) technology with predictive analytics to enhance passenger safety. The system continuously observes physiological and environmental parameters using a respiration sensor and an MQ-series gas sensor. The acquired data is processed by an ESP32 microcontroller, where predictive analysis is employed to identify abnormal conditions such as irregular breathing, absence of respiration, elevated gas concentration, and potential suffocation scenarios. Upon detection of critical conditions, the system autonomously initiates emergency responses, including activation of a servo-based ventilation mechanism to open the vehicle roof or window, and triggering an audible buzzer alarm to alert nearby individuals. Simultaneously, real-time data is transmitted to an IoT cloud platform for remote monitoring and logging. An Android-based application provides continuous status updates and generates instant alerts, including location information, enabling timely response from caregivers or emergency services through WiFi/GSM communication. The proposed system offers a proactive and automated approach to mitigating life-threatening situations within vehicles, thereby improving safety, response time, and reliability.

I. INTRODUCTION

The rapid advancement of automotive technology has significantly improved vehicle performance, comfort, and connectivity. However, passenger safety within confined vehicle environments remains a critical concern, particularly in situations involving unattended occupants, accidental lock-in, or exposure to hazardous conditions. Incidents such as children being left inside parked vehicles, unconscious passengers, and the accumulation of toxic gases have led to severe health consequences, including suffocation and fatalities.

Modern vehicles often lack integrated systems capable of continuously monitoring both human physiological conditions and the internal environment in real time. Existing safety mechanisms are primarily reactive rather than proactive, relying on manual intervention or external observation. This limitation highlights the necessity for intelligent systems that can autonomously detect abnormal conditions and initiate timely corrective actions.

Despite advancements in automotive safety technologies, there remains a significant gap in addressing in-vehicle health emergencies and environmental hazards. Several critical issues persist:

- **Absence of Continuous Monitoring:** Most vehicles do not provide real-time monitoring of passenger health parameters such as respiration or environmental conditions like gas concentration.
- **Child Lock-In Incidents:** Accidental confinement of children or pets inside parked vehicles can lead to rapid temperature rise and oxygen depletion, resulting in life-threatening situations.
- **Delayed Emergency Response:** Existing systems depend on manual detection and intervention, causing delays in providing assistance during critical conditions such as unconsciousness or suffocation.

- Lack of Automated Ventilation Mechanisms: Conventional vehicles do not possess automated systems to regulate airflow or provide ventilation during emergencies.
- Limited Remote Notification: There is inadequate provision for real-time alerts and communication with caregivers or emergency services when abnormal conditions occur.

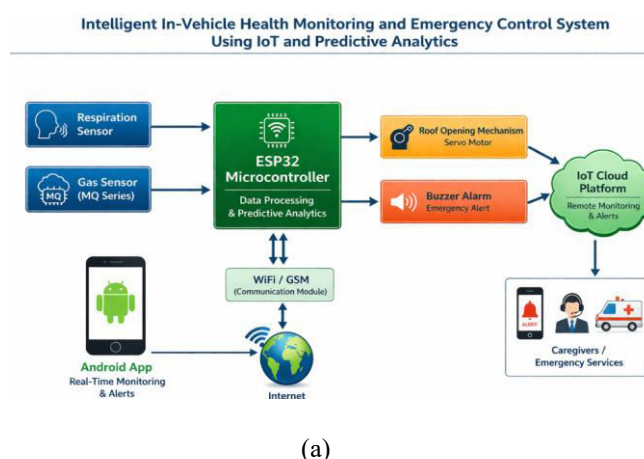
II. LITERATURE SURVEY

Mohit Beri et al. (2022) proposed an IoT-Based Health Monitoring System using ESP32 that employs biomedical sensors to monitor patient health and transmit data to the cloud for remote monitoring. However, the system is limited to healthcare applications and does not support vehicle safety or accident detection. (1) Kazi Kutubuddin et al. (2024) developed a Vehicle Health Monitoring System using IoT that collects vehicle parameters through sensors and sends them to the cloud for real-time analysis and maintenance. However, the system focuses only on vehicle condition and does not monitor driver health. (2) IRJET (2023) presented an IoT-Based Air Quality Monitoring System using ESP32, which utilizes gas sensors to detect pollutants and transmit air quality data via IoT. However, it lacks automatic control mechanisms and emergency response capabilities. (3) Hemaxi Vyas et al. (2025) proposed a Portable IoT-Based Health Monitoring Framework that monitors vital parameters such as heart rate and temperature using sensors and a mobile application. However, the framework is not integrated with vehicle systems or emergency actuation mechanisms. (4) Bakare et al. (2026) introduced an IoT-Based Indoor Environmental Monitoring System using ESP32, MQTT, and ThingSpeak for real-time environmental monitoring and cloud-based analytics. However, it lacks predictive analytics and emergency response features for critical situations. (5) Simamora et al. (2025) developed an IoT-Based Air Quality Detection System using MQ sensors, ESP32, and fuzzy logic for accurate gas detection and classification. However, the system does not monitor human health conditions or support vehicle safety applications. (6)

III. METHODOLOGY

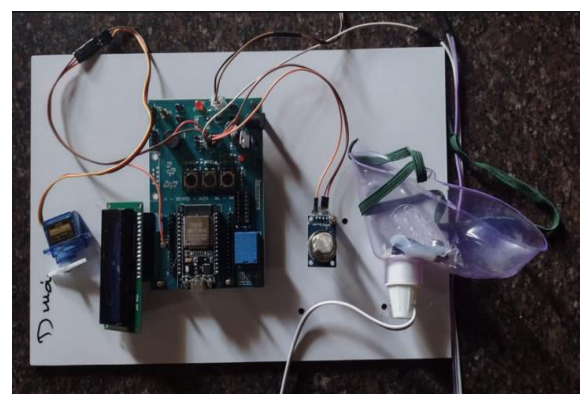
The proposed system is an Intelligent In-Vehicle Health Monitoring and Emergency Control System that ensures passenger safety by continuously monitoring both human health conditions and the vehicle's internal environment. The system uses a respiration sensor to track breathing patterns and an MQ-series gas sensor to detect harmful gases inside the vehicle. All sensor data is processed by an ESP32 microcontroller, where predictive analytics is applied to identify abnormal or critical conditions in real time. When a dangerous situation is detected—such as a child locked inside the car, an unconscious passenger, or gas leakage—the system automatically initiates emergency actions. A servo motor is activated to open the vehicle roof/window for ventilation, and a buzzer alarm alerts nearby people. Additionally, the system is integrated with IoT technology, enabling real-time data transmission to a cloud platform. An Android application provides live monitoring and sends instant alerts to caregivers or emergency services via WiFi/GSM communication.

IV. EXPERIMENTAL RESULTS



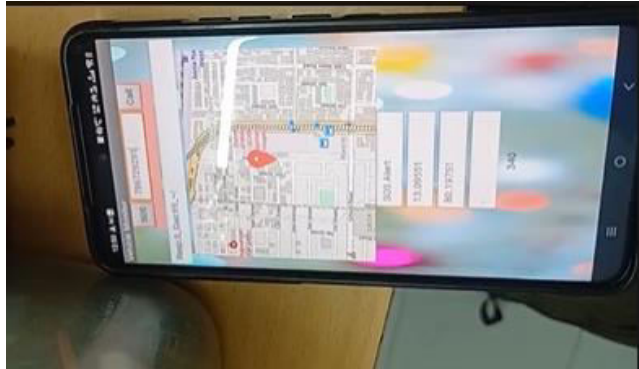
(a)

(a)-proposed system



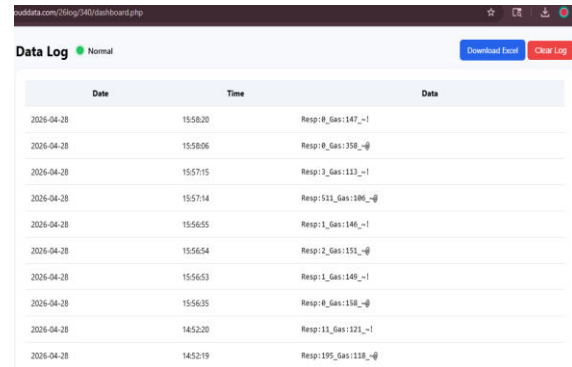
(b)

(b)-system overview



(c)

(c)-GPS monitoring



Date	Time	Data
2026-04-28	15:58:20	Resp:0_Gas:147,-1
2026-04-28	15:58:06	Resp:0_Gas:158,-0
2026-04-28	15:57:15	Resp:3_Gas:113,-1
2026-04-28	15:57:14	Resp:531_Gas:106,-0
2026-04-28	15:56:55	Resp:1_Gas:146,-1
2026-04-28	15:56:54	Resp:12_Gas:151,-0
2026-04-28	15:56:53	Resp:1_Gas:140,-1
2026-04-28	15:56:35	Resp:0_Gas:158,-0
2026-04-28	14:52:20	Resp:11_Gas:121,-1
2026-04-28	14:52:19	Resp:195_Gas:118,-0

(d)

(d)-data sets.

V. CONCLUSION

The proposed Intelligent In-Vehicle Health Monitoring and Emergency Control System successfully addresses critical safety challenges inside vehicles by integrating health monitoring, environmental sensing, and IoT communication. The system continuously monitors the occupant's breathing and detects harmful gases using sensors, while the ESP32 microcontroller processes the data using predictive analytics to identify abnormal conditions. In emergency situations such as child lock-in, unconscious passengers, or gas leakage, the system automatically responds by opening the vehicle roof/window, activating a buzzer alert, and sending real-time notifications through an IoT platform. This project provides a proactive, reliable, and cost-effective solution that minimizes risks and ensures timely intervention. It enhances vehicle safety by combining automation, real-time monitoring, and smart decision-making, making it highly suitable for future smart vehicle applications.

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