AI and IoT-Based Vehicle Carbon Emission Monitoring and Personal Suggestion System

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***Abstract*—The rapid increase in the number of automobiles has resulted in huge increases in air pollution, posing serious environmental and public health risks. Vehicle emissions, including CO, CO_2, and NOx, are major contributors to poor air quality in urban areas. Conventional emission monitoring approaches are based on periodic inspections and cannot track real-time emission trends. To address these limitations, this review paper describes an AI and IoT-based system for monitoring vehicle carbon emissions and making personalized suggestions.**

The proposed framework uses gas sensors and an ESP32 microcontroller to continually monitor exhaust emissions near the vehicle silencer. The measured emission data is displayed locally on an OLED display and wirelessly sent to the Blynk IoT mobile app for real-time visualization and alert messages. When emissions exceed predetermined standards, users are notified immediately.

The use of artificial intelligence to analyse past emission data and generate individualized suggestions is a fundamental feature of the system. These tips help car owners discover maintenance needs such as engine tuning, air filter replacement, and fuel optimization.

The system is intended to be low-cost, scalable, and user-friendly, making it appropriate for usage in personal vehicles, public transportation, and business fleets. Furthermore, connectivity with government databases can facilitate large-scale emission analysis and regulatory compliance. This assessment emphasizes the possibility of merging IoT, AI, and cloud technologies to promote sustainable transportation and ecologically responsible mobility, recommending engine tuning, air filter upgrades, or reduced fuel consumption to improve fuel efficiency and reduce hazardous emissions. This not only allows vehicle owners to take preventive measures, but it also helps to achieve the larger aims of sustainable development and smart city programs.

***Index Terms*—Carbon Emission Monitoring, Internet of Things (IoT), Artificial intelligence (AI), Vehicle Pollution Control, Personalized recommendation.**

I. INTRODUCTION

Vehicular emissions remain a major source of urban air pollution, particularly in quickly developing cities. Traditional emission testing methods are periodic and do not capture real-time fluctuations caused by driving behaviour, engine condition, or fuel quality.

To address these restrictions, IoT-based monitoring systems have emerged as a viable option, allowing for continuous data collecting and remote access. This study builds on the notion introduced in a previous mini-project focusing on daily carbon monoxide tracking by including improved hardware dependability, cloud connectivity, and artificial intelligence-based analytics. The enhanced system is intended to be put near a vehicle's exhaust, where gas sensors continuously monitor CO concentrations. An ESP32 microcontroller processes the sensor data and transmits it over Wi-Fi to a mobile application. Visual and audio alerts notify users immediately when emission levels exceed predefined thresholds.

The addition of AI-driven analysis is a significant improvement to this system. By analysing long-term emission trends, the model can make personalized recommendations such as engine servicing, air filter replacement, or improved fuel efficiency. These recommendations allow car owners to take preventive measures rather than reacting immediately after a problem occurs. From a broader viewpoint, the technology promotes smart city projects by allowing for large-scale data aggregation, which can assist authorities in identifying pollution hotspots and improving regulatory compliance.

The suggested method combines environmental monitoring, embedded systems, and intelligent analytics into a unified, deployable framework. Its low cost and modular design make it suited for both academic study and real-world use, helping to promote sustainable transportation practices.

This review paper expands on an earlier mini-project called the IoT-Based Daily Carbon Emission Tracking System, transforming it into a more robust and intelligent framework. The improved system combines gas sensors and an ESP32 microprocessor to monitor exhaust pollutants in real time. The acquired data is displayed locally on an OLED module before being wirelessly sent to a cloud-based mobile app for visualization and alarm creation. A siren is integrated to offer timely alerts when emission levels exceed predefined thresholds.

From a broader viewpoint, the proposed AI and IoT-based vehicle carbon emission monitoring and personal recommendation system is consistent with worldwide aspirations for smart cities and sustainable development. Large-scale deployment of these devices can help authorities detect pollution hotspots, enforce emission restrictions, and develop data-driven environmental policies.

Furthermore, the system's scalability and cost-effectiveness make it appropriate for use in personal vehicles, public transportation systems, and business fleets.

In conclusion, the combination of IoT and AI technology offers a promising answer to the problems related with vehicle pollution monitoring. By providing real-time sensing, intelligent data analysis, and personalized recommendations, the suggested system helps to reduce vehicular pollution, raise user awareness, and promote environmentally responsible transportation.

II. LITERATURE REVIEW

There has been extensive study into IoT-based air pollution and car emission monitoring systems. Early research concentrated mostly on detecting carbon monoxide with low-cost sensors and microcontrollers. These systems demonstrated real-time monitoring and warning production via GSM or cloud platforms, but were confined to single-gas detection. Later research improved monitoring capabilities by using numerous sensors for CO, CO_2, and NOx detection. These technologies increased pollution awareness and allowed regulators to track high-emission automobiles. However, many studies were confined to prototype testing and did not include long-term performance evaluations.

Recent improvements have provided machine learning and deep learning algorithms that can anticipate emission trends based on previous data. While these systems demonstrated promise accuracy, issues such as sensor calibration, cost, and hardware durability remain unresolved. The research demonstrates a need in low-cost, AI-powered systems that deliver individualized suggestions to individual vehicle owners, which serves as the impetus for the suggested approach.

Subsequent experiments used additional gas sensors to measure pollutants like CO, CO_2, and NOx. These multi-sensor devices enhanced the accuracy of emission assessments and allowed authorities to detect vehicles with high emissions. Cloud platforms were developed to store historical data and generate visual analytics.

However, many solutions were only evaluated under controlled or prototype circumstances, leaving insufficient validation of their performance under different climatic and driving conditions. Several researchers developed IoT-based car pollution monitoring systems with alarm mechanisms that combined gas sensors, GPS, and GSM modules. These technologies enabled the tracking of high-emission cars and provided real-time alerts when pollution levels surpassed regulatory limits. While successful for monitoring, such systems frequently encountered issues such as network dependency, power consumption, and large-scale deployment practicality.

Recent improvements have incorporated AI and machine learning techniques to improve emissions monitoring systems. Predictive models were created to forecast emission levels based on sensor data. Some studies used deep learning architectures to increase forecast accuracy and identify anomalous emission patterns. Although these technologies produced promising results, they frequently need complicated hardware configurations, extensive processing resources, and enormous datasets, raising overall system costs and limiting access for individual vehicle owners.

The proposed AI and IoT-based vehicle carbon pollution monitoring and personal recommendation system overcomes these restrictions by combining real-time sensing, cloud-based visualization, and AI-powered recommendation processes into a single, scalable framework. By emphasizing price, ease of deployment, and user awareness, the system bridges the gap between academic research and practical application.

III. RESEARCH METHODOLOGY

This review paper uses a Systematic Literature Review (SLR) methodology to examine existing research on IoT-based car emission monitoring systems and the use of artificial intelligence for emissions analysis and control. The SLR technique ensures an organized, transparent, and unbiased evaluation of prior studies, allowing for the identification of current advances, limitations, and research gaps in the field of vehicular emission monitoring.

Data Sources and Search Strategy

Relevant research articles were compiled from well-known academic databases such as IEEE Xplore, SpringerLink, ScienceDirect, MDPI Sensors, and Google Scholar. To ensure that current and relevant improvements were included, the literature search covered publications published between 2018 and 2025. Keywords such as IoT-based vehicle emission monitoring, carbon emission monitoring, artificial intelligence in pollution management, smart transportation, and low-cost sensor systems were used both individually and in combination to find relevant studies.

Selection Criteria

To ensure the quality and relevance of the selected studies, precise inclusion and exclusion criteria were used.

Inclusion Criteria:
• Peer-reviewed publications include journal articles, conference papers, and review papers. • Research on IoT-enabled air or car pollution monitoring systems.
• Research in artificial intelligence, machine learning, and predictive analytics.
• Papers focused on low-cost sensor integration and real-time monitoring.

Exclusion Criteria:

- Studies focused exclusively on industrial or indoor air pollution
- Non-IoT-based monitoring frameworks
- Articles lacking experimental validation or technical clarity

Screening and Analysis Process

Initially, the titles and abstracts of the retrieved publications were evaluated to rule out irrelevant studies. The remaining publications were then thoroughly analysed to determine their technical contributions and relevance to vehicle emission monitoring. Duplicate studies and obsolete publications were deleted to ensure uniformity and relevancy.

Evaluation Parameters

Each selected study was assessed using the following parameters: • Gas sensors and microcontrollers used.
• Use communication technologies like Wi-Fi, GSM, MQTT, or Bluetooth.
• Improves cloud platform functionality, scalability, and data storage efficiency.
• Ensuring data accuracy, system latency, and reliability.
• Use AI or machine learning techniques for prediction and analysis.
The retrieved data was rigorously examined to find trends, strengths, and limits among various methodologies.

Synthesis of Findings

The literature review was conducted to identify typical obstacles such as sensor calibration issues, environmental sensitivity, power limits, and internet dependency. Additionally, shortcomings in individualized user recommendations and long-term deployment viability were identified. These findings served as the foundation for analysing the proposed AI and IoT-based vehicle carbon emission monitoring system, which is detailed in this review.

Outcome of the Methodology

This study uses the systematic literature review process to provide a full understanding of current emission monitoring technology and identify potential for improvement. The process assures that the review's conclusions are evidence-based, well-structured, and applicable to both academic research and real-world applications.

IV. PROPOSED SYSTEM OVERVIEW

The proposed AI and IoT-based vehicle carbon emission monitoring and personal suggestion system is intended to provide continuous, real-time monitoring of vehicle exhaust emissions, as well as intelligent and tailored emission reduction recommendations. The technology intends to overcome the constraints of existing emission testing methods by allowing for on-board monitoring, immediate alerts, and long-term data analysis.

The system monitors dangerous exhaust gases, including CO, CO_2, and NOx, which contribute to air pollution. Gas sensors such as MQ-7 and MQ-135 are fitted near the vehicle's silencer, where exhaust gas concentrations are highest. These sensors continuously collect emissions data and convert it into electrical impulses proportional to gas concentration.

The system's core processor is an ESP32 microcontroller. It collects sensor readings, does initial data processing, and oversees wireless communications. The ESP32 was chosen because of its low power consumption, built-in Wi-Fi functionality, and consistent performance in IoT-based applications. Real-time emission numbers are shown locally on an OLED panel, allowing users to rapidly view emission levels without the need for mobile access.

To ensure instant user awareness, the system uses a buzzer-based alert mechanism. When emission levels reach predefined thresholds, the buzzer sounds to alert the vehicle owner. This real-time alert feature allows customers to take immediate corrective action, such as limiting vehicle usage or scheduling maintenance.

The processed emission data is wirelessly delivered to the Blynk IoT smartphone app, which serves as the system's cloud interface. The mobile app includes real-time dashboards, graphical representations of emission trends, and notification warnings. Cloud storage enables the long-term retention of emission data, allowing for historical study and performance evaluation over longer time periods.

The suggested system includes artificial intelligence for intelligent data processing, which is a fundamental feature. AI systems evaluate past emission trends to detect aberrant behaviour and make individualized maintenance recommendations. These suggestions could include engine tuning, air filter replacement, catalytic converter inspection, or fuel optimization. This changes the system from a passive monitoring device to an intelligent decision-support system.

The proposed system is designed to be low-cost, scalable, and user-friendly, making it suitable for deployment in private vehicles, public transportation, and commercial fleets. Its modular architecture allows future enhancements such as GSM connectivity, GPS integration, advanced machine learning models, and integration with government pollution control databases. Overall, the system provides an effective and sustainable solution for reducing vehicular emissions and promoting environmentally responsible transportation.

The system continuously collects emission data, transmits it to the cloud, and stores it for long-term analysis and AI-based recommendations.

V. FINDINGS AND DISCUSSION

According to the review, IoT-based pollution monitoring systems outperform conventional methods in terms of accuracy, frequency, and accessibility. MQ-series sensors are a low-cost alternative, but they must be calibrated properly for use in outside vehicle conditions. Cloud systems improve data visualization and user awareness, while AI-based analytics allow for predictive maintenance and intelligent decision-making. Sensor drift, environmental sensitivity, inadequate battery backup, and internet dependency have all been cited as challenges. Meeting these problems is critical for large-scale deployment.

After analysing existing literature and designing the prototype framework, the following observations were made:

Effectiveness of IoT in Monitoring: IoT frameworks greatly enhance monitoring frequency, accuracy, and accessibility over traditional methods.

Sensor Efficiency: MQ-series sensors are cost-effective, but they must be calibrated for outdoor and silencer-based settings.

Cloud Integration Benefits: Platforms such as Blynk and Firebase simplify real-time monitoring and user alert systems, increasing data accessibility.

User Awareness and Impact: Mobile-based visualization enables car owners to take timely measures, such as servicing engines or replacing filters.

AI for Predictive Maintenance: AI algorithms improve system intelligence by forecasting emissions and recommending maintenance schedules.

Challenges Identified: Sensor drift, environmental sensitivity, low battery backup, and internet dependence are all significant difficulties that require further adjustment.

VI. FUTURE SCOPE

The AI and IoT-based vehicle carbon emission monitoring system has considerable potential for further development and widespread use. While the existing framework is focused on real-time monitoring and individualized recommendations, numerous enhancements and expansions might be considered to improve system efficiency, intelligence, and real-world impact.

One of the most significant future developments is the incorporation of powerful machine learning and deep learning models. Training models on vast amounts of historical emission data allows the system to reliably anticipate future emission trends, identify aberrant emission patterns, and detect probable engine defects early on. Predictive analytics can help car owners do preventative maintenance, which reduces long-term repair costs and environmental effect.

The system can also be upgraded to provide complete wireless independence by incorporating GSM, LTE, or NB-IoT connection modules. This upgrade will reduce reliance on Wi-Fi networks and allow for continuous data transmission in remote and rural places. Furthermore, Bluetooth Low Energy (BLE) can be used for short-range data access and offline diagnostics.

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VII. CONCLUSION

This review paper highlights the growing importance of IoT-based emission monitoring systems in tackling vehicular pollution. The review of various research works indicates that IoT, when combined with AI and cloud computing, offers a reliable, scalable, and low-cost solution for emission control. The proposed system is designed to monitor CO, CO_2, and NOx in real time, display readings on an OLED, and transmit data to the cloud for analysis. Mobile app alerts and trend graphs help users stay aware of their vehicle's environmental impact. Future integration of AI will further enhance prediction accuracy and provide personalized maintenance recommendations.

In conclusion, the IoT-Based Vehicle Carbon Emission Monitoring System represents a vital step toward achieving smart, sustainable, and environmentally responsible transportation systems

REFERENCES

[1] Gupta, R. et al., "IoT-Based CO Monitoring Using ESP32 and Blynk," IEEE Access, 2023.

[2] Patel, S. & Shah, A., "Vehicle Pollution Monitoring via IoT Sensors," Springer Smart Systems Journal, 2024.

[3] Meena, R. et al., "Cloud-Based IoT Platforms for Real-Time Environmental Monitoring," MDPI Sensors, 2024.

[4] Rao, K. et al., "Calibration of MQ-Series Sensors for Urban Air Monitoring," Elsevier Measurement Journal, 2023.

[5] Kumar, A. & Singh, R., "AI Prediction Models for Vehicular Emission Trends," IEEE Transactions on AI in IoT Systems, 2024.

[6] Marquez-Zepeda, C. et al., "IoT-Based CO_2 Monitoring and Forecasting for Urban Air Quality," Mathematics and Computer Applications, 2025.

[7] Mota, J. et al., "IoT Architecture for Air Quality Monitoring Using ESP32-C6," PMC Open Access, 2025.

[8] Gangwar, P. et al., "Air Pollution Monitoring Using IoT and Machine Learning," arXiv Preprint, 2023.

[9] Huang, X. et al., "A Novel IoT Framework for Reducing Vehicle Emissions," Journal of Environmental Informatics, 2024.

[10] Johnson, D. & Woodward, P., "Calibration of Low-Cost IoT Sensors for Urban Air Monitoring," IEEE Sensors Journal, 2025.