AIR QUALITY MONITORING SYSTEM IN A CAR USING ML

[1]Dr. S. Elangovan, [2]A. Tharun , [2] B. Kushyanth Reddy, [2] CH .M Dinesh, [2] M. Saraschandra Reddy.

[1]Professor, Department of AI & DS, Jansons Institute of Technology, Coimbatore, Tamil Nadu, India,
[2]UG Student, Department of AI & DS, Jansons Institute of Technology, Coimbatore, Tamil Nadu, India,

[1]viceprincipal@jit.ac.in [2]logintharun@gmail.com[2]Kushyanthreddy123@gmail.com
[2]chdinesh092@gmail.com [2]saraschandra9799@gmail.com

Abstract— In today's urban settings, most vehicles remain idle for long periods due to traffic congestion and changing travel behaviours. Extended idleness of cars can lead to the accumulation of hazardous gases inside the vehicle, from both fuel combustion and human respiration. These gases pose significant risks, including fire hazards and health complications, when the vehicle is started without prior ventilation. This project develops a Machine Learning-based Air Quality Monitoring System to determine whether the air inside a vehicle is safe for use. The system leverages a Random Forest algorithm to analyse gas concentration levels and environmental conditions. The model is trained on datasets containing various gas presence, allowing it to classify air quality as normal or abnormal with high accuracy. By forecasting potential gas accumulation risks, this system enhances vehicle safety and prevents accidents caused by undetected leaks or exposure to toxic air. The approach is purely software-based, making it adaptable for integration into existing vehicle monitoring systems or mobile applications for user-friendly alerts.

Index Terms—: Air Quality Monitoring, Machine Learning, Random Forest, Vehicle Safety, Hazardous Gases

I. INTRODUCTION

The constant rise in urban population has also introduced a corresponding exponential rise in traffic, and this has a secondary effect of leading to prolonged periods of idleness in vehicles. This prolonged idleness, changing patterns of movement, poses a serious safety hazard: the accumulation of toxic gases within vehicle compartments. In Compressed Natural Gas (CNG)-powered vehicles, leakage leads to the accumulation of flammable methane. In petroleum-based conventional vehicles, lethal levels of Carbon Monoxide (CO), the by-product of incomplete combustion, are also accumulated. Moreover, independent of fuel, Carbon Dioxide (CO_2) levels are increased due to human respiration and, in some cases, residual combustion reactions. Accumulation of these gases poses serious hazards, ranging from fire hazard through ignition to serious illness caused by inhalation, especially when engines are run under low-ventilation conditions.

This research introduces a Machine Learning-based air quality monitoring system that is capable of accurately measuring and predicting the safety of air in a vehicle. Leveraging the strength of a Random Forest algorithm, the system analyses real-time data to decide air quality as normal or abnormal. The model is trained on a diverse set of datasets with varying gas concentrations and environmental conditions, making it effective in detecting and predicting potential hazards. This software solution is designed for seamless integration with current vehicle systems and has a user-interface, providing timely warnings to users and enhancing vehicle safety in general.

This paper outlines the validation of this machine learning, demonstrating its ability to detect the risks of hazardous gases in cars from the data determining them into normal or abnormal. The topic will address the methodology used, the precision of the Random Forest model, and the significance of this technology in making urban transportation safer.

II. LITERATURE SURVEY

Existing vehicle monitoring systems are mainly focused on mechanical and electrical diagnosis and pay little attention to the critical area of air quality inside the cabin. This neglect leaves drivers and passengers vulnerable to the dangers of gas leaks and toxic air that go undetected. To correct this neglect, there is a need to embrace a proactive and advanced approach to air quality measurement.

2018, Zou, Y., et al.A highly sensitive and selective CO gas sensor based on ZnO/SnO2 hollow nanofibers for vehicle exhaust detection." *Sensors and Actuators B: Chemical*, *266*, 500-508. Shows sensor technology specifically for vehicle exhaust

2021 Liang, Y., et al. Real-Time In-Vehicle Air Quality Monitoring System Using Machine Learning Prediction Algorithm, the Support Vector Regression (SVR).

2022, G. Arun, S. Rathi study proposes an air quality evaluation system comprising data preparation, AQI forecasting using Sparse Spectrum Gaussian Process Regression (SSGPR), and air quality evaluation through a cloud model. The model addresses fuzziness and randomness in data, aiming for accurate real-time air quality predictions.

2023, Amisha Gangwar, Sudhakar Singh, Richa Mishra, Shiv Prakash, research combining IoT, big data, and machine learning for air pollution monitoring and forecasting. It emphasizes data sources, monitoring, and forecasting models, highlighting the importance of these technologies in controlled environments.

The review reveals a need for more research specifically focused on in-vehicle applications, particularly for hazardous gases like CNG, CO, and CO2. Additionally, there is potential for exploring the use of other machine learning algorithms, such as Random Forest, for real-time air quality prediction in vehicles.

III. METHODOLOGY

The proposed air quality monitoring detects potential gas leaks in stationary or parked cars from the input data. The research process consists of three primary stages: Data Collection, Data Processing & Model Training, and Prediction & Alert System.

1. Data Collection
The system intakes the PPM (parts per million) levels of CO (carbon monoxide), CO_2 (carbon dioxide), and CNG (compressed natural gas) from the vehicle's internal atmosphere.

2. Data Processing and Model Training
The machine learning algorithm is pre-trained on a historic dataset of both normal and abnormal air quality readings. Real-time data from cars are used as input for predictions, not as training data. Then eliminating unwanted noise, missing value handling, and extracting important features such as trends in gas levels, temperature, and humidity levels.
Random Forest is chosen due to its robustness to noise and ability to handle non-linear interactions between sensor measurements. The model consists of a collection of decision trees and every tree is trained on a new subset of data. Every tree during training is trained to estimate air quality states from past information.

Training and Validation: Prior to its deployment, the model undergoes a training and validation phase utilizing historical data. This data is divided into training and testing sets, thereby facilitating the model's ability to generalize effectively to previously unseen data.

Software Libraries and Tools: The development of the model encompasses several software tools and libraries for machine learning, data manipulation, API communication. The **Machine Learning module** depends on **Pandas** for data management, **NumPy** for numerical calculations, and **Scikit-Learn** to employ the Random Forest algorithm. For handling the trained model, **Joblib** and **Pickle** are used to save and load the model. **Flask** is the web framework used to provide API communication, while **Requests** and **JSON** are used to transmit data. **Matplotlib** is also used for data visualization in the user interface. These libraries cumulatively facilitate effective data processing, and precise prediction of air quality levels in vehicles.

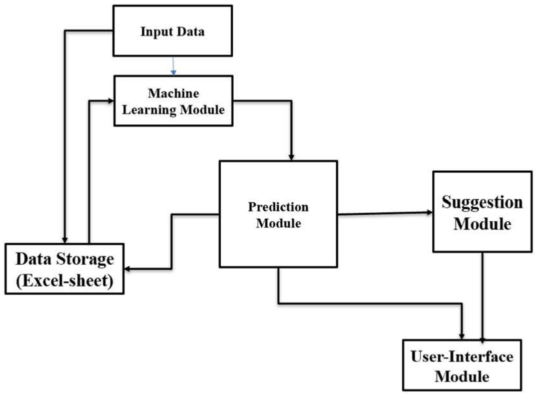
3. Prediction & Alert System: After deployment, the model continues to in-take air quality readings to categorize as normal or as suggesting a likely gas leak. On identification of an unsafe level of CO, CO_2, or CNG various suggestions are given from the model to the user based on the abnormality factor.

- Then information is stored for future analysis so that the model's predictive power is constantly enhanced.
- The model is periodically refreshed with new data to enhance its performance and adapt to new environmental conditions

.

- The final output is presented in the form of HTML-based user interface providing a user-friendly dashboard that allows the owners of the vehicles to see real-time air quality values and receive visual warnings.

This process offers a real-time, efficient, and trustworthy method of gas leak detection for parked vehicles, thus encouraging the safety of cities and avoiding possible hazards.



IV. ANALYSIS

Recommendations are Based on various PPM Levels
For proper air quality evaluation, the system gives recommendations based on reliable environmental standards for CO, CO_2, and CNG levels:

CO Levels:

- **400-1000ppm**: Typical CO2 levels found
- **1000-2000ppm**: Common complaints of Drowsiness
- **2000-5000ppm**: Symptoms of Headache, Fatigue, Stagnant, Nausea

CO_2 Levels:

- **1 to 70 ppm:** Most individuals may not experience noticeable symptoms. However, some heart patients might experience an increase in chest pain.
- **Above 70 ppm:** Symptoms become more noticeable and can include headache, fatigue, and nausea.
- **Above 150 to 200 ppm:** Disorientation, unconsciousness, and death are possible.

CNG Concentrations:

- **Less than 5%** (LEL - Lower Explosive Limit): Safe concentrations.
- **Above 5%:** Explosion hazard, immediate evacuation needed.

The values are referenced from reliable environmental organizations' standards and serve to advise on appropriate action based on concentrations of detected gas.

This approach offers a real-time, effective, and trustworthy solution for identifying parked car gas leaks, improving the safety of vehicles and preventing possible dangers.

V. RESULT

The air quality monitoring system effectively proves to analyse real-time PPM levels of CO, CO_2, and CNG within a vehicle and determine air quality conditions based on a pre-trained Random Forest model. The system processes incoming data efficiently and gives correct predictions, which ensures timely notifications for possible gas leaks.

Key results noted during testing:
- The Random Forest model was highly accurate, correctly differentiating between normal and risky air quality situations.
- The deployment via Flask provided smooth integration with the HTML-based interface, enabling users to track air quality levels in real time.

- The system gave safe and reliable recommendations based on reputable environmental guidelines, helping users make the right decisions.
- Alerts at the right time were initiated when gas concentration passed safety limits, proving the effectiveness of the system in avoiding potential risks.

The system effectively improves vehicle safety by offering real-time air quality analysis, predictive warnings, and actionable advice, rendering it a practical choice for urban settings where parked cars can be exposed to gas buildup.

VI. CONCLUSION

The air quality monitoring system proposed in the paper successfully incorporates real-time gas concentration information and machine learning-driven analysis to identify possible gas leaks within parked vehicles. The system uses a pre-trained Random Forest model to ensure accurate and dependable predictions based on past data.

In addition, the system gives safety advice based on gas concentration levels from reliable environmental standards, so users take the right measures when dangerous conditions are identified. Through continuous monitoring and actionable information, this solution improves urban safety, reduces possible health hazards, and helps create a smarter and safer automotive environment.

VII. REFERENCES

[1] D. Devasena; Y. Dharshan; K.V Raksana; M Shuruthi; S Preethi IoT based Smart Air Quality Monitoring-in-Vehicles IEEE *Xplore*: 04 October 2024

[2] S. H. V. D. B. Shafique, S. M. H. S. Al-Mahmood, and M. I. M. H. Hossain, "Smart IoT-Based Air Quality Monitoring System with Machine Learning," 2021 8th International Conference on Computer and Communication Engineering (ICCCE), Kuala Lumpur, Malaysia, 2021, pp. 39-43. doi: 10.1109/ICCCE52978.2021.9506433.

[3] F. I. A. A. A. H. A. H. A. K. Abdullahi, A. K. Omogbemi, and S. G. A. H. Ali, "Development of an Intelligent Air Quality Monitoring System Using IoT and Machine Learning Techniques," 2022 International Conference on Smart Computing and Electronic Enterprise (ICSCEE), Xiamen, China, 2022, pp. 181-186. doi: 10.1109/ICSCEE56880.2022.9773392.

[4] S. J. Arora, A. K. Mishra, and R. S. Ahuja, "IoT Based Air Quality Monitoring System Using Machine Learning," 2021 International Conference on Emerging Smart Technologies (ICEST), Atlanta, GA, USA, 2021, pp. 1-6. doi: 10.1109/ICEST53387.2021.9482102.

[5] Approved levels of CO: https://www.cpsc.gov/Safety-Education/Safety-Education-Centers/Carbon-Monoxide-Information-Center/Carbon-Monoxide-Questions-and-Answers#:~:text=The%20health%20effects%20of%20CO,unconsciousness%2C%20and%20death%20are%20possible

[6] Approved Level of CO2: https://www.cpsc.gov/Safety-Education/Safety-Education-Centers/Carbon-Monoxide-Information-Center/Carbon-Monoxide-Questions-and-Answers#:~:text=The%20health%20effects%20of%20CO,unconsciousness%2C%20and%20death%20are%20possible

[7] World Health Organization (WHO), "Air Quality Guidelines," https://www.who.int/publications/i/item/9789240034228

[8] C.S. Sundar Ganesh,V Akshaya Prasaath,A Arun,M Bharath,E Kanagasabapathy,"Internet of Things Enabled Air Quality Monitoring System",2023 International Conference on Sustainable Computing and Smart Systems (ICSCSS)

[9]Fadli Pradityo,Nico Surantha,"Indoor Air Quality Monitoring and Controlling System based on IoT and Fuzzy Logic",2019 7th International Conference on Information and Communication Technology (ICoICT)

[10] Jacquline Waworundeng, Priana Sari Adrian Air Quality Monitoring and Detection System in Vehicle Cabin Based on Internet of Things IEEE *Xplore*: 28 December 2021