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Proactive Monitoring and Prediction of Vehicle Exhaust Emissions for Urban Air Quality

Mr A Mohamed Noordeen¹, Jayasrees², Niranjana Devi M.C³, Abinaya K⁴

Assistant Professor, Department of Artificial Intelligence and Data Science, Dhaanish Ahmed Institute of Technology,

Coimbatore, India¹

UG Scholar, Department of Artificial Intelligence and Data Science, Dhaanish Ahmed Institute of Technolog,

Coimbatore, India²

UG Scholar, Department of Artificial Intelligence and Data Science, Dhaanish Ahmed Institute of Technology,

Coimbatore, India³

UG Scholar, Department of Artificial Intelligence and Data Science, Dhaanish Ahmed Institute of Technology,

Coimbatore, India⁴

ABSTRACT: Exhaust Emission Index (EEI) quantifies the rate of air pollutants emitted by a vehicle, with higher emissions correlating to poorer air quality. Traditional emission control methods, such as the Pollution Under Control (PUC) Certificate, provide static test results rather than dynamic assessments of vehicle health. As vehicle numbers increase, the need for advanced solutions to monitor and predict exhaust emissions in real-time has become crucial. This project introduces the Emission Tracker, an innovative system utilizing deep learning techniques, specifically Long Short-Term Memory (LSTM) networks, to address this need. The Emission Tracker employs an LSTM model deployed on a central server to analyze vehicle carbon emission data, predicting trends in the Vehicle Exhaust Emission Index (VEEI). The system features a web-based dashboard that provides an intuitive user interface for visualizing emissions data. Through location-based insights, users gain a comprehensive understanding of emission patterns, which supports informed decision-making. The Emission Tracker not only enables real-time monitoring but also offers predictive analytics to forecast future emission trends. This proactive approach aids in implementing timely interventions, ultimately contributing to improved air quality and enhanced public health by fostering environmental sustainability.

KEYWORDS: Exhaust Emission Index, PUC ,LSTM ,Web based dashboard ,VEEI.

I. INTRODUCTION

Vehicle exhaust emissions are created when the air-fuel mixture burning inside internal combustion engines releases carbon dioxide back into the atmosphere. Diesel-powered, gasoline-powered, and hybrid vehicles all produce vehicle exhaust emissions; as the fuel used to power them contains hundreds of differently structured hydrocarbons that burn at different rates in different ways. Vehicle exhaust emissions are also generated by the evaporation of fuel within the vehicle when the vehicle stops, and during fueling. The composition of exhaust emissions from gasoline-powered or diesel-powered vehicles differs depending on the individual vehicle's operating characteristics, as well as the type of fuel used. The majority of vehicle exhaust emissions are composed of carbon dioxide, nitrogen, water vapor, and oxygen in unconsumed air. Carbon monoxide, unburned fuel, nitrogen oxides, and particulate matter such as mercury are also present in vehicle exhaust emissions in smaller quantities. A number of these substances play a significant role in vehicle-related air pollution, and carbon dioxide – a greenhouse gas – contributes to climate change.

II. LITERATURE SURVEY

Vehicle exhaust emissions are a major source of air pollution, releasing harmful substances like carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NOx), and particulate matter (PM). These pollutants not only degrade the environment but also pose serious health risks. Traditionally, emissions are measured during Pollution Under Control





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(PUC) tests, which only provide a momentary reading and cannot predict future emission levels. While machine learning techniques like Support Vector Machines (SVM) and decision trees have been used to estimate emissions, they struggle to handle time-based data and often require large datasets. Recently, deep learning models like Long Short-Term Memory (LSTM) networks have gained attention because they can analyze patterns in data over time, making them suitable for real-time emission prediction. However, there is still a gap in systems that provide continuous monitoring, accurate prediction, and actionable alerts in a user-friendly format. The proposed "Emission Tracker" system aims to fill this gap using LSTM models, real-time data, and web-based dashboards for better decision-making and environmental health.

III. METHODOLOGY

1. Data Collection

The system starts by collecting real-time data from vehicle sensors. These sensors measure gases like carbon monoxide (CO), hydrocarbons (HC), and nitrogen oxides (NOx). Environmental data such as air quality and location is also collected to provide more accurate and context-aware predictions.

2. Data Preprocessing

Once the data is collected, it is cleaned and prepared for analysis. This includes removing errors, handling missing values, and selecting only the most useful information. Feature extraction methods like FFT are used to highlight important patterns in the data.

3. Model Development

An LSTM (Long Short-Term Memory) deep learning model is built and trained using the processed data. This model learns how emissions change over time and predicts the Vehicle Exhaust Emission Index (VEEI). The trained model is then deployed on a central server for live use.

4. Web Application

A web-based dashboard is developed to let users interact with the system. It shows real-time emission levels, historical trends, and predictions in a simple and clear format. Users can filter data by location, vehicle, or time.

5. Alert System

If a vehicle's emissions go above a certain level, the system automatically sends alerts. These alerts are sent to the vehicle owner and the Central Pollution Control Board (CPCB) through SMS or email, allowing quick action to be taken.

6. User Roles

Different users have different roles in the system. Admins manage the data and model. RTO officers add vehicle information and monitor emissions. CPCB officials review predicted results and take necessary actions. Vehicle owners can check their vehicle's emissions and receive alerts or certificates.

IV. EXPERIMENTAL RESULTS

To evaluate the effectiveness of the proposed Emission Tracker system, several experiments were conducted using realtime and historical vehicle emission data. The trained LSTM model was tested for its accuracy in predicting the Vehicle Exhaust Emission Index (VEEI). The results were analyzed to measure the system's performance in terms of prediction accuracy, responsiveness, and reliability in real-world conditions. The following section presents the key findings from these experiments.





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	#	PM2.5	PM10	NO	NO2	NOx	NH3	со	S02	03	Benzene	Toluene	Xylene
	1	239.54	189.8	3.12	14.6	9.98	27.35	1.2	1.57	Null	0.0	1.28	0.0
	2	121.43	164.52	8.95	59.53	35.01	32.86	0.91	2.47	56.77	1.91	3.13	Null
	3	56.05	156.52	5.25	29.32	21.42	32.86	2.11	3.50	57.03	1.95	1.42	Null
	4	50.78	111111111111	0.00	02.40	21.42	6.4.1.9	0.02	9.1 L	11.42	1.00	1.42	1 M MILL
	4	50.78 46.16	115.95	11.52	17.19	18.59	16.35	Null	9.18	16.94	0.13	2.51	0.13
	4 5 6	50.78 46.16 34.31	115.95	11.52 9.19	17.19 20.85	18.59 18.66	16.35 15.88	Null	9.18 13.97	16.94 16.28	0.13 0.1	2.51	0.13
	4 5 6 7	50.78 46.16 34.31 16.62	115.95 107.74 39.94	11.52 9.19 4.9	17.19 20.85 8.18	18.59 18.66 8.43	16.35 15.88 11.53	Null Null 0.58	9.18 13.97 6.37	16.94 16.28 12.68	0.13 0.1 0.01	2.51 2.44 1.52	0.13 0.12 Null
	4 5 6 7 8	50.78 46.16 34.31 16.62 35.91	115.95 107.74 39.94 71.26	11.52 9.19 4.9 2.94	17.19 20.85 8.18 6.99	18.59 18.66 8.43 6.19	16.35 15.88 11.53 13.53	Null Null 0.58 0.67	9.18 13.97 6.37 3.69	16.94 16.28 12.68 27.58	0.13 0.1 0.01 0.01	2.51 2.44 1.52 1.69	0.13 0.12 Null
	4 5 7 8	50.78 46.16 34.31 16.62 35.91	115.95 107.74 39.94 71.26	11.52 9.19 4.9 2.94	17.19 20.85 8.18 6.99	18.59 18.66 8.43 6.19	16.35 15.88 11.53 13.53 Memory us No. of Co No. of Ro Null Values O	Null Null 0.58 0.67 age 3198.0 lumns: 13 wws: 4264 Count: 1012	9.18 13.97 6.37 3.69	16.94 16.28 12.68 27.58	0.13 0.1 0.01 0.01	2.51 2.44 1.52 1.69	0.13 0.12 Null Null





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V. CONCLUSION

The Emission Tracker project is a groundbreaking initiative in environmental monitoring, focusing on vehicle emissions. By leveraging ******machine learning******, specifically **LSTM networks**, it predicts future emission trends, enabling proactive interventions. The **system architecture** ensures seamless data exchange among stakeholders, offering tailored functionalities through an intuitive web interface for real-time monitoring. Beyond tracking emissions, the project fosters **environmental stewardship**, encouraging **sustainable practices** and **policy reforms**. Through **data analytics and predictive modeling**, it aims to mitigate air pollution and promote a healthier, greener future.Safe& Controlled Responses — hallucination minimized via retrieval augmentation.

- Integration with Smart City Infrastructure
- Air Quality Forecasting

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