IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 2, November 2024

A Study on Role of Machine Learning: Analysis of Factor Influencing Vehicle Carbon Emission

Sindhu M[1] and Mahesh N[2]
Student, Department of CSE[1]
Assistant Professor, Department of CSE[2]
Channabasaveshwara Institute of Technology, Gubbi, Tumkur, India

Abstract: *It is essential to comprehend and reduce the variables impacting the transportation sector's increasing carbon emissions as these emissions play a major role in the global warming process. In this work, secondary data on vehicle carbon emissions is analyzed using machine learning to determine the major factors influencing emissions and evaluate their relative significance. Records on vehicle specs, driving habits, ambient conditions, and fuel kinds are examples of secondary data sources. Numerous machine learning models, such as regression analysis and feature significance techniques to rank variables according to their contribution to emissions levels, are used to investigate and forecast the impact of these elements. The results show that several variables have a significant effect on emission rates, including vehicle type, fuel economy, speed, and road conditions. The study also explores how these findings may be applied to the formulation of policies and the creation of focused emission reduction plans. This study adds to the expanding corpus of research on the use of machine learning in environmental sustainability and lays the groundwork for future investigations that may increase emission reduction efforts by utilizing real-time data and sophisticated modeling approaches.*

Keywords: machine learning

I. INTRODUCTION

The rise in carbon emissions worldwide, particularly from the transportation industry, has heightened worries about environmental sustainability and climate change. Large volumes of carbon dioxide (CO_2) and other pollutants are released into the atmosphere by fossil fuel-powered vehicles, making them one of the main sources of greenhouse gas emissions. Understanding the variables driving vehicle emissions is essential to manage and lessen their environmental effect, as urbanization and population expansion drive increased vehicle usage.

Traditionally, empirical observations and statistical analysis have been the mainstays of automobile emissions research. The many variables influencing emissions, including vehicle type, fuel economy, driving habits, road conditions, and environmental factors, are sometimes difficult for these methods to capture due to their complex and nonlinear interactions. Machine learning (ML) presents a potential way to analyze emissions and determine the main variables impacting them because of its capacity to handle big datasets and reveal hidden patterns. By processing high-dimensional data, machine learning models can uncover important links that conventional analysis would miss, leading to more accurate predictions and insights.

This paper highlights how data-driven insights may guide sustainable transportation operations, adding to the expanding body of research on machine learning applications in environmental studies. This work is a useful reference for upcoming research in machine learning and environmental policy as it highlights the value of secondary data sources and shows how current datasets can be used to address pressing environmental challenges. Decision-makers may find the research's conclusions useful in creating focused actions to reduce vehicle emissions and promote a greener, more sustainable transportation system.

VEHICLE CARBON EMISSION

Carbon dioxide (CO_2) emissions from automobiles that use fossil fuels, such as gasoline or diesel, to power their engines are known as vehicle carbon emissions. Emissions like this have a major role in global warming and air pollution. The majority of global greenhouse gas emissions are caused by the transportation sector, which includes automobiles, trucks, buses, and other vehicles. Fuel-burning produces carbon dioxide, the primary pollution that traps heat in the atmosphere and exacerbates climate change.

ROLE OF MACHINE LEARNING IN VEHICLE CARBON EMISSION

Because machine learning (ML) offers sophisticated tools for data analysis, predictive modeling, and the creation of efficient emission reduction strategies, it plays a crucial role in reducing vehicle carbon emissions. By examining both past and present data on variables like vehicle kinds, driving habits, fuel usage, and environmental circumstances, machine learning algorithms can precisely forecast emissions and pinpoint their main causes. A continuous emission monitoring using car sensors is made possible in real-time applications by machine learning algorithms. These algorithms generate notifications for high-emission events, allowing for prompt remedial action, such as changing driving habits or planning repair.

II. LITERATURE REVIEW

Vehicle emissions based on traffic circumstances and driving behaviors using machine learning models like support vector regression and random forests. Their study shows that machine learning models perform better than conventional regression methods, yielding predictions that are more precise and scalable. *Zheng et al. (2021)*

Road type, acceleration patterns, and weather have a substantial influence on emissions, according to research using gradient boosting to evaluate emissions across various vehicle kinds and driving scenarios. This study demonstrated how useful machine learning (ML) is for pinpointing important variables and serving as a foundation for focused emission reduction plans. *Li and associates (2020)*

Using sensor data from cars, an Internet of Things (IoT)-enabled machine learning system can measure emissions in real time and warn drivers of excessive emissions. Their work demonstrates how ML may improve on conventional monitoring techniques by enabling prompt remedial measures that instantly lower emissions. *Wang and Chen (2019)*

Real-time driving behavior optimization using reinforcement learning (RL), in which the system actively learned and recommended driving habits that reduced emissions. RL models demonstrated the potential of ML not just for prediction but also for intervention and control by successfully identifying eco-friendly driving practices and fuel-efficient routes. *Matsuda and associates (2022)*

Finding patterns and irregularities in emissions across a huge commercial fleet to guide more environmentally friendly fleet operations. By identifying and fixing high-emission cars before they reached critical levels, the study revealed that using machine learning (ML) for predictive maintenance allowed for considerable emissions reductions. This application of machine learning is consistent with research showing how predictive maintenance may increase vehicle longevity, lower emissions, and improve efficiency in operation. *Kumar et al. (2020)*

III. RESEARCH METHODOLOGY

This study aims to identify and quantify the characteristics that contribute most substantially to carbon production by using machine learning to assess secondary data on vehicle emissions. We look at several operational, environmental, and vehicle-related factors to identify the main sources of emissions and evaluate their relative significance. There are three goals for the research:

1. To know different machine learning models
2. To identify the elements that significantly affects emissions.
3. To know about practical ideas that might guide emission reduction measures.

IV. MACHINE LEARNING MODELS USED TO ANALYZE THE VEHICLE CARBON MISSION CONTROL

Regression Linearity

This model is frequently used as a baseline. It assists in determining the connections between independent factors (such as vehicle weight, engine size, and fuel type) and carbon emissions.

Trees of Decision

Beneficial for jobs involving regression and classification. Complex linkages and interactions between variables may be modeled using decision trees, which makes them interpretable.

Forest at Random

A group approach that blends many decision trees. By averaging the output of many trees, it decreases overfitting and increases prediction accuracy.

GBMs, or gradient boosting machine

Another group method constructs trees one after the other, fixing mistakes in each tree as it goes. XGBoost and Light GBM are two variants that are effective and potent for big datasets.

SVMs, or support vector machines

Regression (SVR) using SVM may capture nonlinear connections between emissions and features. It performs admirably in high-dimensional environments.

Networks of Neural Systems

Complex patterns in huge datasets can be captured by deep learning models, particularly feedforward neural networks. Although they need more data to function properly, they are appropriate for regression problems.

k-NN, or k-Nearest Neighbors

A non-parametric technique for regression and classification. By comparing emissions to those of other cars, it can be useful.

Clustering algorithms, such as Hierarchical Clustering and K-means

Helpful in identifying patterns and trends by grouping automobiles according to their emission characteristics.

Analysis of Time Series

Time series forecasting models, such as ARIMA and LSTM, can be used to anticipate future emissions based on previous data if emissions data is gathered over time.

Methods of Group Learning

The accuracy and robustness of emissions estimates can be improved by stacking or combining projections from many models.

V. FACTORS INFLUENCING VEHICLE CARBON EMISSION

Analysis of Time Series

Time series forecasting models, such as ARIMA and LSTM, can be used to anticipate future emissions based on previous data if emissions data is gathered over time.

Methods of Group Learning

The accuracy and robustness of emissions estimates can be improved by stacking or combining projections from many models.

Age and Type of Vehicle

Generally speaking, older cars release more CO_2 than newer models, particularly if they don't have the most latest emission control technology. Larger and heavier cars, such as SUVs and trucks, often use more gasoline and release more carbon dioxide into the atmosphere.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 2, November 2024

Type and Quality of Fuel

The kind of gasoline a car consumes has a big impact on emissions. Compared to electric cars, CO2 emissions from diesel and gasoline engines are higher. High sulfur content and low-quality gasoline also contribute to increased emissions.

Engine Performance and Upkeep

Engines that receive regular maintenance use less fuel and emit fewer pollutants. Carbon emissions may be decreased by routine maintenance, such as oil changes, filter replacements, and prompt repairs.

Weather & Temperature

Vehicles need more energy to start and warm up in colder climates, which can reduce fuel economy. The usage of heating or air conditioning during severe weather also raises emissions.

Vehicle Load

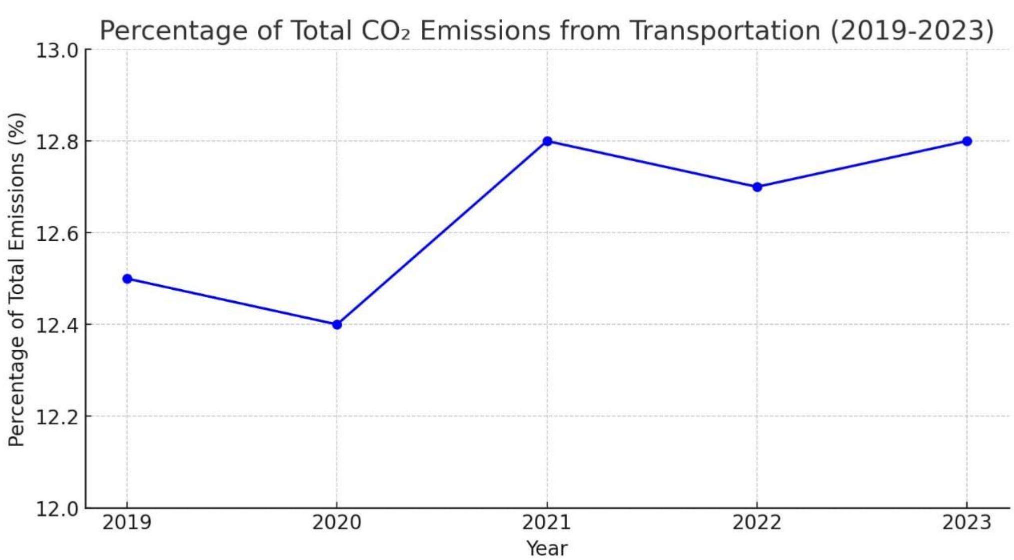
A car with a lot of cargo needs more power to run, which raises pollutants and fuel consumption. Fuel economy may be improved by cutting out on superfluous freight.

Terrain & Road Conditions

Compared to driving on level, smooth roads, driving uphill or on uneven terrain uses more gasoline. Higher emissions result from more frequent braking and accelerating on bad roads

India's total CO_2 emissions and the transportation sector's contributions over the past five years:

Year	Total CO_2 Emissions (Million Metric Tons)	Transportation Sector Emissions (Million Metric Tons)	Percentage of Total Emissions from Transportation
2019	2,400	300	12.5%
2020	2,200	272	12.4%
2021	2,500	320	12.8%
2022	2,600	330	12.7%
2023	2,650	340	12.8%



India's CO_2 emissions showed a notable increase trend between 2019 and 2023, with the transportation sector making a continuous contribution. Transportation accounted for 300 million metric tons (12.5%) of the 2,400 million metric tons of emissions in 2019. In 2020, transportation emissions dropped to 272 million metric tons (12.4%), while emissions temporarily decreased to 2,200 million metric tons due to the COVID-19 epidemic. The economy's recovery led to a significant increase in emissions, which in 2021 reached 2,500 million metric tons, with 320 million metric tons coming from transportation (12.8%). With 2,600 million metric tons of emissions overall and 330 million metric tons (12.7%) from transportation, the trend persisted in 2022. Total emissions increased to 2,650 million metric tons by 2023, of which 340 million metric tons (12.8%) came from the transportation sector. These numbers demonstrate the pressing need for sustainable practices and efficient regulations to cut emissions, especially in the transportation sector, which contributes significantly to the total amount of carbon produced.

VI. IMPORTANCE OF MACHINE LEARNING IN CONTROLLING VEHICLE CARBON EMISSION

Predictive Emission Monitoring

To forecast emission levels, machine learning algorithms can examine trends in fuel consumption, driving circumstances, and vehicle performance. This makes it possible to identify cars or driving habits that are likely to result in excessive emissions early on and take preventative action.

Optimizing Traffic Flow

ML is used to improve traffic flow, control traffic lights, and lessen congestion. Real-time traffic pattern analysis using ML models can reduce stop-and-go driving, which lowers pollutants and fuel consumption in cities.

Vehicle Routing and Scheduling

ML algorithms can optimize vehicle routing and scheduling for delivery and logistics organizations, ensuring that vehicles avoid crowded locations and travel shorter routes, hence lowering emissions and fuel consumption.

Eco-Driving Assistance

By monitoring and giving drivers immediate feedback on their driving habits, in-car machine learning (ML) systems can encourage drivers to adopt fuel-efficient habits including smooth acceleration, appropriate speed, and little idle, all of which lower emissions.

Predictive maintenance

Machine learning keeps engines and emissions-control systems in top condition by using machine learning (ML) algorithms to evaluate vehicle data and forecast maintenance requirements. Vehicles that receive regular maintenance use less fuel and produce less pollution.

EV Battery and Energy Management

Machine learning (ML) can improve battery and energy use for electric cars (EVs), increasing EV efficiency and range. ML assists in lowering energy waste and emissions that are indirectly linked to the power grid by controlling the charging process and forecasting energy requirements.

Fleet Emission Monitoring and Compliance

Fleet operators utilize machine learning (ML) to track emissions data in real-time throughout their whole fleet. This facilitates the identification of high-emission automobiles that could require replacement or modification, as well as compliance with environmental standards.

Smart City Integration

By combining data from several sources, such as traffic, weather, and road conditions, machine learning (ML) helps smart city projects by promoting public transportation and designing low-emission zones. This lessens the need for high-emission cars and helps create a sustainable urban environment.

IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

Impact Factor: 7.53

Volume 4, Issue 2, November 2024

VII. CONCLUSION

In summary, by offering sophisticated, data-driven solutions, this study emphasizes the critical role that machine learning plays in assessing and reducing vehicle carbon emissions. Machine learning models provide important insights into emission sources and behaviours that may be enhanced by looking at important aspects that affect emissions, such as vehicle type, fuel quality, driving habits, and road conditions. These insights make it possible for eco-driving assistance, traffic flow management, predictive maintenance, and effective route optimization—all of which have a major positive impact on lowering carbon emissions. Additionally, machine learning facilitates real-time emissions monitoring, helps legislators create efficient environmental regulations, and encourages the use of sustainable transportation methods, all of which contribute to regulatory compliance.

A significant decrease in emissions is made possible by the use of machine learning in the transportation industry, which also encourages the development of innovative low-emission solutions. In addition to encouraging ethical vehicle usage and production methods, this supports global environmental goals. Overall, machine learning offers a strong foundation for further initiatives to lessen the negative effects of transportation on the environment, making it a crucial instrument for building a more sustainable and greener future.

REFERENCES

[1]. Sarkar, K., Chakrabarti, S., Pilla, F., Basu, B., Basu, A. S., Sannigrahi, S., and Roy, P. S. (2020). Using remote sensing techniques to investigate how forest fires in India affect terrestrial carbon emissions and ecosystem productivity. j.scitotenv.2020.1383, Science of the Total Environment, 138331. doi:10.1016

[2]. Angulo-Meza, L., Iriarte, A., Rebolledo-Leiva, R., and González-Araya, M. C. (2017). Combined data envelopment analysis with carbon footprint assessment to lower greenhouse gas emissions from agricultural operations. doi:10.1016/j.scitotenv.2017.03.1 Science of the Total Environment, 593–594, 36–46

[3]. Li, J., Gautam, A., Sun, S., Li, L., Wu, Z., & Zhao, W. (2020). Industrial air pollution emissions fluctuate according to VIIRS thermal anomaly data. 10.1016/j.atmosres.2020.10502, Atmospheric Research, 105021

[4]. Chen, Y., and Luo, L. (2020). An analysis of the energy management of carbon emissions in the construction of LCA-based fabricated buildings. doi:10.1016/j.suscom.2020.100405, Sustainable Computing: Informatics and Systems, 100405.

[5]. Shougat Hossain, Rahul Amin Sujon, Nazrul Islam, and Ali Newaz Bahar1 (2015). Nevşehir Bilim ve Teknoloji Dergisi Cilt 4(2) 99-107 (2015), "A Novel Automation Approach for Fuel Station Management System," DOI: 10.17100/nevbiltek.210935, URL: http://dx.doi.org/10.17100/nevbiltek.210935

[6]. Nuzhat F. Shaikh and R. Kale (2024). Smart fuel management and IoT-enabled vehicle-based carbon emission forecasting: maximizing effectiveness and performance. February 24, 2024, 12(19s), 161–167, International Journal of Intelligent Systems and Applications in Engineering (IJISAE), ISSN: 2147-6799214,

[7]. Khandare, A., Patil, M., Jadhav, A., Choubey, N., Dahake, R., and Dhotre, D.R. (2024). Machine Learning-Deep Learning techniques and ranking-based similar image retrieval from large datasets are used for multi-class classification of brain diseases. 12(1s), pp. 771–782, International Journal of Intelligent Systems and Applications in Engineering.