v. 4, n. 10, 2024

Journal of Engineering Research

SOFTWARE TO MODEL THE POLLUTION GENERATED BY CO_2 EMISSION BY AUTOMOBILES IN MEXICO CITY

Brenda Ivonne Serna Del Razo
Systems Department, computer systems area, ``Universidad Autónoma Metropolitana``, Unidad Azcapotzalco, Mexico

Marco Antonio Gutiérrez Villegas
Systems Department, computer systems area, ``Universidad Autónoma Metropolitana``, Unidad Azcapotzalco, Mexico

Esiquio Martín Gutiérrez Armenta
Systems Department, computer systems area, ``Universidad Autónoma Metropolitana``, Unidad Azcapotzalco, Mexico

Josué Figueroa González
Systems Department, computer systems area, ``Universidad Autónoma Metropolitana``, Unidad Azcapotzalco, Mexico

Alfonso Jorge Quevedo Martinez
Computer Systems Engineering Division, TESE- TecNM, Mexico

Lourdes Sánchez Guerrero
Systems Department, computer systems area, ``Universidad Autónoma Metropolitana``, Unidad Azcapotzalco, Mexico

Israel Isaac Gutiérrez Villegas
Department of Administration, Mathematics and Systems area, ``Universidad Autónoma Metropolitana``. Unidad Azcapotzalco, Mexico

Juan Manuel Figueroa Flores
Department of Engineering and Social Sciences, Higher School of Physics and Mathematics -IPN, Mexico

Abstract: Air pollution, driven by vehicle emissions, is a serious problem in Mexico City. Emissions modeling, focused on CO_2 and supported by graphics, is presented as a tool to understand and analyze the magnitude of the problem. The proposed modeling considers various factors, such as the duration of the journeys, the brand of the vehicles, the type of fuel they use, the route they travel on and the number of cars on it.
Through graphs, modeling provides estimates and reveals trends in emissions over different periods. The model creation process involves collecting information provided by users. The least squares technique is applied to fit the line to the recorded CO_2 emissions data. The data visualization includes a pie chart to show the proportion of CO_2 emissions by vehicle brands, a bar chart to represent the estimated number of vehicles on the road by month, and a line chart to illustrate how emissions change over time, identifying patterns and trends. Upon completion, a final report is prepared that synthesizes the results, providing clear and understandable information on the emissions calculations for end users. This approach seeks to guide actions to reduce emissions and facilitate understanding of the situation.

INTRODUCTION

Air pollution is a major environmental problem worldwide, with polluting gas emissions generated by vehicles being one of the main causes of this situation in cities. In the case of Mexico City, the situation is particularly alarming due to the increase in vehicular traffic, which translates into longer circulation times and the consequent emission of polluting gases by internal combustion engines, which use fossil fuels such as gasoline and diesel, which negatively affect air quality and, therefore, the health of the population.

In this context, modeling polluting gas emissions from automobiles in Mexico City

becomes a crucial tool to understand the problem and take effective measures to reduce them. Following this line, it is important to highlight that modeling facilitates a simpler understanding of the pollution phenomenon in Mexico City. In order to present the results in a clear and visual way, various types of graphs will be used to show changes and patterns in the data.

Modeling CO_2 emissions from vehicles in Mexico City is essential to address environmental problems. It allows you to precisely visualize the impact of emissions, understanding their magnitude. Estimates emissions considering trip duration, vehicle brand, fuel, routes and number of vehicles. This identifies the most polluting fuels, guiding actions to reduce emissions and improve quality of life. This model can provide the amount of CO_2 produced per month.

Among the gases emitted in greater quantities by vehicles are carbon dioxide, carbon monoxide, nitrogen oxides, sulfur oxides and fine particles. However, in this study carbon dioxide CO2 will be specifically analyzed because its polluting impact is greater than the others. It must be noted that this does not imply that other gases are unimportant.

Exposure to these pollutants can cause health problems such as respiratory and cardiovascular diseases. Therefore, it is important to develop strategies to reduce polluting gas emissions from vehicles and improve air quality in Mexico City. Modeling emissions of polluting gases from automobiles can be a valuable tool to achieve this goal.

DEVELOPMENT OR METHODOLOGY

Software was developed in the Java programming language using libraries such as Java Swing, Apache POI, and IText. This software is made up of various graphical interfaces. The welcome window will contain a main menu that will provide access to various system functionalities, such as data logging, emissions calculation, data visualization, report generation and log cleaning. Data that will be used for the development of the article.

FUEL TYPE

In the context of the presented project, the user has the ability to select between two fuel type options, based on data obtained from reliable sources [4]. Specifically, it is established that one liter of diesel produces 2.68 kg of CO_2, while one liter of gasoline generates 2.31 kg of CO_2.

FUEL CONSUMPTION

Fuel consumption is directly related to the make and model of the vehicle. For this, specific consumption data was collected for a total of 289 models of the brands Acura, Buick, Cadillac, Chevrolet, GMC, Honda, Kia, Mercedes-Benz, MG, Mitsubishi, Renault, Stellantis, Suzuki, and Renault (test). This information has been extracted from the report "Fuel performance in light vehicles sold in Mexico 2023" [6].

It is relevant to highlight that Renault (test) has been specifically included in the data set and has been used as a test model to validate the operation of the developed system.

ROUTES

The busiest avenues were deliberately selected as a fundamental part of data collection. In addition, a test route was incorporated to evaluate and validate the

developed system. The distances used in these routes were obtained from Google [8].

SELECTED AVENUES

- Test1 - Distance: 6 km (kilometers)
- Insurgentes Avenue - Distance: 29 km (kilometers)
- Interior Circuit Avenue - Distance: 40 km (kilometers)
- Constituciónntes Avenue - Distance: 14 km (kilometers)
- Chapultepec Avenue - Distance: 7 km (kilometers)
- Paseo de la Reforma - Distance: 14 km (kilometers)
- Miguel Alemán Viaduct - Distance: 20 km (kilometers)

NUMBER OF VEHICLES

The number of vehicles traveling in Mexico City was obtained monthly from 2018 to 2023. These data were extracted from the National Institute of Statistics and Geography (INEGI) [9], providing essential information to graphically represent the evolution of traffic. over time.

The least squares method was used to fit the observed data (discrete case) to a curve (continuous case).

DESCRIPTION OF THE GRAPHICAL INTERFACES USED IN THE MODELING SYSTEM

The data logging interface allows the user to enter relevant information that is used later. Here, the user enters data such as outbound trip time, return trip time, overtime, and regarding fuel consumption, selects from a combo box among the 14 available car brands, also choosing the model. Likewise, choose the type of fuel between gasoline and diesel, and as for the routes, select between six avenues preselected as the most traveled. Also, enter the corresponding number of vehicles. This data is stored in a database for later consultation. This interface is shown in Figure 1-

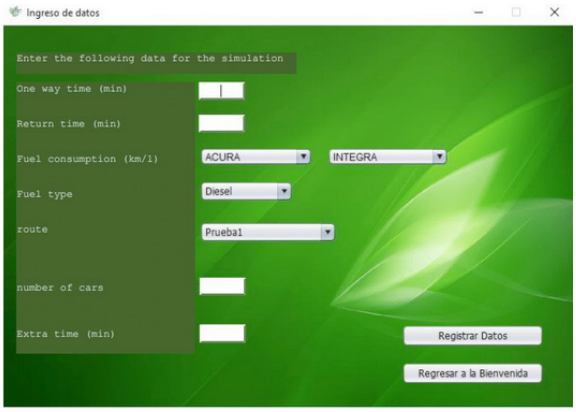

Figure 1. Data Record Window

Once the user has completed the task of recording their data, they select the "Emissions Calculation" button. By doing so, you are redirected to the corresponding interface, where all the records made are displayed and detailed information about the emissions generated based on the data entered is obtained.

Later, by clicking on the button called "Full time vs. Total CO_2 emission", which, when activated, takes the user to the interface where a table is presented that shows the variables CO_2. The table reveals the sums by column and presents the equation, an estimate using the least squares method to fit a line to the data.

Then, the Data View button, which leads to an interface where three graphs are displayed, each offering relevant information.

The pie chart or pie chart presents, based on the data provided by the user, each vehicle brand with a distinctive color, additionally providing the name of each brand along with the percentage it represents in terms of CO_2 emissions. This visual representation facilitates the identification of the most polluting brand,

allowing a quick and clear understanding of the contribution of each brand to total CO_2 emissions. This can be seen in Figure 2.

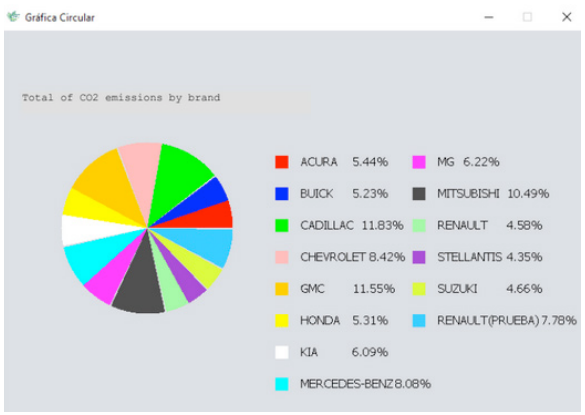

Figure 2. Graph representing the percentage of CO_2 of the vehicles used

In the bar graph interface, a graph is displayed that uses the data from the previous graph to identify the most polluting brand, looking for the maximum value to make the estimate. The graph is shown based on the selected year, and below each month the number of vehicles is indicated, while above it is represented the amount of emissions that would be generated with that number of cars per month. This visual representation allows the user to clearly observe the variation of emissions over time, providing a detailed perspective of the relationship between the number of vehicles and the emissions generated. This is shown in Figure 3.

Figure 3. Bar graph shows CO_2 emission per month, you can choose the year.

By clicking on the corresponding button, an Excel document is generated that incorporates the line graph. In this representation, the X axis reflects the entire time in blue, while the Y axis illustrates CO_2 emissions in orange. This Excel document provides a visual tool to analyze the dynamic relationship between time and CO_2 emissions. This is shown in Figure 4.

Figure 4. Line graph showing emissions over time.

Finally, the report interface is displayed. When you click on the corresponding button, the report interface is displayed with the message "Report created successfully". This report generates a PDF document containing essential information. Includes a detailed table with log information provided by the user. Next, a table is presented that illustrates the calculation of emissions for each record. In addition, a least squares table is incorporated for the relationship between full time and total CO_2 emission. At the end of the document, the estimated equation based on the user's data is provided, along with an explanation of it.

This report serves as a comprehensive document that summarizes and analyzes

the information collected, offering the user a detailed view of the records, emissions calculations and the temporal relationship between full time and CO_2 emissions.

DISCUSSIONS AND RESULTS

In the previous section, it was evident that the results were obtained through the analysis of test data, which represent a reduced sample that illustrates the usefulness of the tool used. The crucial performance of graphs in interpreting and presenting the collected information was highlighted, especially through the use of the least squares estimation module. The latter provided a mathematical tool that allowed us to understand the relationship between total driving time and CO_2 emissions.Carbon dioxide

The generated graphics, such as the pie chart, played an essential role in facilitating the visual identification of the most polluting brand, simplifying the evaluation of each brand's contribution to emissions. The bar graph, derived from the information in the pie chart, revealed the temporal evolution of emissions in relation to the number of vehicles, while the line graph in Excel provided a visual representation of the variation in emissions over time. weather. These visual tools offer the user the ability to easily interpret trends, providing essential information for decision making.

It is crucial to recognize that the emissions obtained are estimates and may be influenced by external factors such as traffic and weather. Variability in these external conditions can affect the precision of the estimates, and this point must be considered when interpreting the results.

In terms of recommendations for future research, it is suggested to expand the database to include a more diverse set of makes and models, as well as explore the variability in emissions under different traffic conditions.

ANALYSIS AND RESULTS

One of the problems that Mexico presents is environmental pollution, this is not only the country but the entire world, because fossil fuels, coal and other materials that are produced when burned are carbon dioxide, which is the that pollutes too much, just as the documents reviewed are the only ones that give an approximation per liter of fuel of the amount of pollution that is released from it, this does not mean that the others are not important or that they do not cause diseases, they may even be more serious for health, so this is used to make an approximation, tons of this contaminant are obtained in the country each year, so if a generation is carried out, millions of tons of this contaminant alone would be obtained throughout the world. CO_2

CONCLUSIONS

In conclusion, this project ranges from data collection, generation of a model and visual presentation of results. With this, an effective tool has been provided to understand and analyze air pollution in Mexico City. The use of test data has made it possible to demonstrate the functionality of the system, highlighting its usefulness to visually represent CO_2 emissions over time, identify the most polluting brands and make estimates using the least squares method. The results obtained and the tools developed provide a basis to continue exploring and addressing the problem of vehicular pollution in urban environments. This integrated approach contributes to the understanding and awareness of the importance of implementing effective strategies to reduce emissions in Mexico City.

REFERENCES

[1] L.Nicolás Lázaro, "Simulation of a vehicular traffic model in an unsignalized intersection using cellular automata," Terminal project, Division of Basic Sciences and Engineering, Universidad Autónoma Metropolitana Azcapotzalco, México, 2009.

[2] JO Avila Romero, "Simulation of vehicular traffic within a roundabout using cellular automata," Terminal Project, Division of Basic Sciences and Engineering, Universidad Autónoma Metropolitana Azcapotzalco, México, 2009.

[3] AND.González Valladolid, "Modeling of transport and dispersion of pm2.5 and pm10 particles using an Eulerian model at the mesoscale level in the region of the metropolitan area of Mexico City," Research project to obtain the degree of Master of Science and Engineering Environmental, 2003.

[4] Michelin. (October 27, 2022) Calculate co2 emissions. [On-line]. Available: https://connectedfleet. michelin.com/blog/calculate-co2-emissions

[5] A. Insurance. (Unknown) Affects bycdmx traffic. [On-line]. Available: https://ahorraseguros. mx/auto-insurance/transito/trafico-df/#Affectations by CDMX Traffic

[6] government ofMexico. (2022/12) Fuel efficiency in light vehicles sold in Mexico 2023. [Online]. Available: https://www.gob.mx/cms/uploads/attachment/file/789520/ Cat logo de Rendimientos 2023 Ver22.12.pdf

[7] Rentingfinders. (2023) Co2 emissions. Consultation carried out on December 30, 2023. [Online]. Available: https://rentingfinders.com/glosario/emisiones-co2/

[8] Google Maps. (2023) Google maps. Consultation carried out on December 30, 2023. [Online]. Available:https://www.google.com/maps/dir///@36.704605,-4.459998,16z?hl=es-ES&entry=ttu

[9] National Institute ofStatistics and Geography (INEGI). Economy and productive sectors. Consultation carried out on December 30, 2023. [Online]. Available: https://www.inegi.org.mx/temas/vehiculos/