Visual Exploration of Electric vehicles and CO2 Emissions

DS808 - Visualization
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1 Introduction

Since its creation, automobiles have contributed to the pollution of our planet, primarily due to carbon dioxide (CO2) emissions. Approximately 20 percent of all CO2 emissions globally are attributed to road traffic (Muniamuthu et al., 2018). Electric vehicles have seen substantial growth, since their numbers together with plug-in hybrid electric vehicles (PHEVs) have tripled in quantity from 2012 to 2017(ibid). Unlike traditional gasoline cars, electric vehicles do not produce tailpipe emissions when driving, however, there are other ways electric vehicles contribute to the destruction of our environment. These include emissions from the manufacturing process and battery production. Choosing the right vehicle for environmentally conscious people can be difficult due to factors such as CO2 emissions, energy consumption, and the impact on production. Visualization can help this decision making by visualising data through charts or interactive maps to help individuals make the right decision. The purpose of this paper is to explore and visualize EV's specifications and the environmental implications of different EV models, allowing users to compare these models and relate the emissions to gasoline vehicles. The goal is to help environmentally conscious consumers decide which vehicle would be the right choice for them. This will be presented through an interactive dashboard that will allow users to change between different models.

2 Data Description

Our data is mainly collected from 3 sources, kaggle, ev-database and uppladdning. The data from Kaggle was originally sourced from the EV-Database, and provided detailed information about EV cars and specific attributes (EVs - One Electric Vehicle Dataset - Smaller, 2020). Using the ev-database we decided to add data regarding the cars driving range during "mild" and "cold" weather conditions, battery size as well as updating the stated range (ev-database, n.d.), since these attributes was not available on the website when the dataset was created in 2020. In total, the dataset include 102 different EV's divided into 6 categories based on the vehicle's body type. The included EV's vary widely in size, efficiency and maker which gives the user of the dashboard a wide selection of cars to choose and compare. Uppladdning was used to gather information about where public charging stations are available in Denmark. Uppladdning is a Scandinavian website that has data for charging stations from several countries and amongst them is Denmark. The data was downloaded and stored in a json-file with all the coordinates for stations in Denmark (Shishkov, n.d.). The project also includes calculations that visually compare EV's, petrol cars, and diesel cars, based on their carbon emissions. These calculations are based on parameters entered by the user, estimated future emission factors, and real-world factors used by the author Perkild (2023).

3 Methodology

Several models have been developed for introducing the foundational stages of creating visualisations. The Visualization Reference Model by Card (1999) emphasizes the flow of data through stages of transformation to views that show different parts of the visual structures. Keim et al. (2008) extends the idea of visualization through The Visual Analytics Model, and accounts for the lack of iterations or redesign steps.This model incorporates an iterative cycle highlighting the relationship between data analysis and user exploration. In this project the Four Nested Level Design Model by Munzner (2014) has been used as a framework for developing the visualization. The model allows us to recognize upstream and downstream threats that might occur and account for them during the development of the project. Jänicke et al.(2020) further extended the model and developed the Participatory Visualization Design Model, which implemented feedback loops between the levels of development, allowing for the target users to evaluate if plans and designs were appropriate and practical for the target users. However, for the development of this project, there was limited access to the target users, making it challenging to incorporate real-world feedback into the development process. The target users for the visualization, which were environmentally conscious car buyers remained hypothetical. Because of this restraint we decided to use Munzners Model for the development of this project.

4 Data and Task Abstraction

The dataset from kaggle had many attributes, however we also would like to see how the EV-cars performed in different weather conditions. The dataset lacked this attribute and due to the fact that ev-database.org did not allow for webscraping we had to put in these attributes manually (ev-database. n.d.). Our dataset consists of 102 unique EV models, with attributes including bodystyle, Combined Cold, Combined Mild, battery size, Range(Km(, topspeed(KmH), and efficiency(WhKm). The dataset includes a combination of quantitative and nominal variables. The quantitative data consists of both integers and floating-point numbers, while the nominal variables are represented as strings. Although additional attributes were available in the dataset, we decided that they did not contribute meaningful insights for the aim of this project and were therefore excluded from further investigation. The other data source we used was the excel sheet to calculate how much Co2 an electric car produces in comparison to a petrol or diesel car. We also used the data from Uppladning for the geographical placement of charging stations (Perkild, L. P. 2023). Both these files contain numerical data. The task abstraction for this project aims to explore and visualize the environmental impacts of various EV models, providing users with the ability to compare these models and relate their emissions to those of gasolinepowered vehicles. We wanted to bring awareness to the consumer from the chosen visualization tools we have selected. The tools visualise different important attributes that a consumer might find helpful to determine which car is the greenest alternative.

5 Visual encoding and Interactions

This project consists of 4 visualizations/main components: EV map (A); sunburst diagram for choosing a car (B); radar chart for comparing car specifications (C); time series chart for vehicle parameters and comparing CO2 emissions (D). The components are visualized using marks such as “Points”, ”Lines”, and “Areas”. In component B the user can choose between 6 different types EV types. To distinguish between the car types we have used the visual channel of color hue as a categorical attribute encoder. Furthermore, we use angle as a magnitude channel, meaning that larger angles for an EV type and car maker correspond to larger counts. When a car is chosen in component B the specifications for the car will be loaded in component A, C, and D. Component A show the EV’s range from a chosen point and the user can furthermore toggle between cold and mild weather conditions to see the change in projected range. The map uses channels like color hue to highlight the different driving ranges, and color luminance and point marks for the heat map showing the charging stations. In component C the user can then choose another car model to compare the specifications of the 2 models. Color hue is used as an identity channel and the position from the center of the chart is used as a magnitude channel for the variables. The purpose of component D is to compare the CO2 emissions of the chosen EV, with petrol and diesel cars over time. Therefore, the battery size of the chosen EV will be loaded based on the choice in component B, and the user can specify other parameter details to make the comparison. For this visualization, points and line marks are used as well as a color hue identity channel to differentiate between the fuel types.

6 Future Works

In future works, the Implementation of Jänicke et al.’s (2020) model could enhance the development of the visualization by allowing user evaluations and using these to develop a visualization that is closer aligned with the needs of the target user. Furthermore in future works, the inclusion of price data, should be prioritized. Including price in the visualization would allow users to better evaluate the different trade-offs between cost, environmental impact, and performance of the different vehicles. The inclusion of similar data for gasoline cars in future works could help the users decide on a new model. Car owners transitioning from gasoline cars to EV’s could use the visualization to compare models to their current gasoline car, in order to decide on what EV would be best to replace their current car.

7 Conclusion

The project aimed to assist environment conscious individuals in selecting vehicles through an interactive dashboard consisting of connected charts and graphs. A limitation of this project is the absence of price data, which is considered as an important attribute for potential car buyers. The goal of the Project was achieved through 4 visualization components, assembled as one interactive dashboard allowing the user to compare model specifications and fuel types to decide on the right vehicle.

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