CS 732: Data Visualization Assignment 3

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I. Dataset

For this assignment, we worked with Electric Vehicle Title and Registration Activity [2] [3]. This dataset shows the title activity of Battery Electric Vehicles (BEVs) and Plug-in Hybrid Electric Vehicles (PHEVs) that are currently registered through the Washington State Department of Licensing. The major variables in our dataset are -

- **Clean Alternative Fuel Vehicle Type** : BEV or PHEV
- **Make** : The manufacturer of the vehicle
- **Model** : The model of the vehicle
- **Model Year** : The model year of the vehicle
- **New or Used vehicle** : Vehicle state at the time of registration
- **Sell Price** : The selling price of the model
- **Electric Range** : The range of the vehicle (in miles)
- **City & County** : Residence of vehicle owner
- **Transaction Year** : The year upon which the transaction was recorded with Department of Licensing.

We used the same dataset for Assignment-1. Some additional datasets were explored but we were unable to find more datasets which exclusively contained information about EVs in Washington State.

II. Visual Analytics Tasks

Visual analytics involves employing sophisticated tools and processes to analyze datasets using visual representations, such as graphs, charts, and maps. This method helps users identify patterns and develop actionable insights from the data. Figure 1 illustrates a typical visual analytic workflow, demonstrating the integration of visualization and data analysis and highlighting a clear feedback loop. For this assignment, it is essential to draw inferences from the dataset, leading to its transformation and initiating a subsequent iteration of the visual analytics workflow. To minimize self-loops, the feedback loop can be alternatively depicted by ”unrolling” the workflow diagram.

III. Visual Analytics workflow 1

A. Initial Visualizations

We initiated our visual analytics exploration with the first iteration, generating visualizations to identify patterns patterns within our dataset. Figure 2 shows a histogram depicting the distribution of selling prices for electric vehicles (EVs) across Washington State. Additionally, we created violin plots (Figure 3) showing the selling prices of the top 8 EV manufacturers, identified by units sold. The histograms were made using Tableau and the violin plots were created using the Seaborn library in Python.

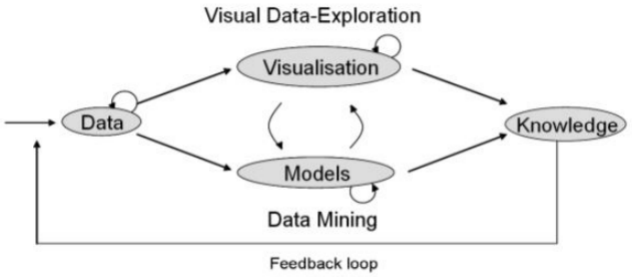

Fig. 1. Tight integration of visual and automatic data analysis methods with database technology for scalable interactive decision support

To refine our analysis, we applied filters to exclusively consider new vehicles and focused on ”Original Transactions” to eliminate duplications, recognizing the potential impact of multiple registrations.

To refine our analysis and clean our data, we applied filters to exclusively consider new vehicles and focused on ”Original Transactions” only. This was done because a vehicle may be registered many times and we wanted to avoid duplicate entries.

B. Feedback/Knowledge

Immediately from Figure 2 we can infer that there is a concentration of vehicles with selling prices in the 0 to 10k dollar range, which is unlikely considering the average prices of EVs. This anomaly originated from instances where the selling price was unavailable, necessitating the use of 0 as a placeholder — an issue previously highlighted in Assignment-1. Simultaneously, observations from the violin plot in Figure 3 reveal records with a selling price of 0 for all major manufacturers, indicating that this issue is not localized to a single model or manufacturer.

C. Data Mining

To take care of missing values in our visualizations, the first option we considered was to drop those rows. However there were more than 20k such rows, and dropping all of them might affect our further analysis. Therefore, we decided to use Supervised Machine Learning methods address this issue.

We used the existing data to train a ML model and used that to predict the selling price of a vehicle. We first identified

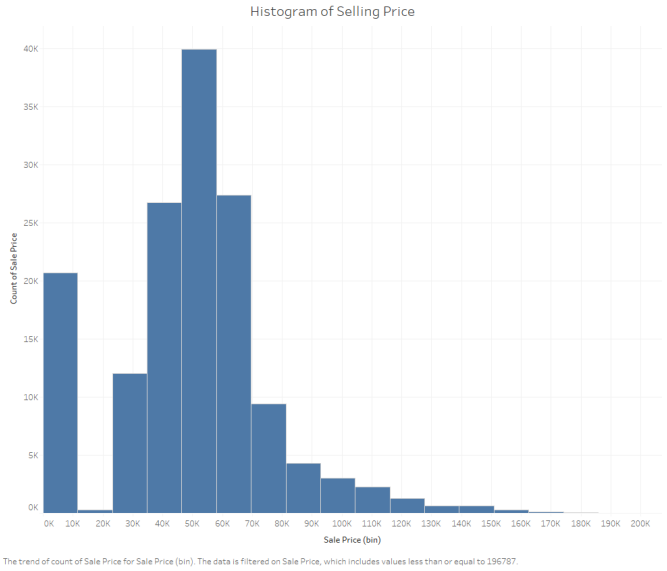

Fig. 2. Histogram of Sale Price of EVs across Washington State

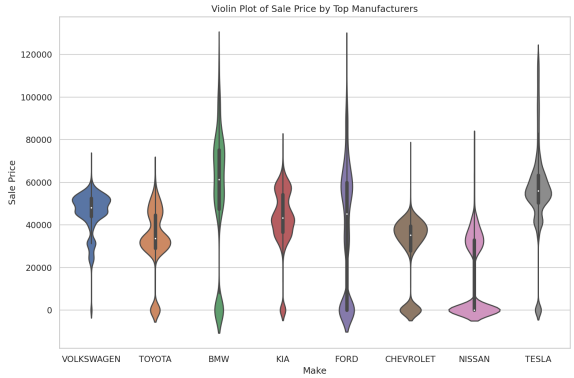

Fig. 3. Violin Plot of Sale Price by Top Manufacturers

and dropped non-influential columns, i.e. columns which have little or no correlation with the selling price. We visualized the correlation matrix using a heatmap with a "coolwarm" diverging colormap to distinguish between positive and negative correlations, as shown in Figure 4. We notice that columns such as City and County, have no correlation with the selling price, because unlike real-estate prices, vehicle prices are likely to remain same across geography. Features which most impact the selling price of a vehicle are model year, fuel-type, make and model, base MSRP and transaction year.

We initially used sklearn to train a simple Linear Regression model after applying Principal Component Analysis (PCA) for dimensionality reduction (PCA also serves as an outlier removal technique). Using Linear Regression, we got a mean absolute error (MAE) of about 18000, which is quite high. Employing Ridge and Lasso regression for regularization didn't yield substantial improvements, prompting a shift to a Neural Network (using pytorch). A straightforward neural architecture

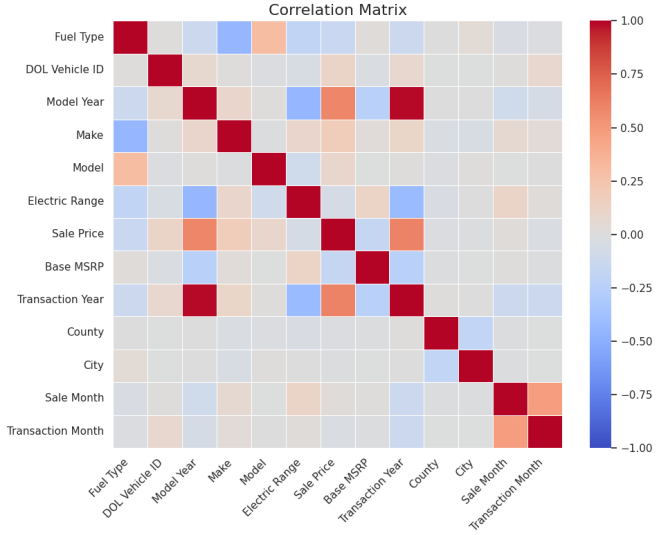

Fig. 4. Correlation Matrix of all the columns

of 3 layers (64, 128, 64 layers) significantly reduced the MAE to approximately 8000. Our error was still decreasing when we stopped our training process, so there is potential for further error reduction through extended training and experimenting with different architectures.

After training our model, we transformed our dataset by replacing the missing selling prices with our predicted values.

D. Improved Visualizations

With the transformed dataset, we plotted our initial visualizations again (Figure 5 & 6). As expected, the distribution of selling prices is much more uniform. Moving forward, we will use this transformed dataset for our second visual analytics workflow.

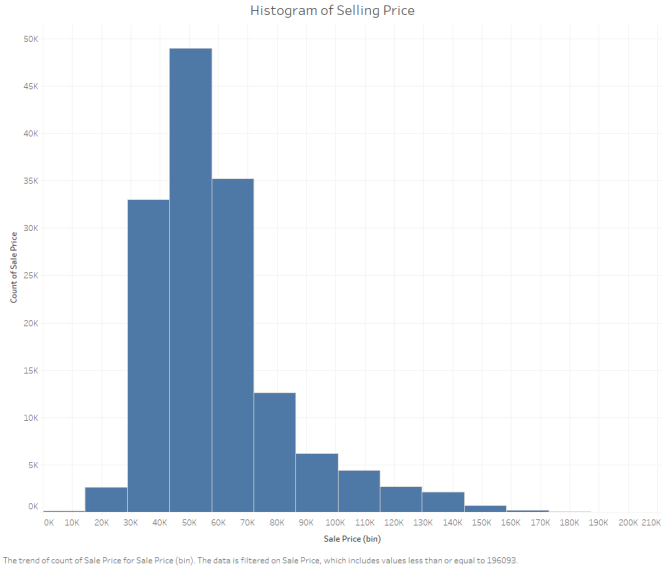

Fig. 5. Histogram of Sale Price of EVs (transformed dataset)

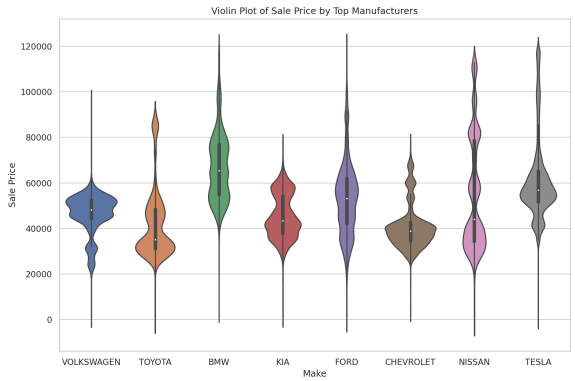

Fig. 6. Violin Plot of Sale Price by Top Manufacturers (transformed dataset)

E. Unrolled workflow diagram

Figure 7 shows the first iteration of our unrolled workflow diagram.

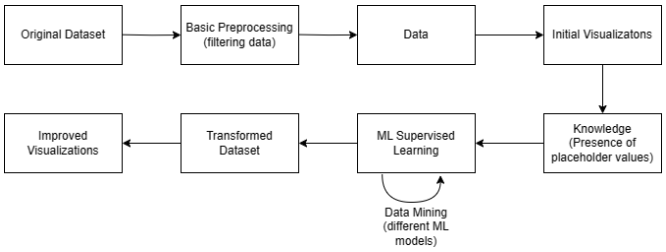

Fig. 7. Workflow diagram for Visual Analytics Task 1

IV. Visual Analytics Workflow 2

A. Task

The primary goal is to delve into the reasons why certain Battery Electric Vehicle (BEV) companies outshine their counterparts in the Plug-in Hybrid Electric Vehicle (PHEV) domain, aligning with the objectives outlined in Task 3 of our A1: Compare and analyze trends between BEVs and PHEVs. The focus will be on leveraging the Sales Price column for visualization to draw meaningful insights.

B. Preprocessing

For this task, we used the transformed dataset from Workflow 1, which handled the issue of null values in Sales Price. Some additional preprocessing and data filtering was done as required.

C. Statistical Analysis

To set the stage, violin plots illustrating Electric Range versus Clean Alternative Fuel Vehicle Type were crafted (Figure 8). Previous findings have solidified the argument that BEVs, with their higher efficiency and lower ownership costs, outperform PHEVs. However, a deeper dive into specific companies, such as Tesla and Nissan in the BEV sector, and Volvo in the PHEV sector, reveals nuances in their Sales Price distributions (Figures 9, 10, 11, 12). This analysis underscores the influential role of Sales Price in the dominance of certain companies within their respective electric vehicle categories. See TESLA it is offering its vehicles at a very low median Sales Price, whereas if you see Hyundai it is offering its vehicles at a higher price and is a PHEV which offers less Electric Range that is why it is not preferred by People of Washington.

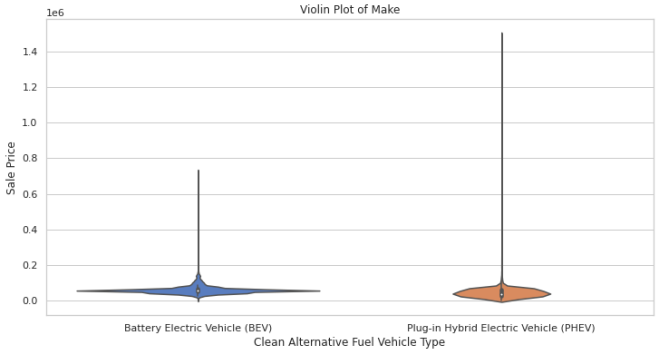

Fig. 8. Violin Plot of Sale Price vs BEV and PHEV

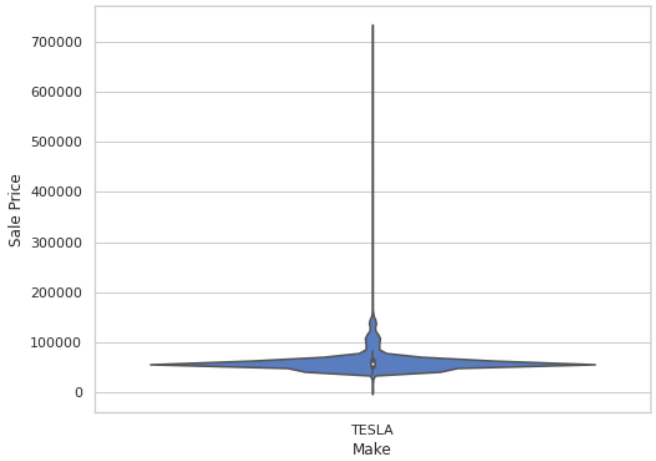

Fig. 9. Violin Plot of Sale Price vs BEV: TESLA

D. Visualization

The visualization began with a bar chart elucidating the distribution of BEVs and PHEVs (Figure 13). Subsequently, a more intuitive and visually appealing pie/donut chart was introduced to emphasize the proportionality of the distribution. These visualizations served as a foundation for understanding the broader market dynamics(Figure 14).

In attempting to illustrate the distribution of companies within the landscape, we initially employed a treemap to showcase the dominance of various makers in the market. However, the treemap proved challenging to interpret as it became cluttered with extensive text, making it difficult to discern which maker corresponded to each company (Figure

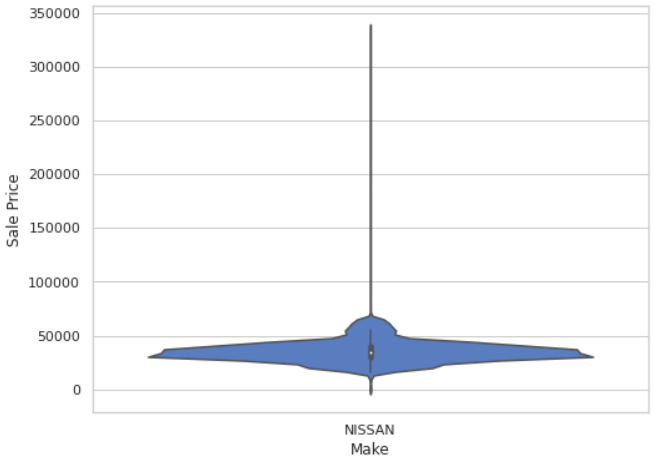

Fig. 10. Violin Plot of Sale Price vs BEV: NISSAN

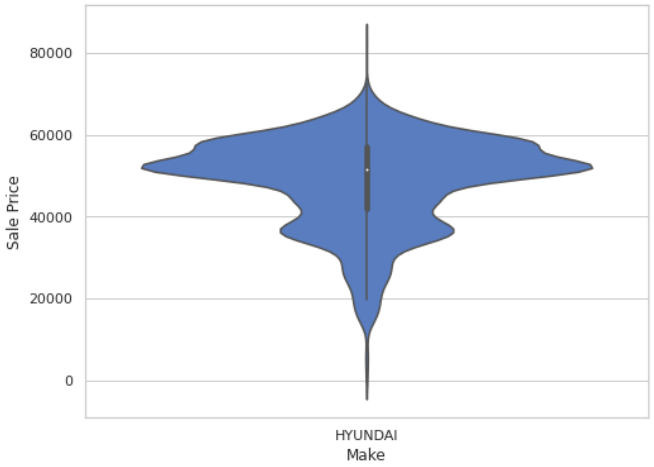

Fig. 11. Violin Plot of Sale Price vs PHEV: VOLVO

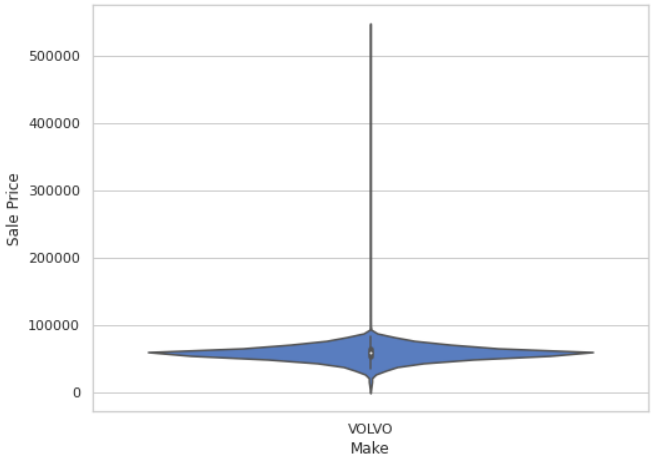

Fig. 12. Violin Plot of Sale Price vs PHEV: VOLVO

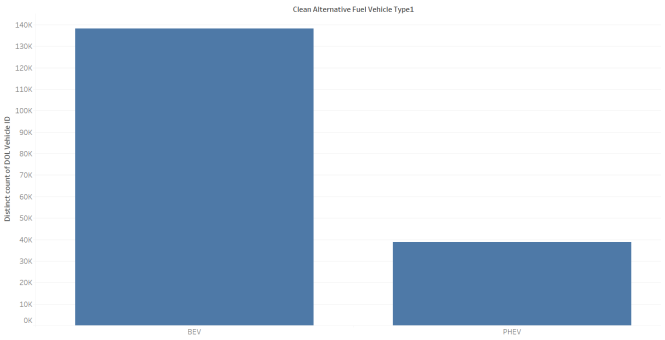

Fig. 13. Bar Chart showing distribution of BEV and PHEV

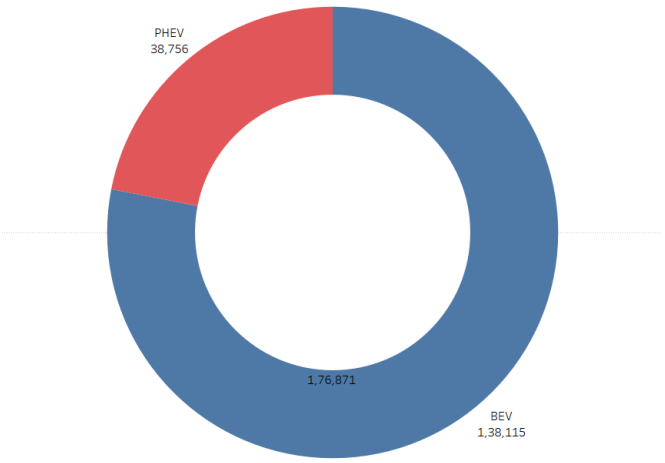

Fig. 14. Donut Chart showing distribution of BEV and PHEV

15). Seeking an improvement in visualization, we transitioned to using a word cloud, recognizing its ability to offer a more intuitive representation where the size of each word corresponds to its frequency. This shift allowed viewers to easily grasp the most prevalent makers at a glance, especially in scenarios where qualitative insights are paramount, such as identifying key themes in textual data or emphasizing the significance of specific terms. The aesthetic appeal of word clouds further enhanced their effectiveness, rendering them a compelling choice for capturing the essence of textual information in a visually engaging manner. (Figure 16)

Despite the progress made with the word cloud, a challenge persisted in merging makers with the corresponding categories, namely BEV or PHEV. This necessitates further exploration to seamlessly integrate the valuable insights gained from these visualizations.

E. Knowledge: Feedback Loop

While the initial visualizations successfully outlined the distribution of BEVs and PHEVs,but we were not able to merge makers alongside, it became apparent that there was a missing link in effectively conveying the dominance of specific companies within each category. A more nuanced approach

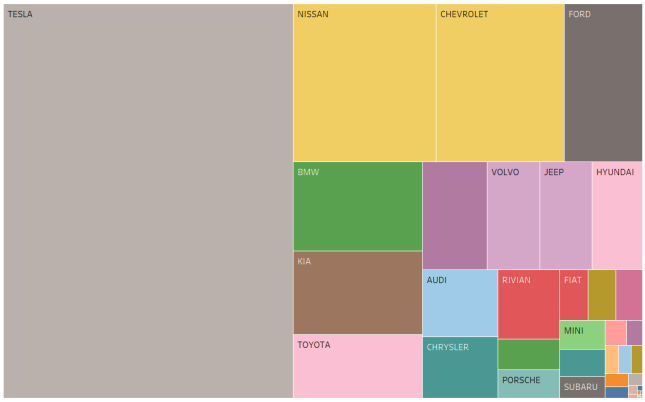

Fig. 15. Treemap showing makers in the market

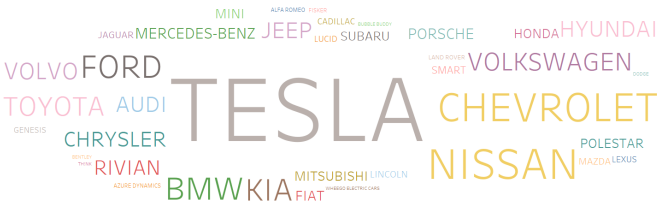

Fig. 16. Wordcloud showing makers in the market

was needed to capture the intricate market dynamics and communicate them comprehensively.

F. Better Visualization

To address this gap, the transition to Sunburst charts was deemed necessary. Renowned for their prowess in representing hierarchical data structures and facilitating multilevel analysis, Sunburst charts provide an interactive exploration experience (Figure 17). This new visualization aims to offer a clearer representation of market dominance, showcasing the hierarchical relationships among companies in both BEV and PHEV categories. By adopting this radial layout, the Sunburst chart enhances visual engagement and aids in deciphering the intricate market dynamics more effectively.

In summary, this enriched visual analytics workflow not only highlights the distribution patterns but also delves into the hierarchical market structure, providing a more holistic understanding of why certain companies excel in the dynamic landscape of electric vehicles.

G. Unrolled workflow diagram

We can see below the stages that we have discussed in the form of an unrolled workflow diagram (18). Shows the Second iteration of our unrolled workflow diagram.

V. Visual Analytics Workflow 3

A. Initial Visualizations

In our third task, we aimed to explore the sales distribution of Electric Vehicles (EVs) across various cities in the US. This

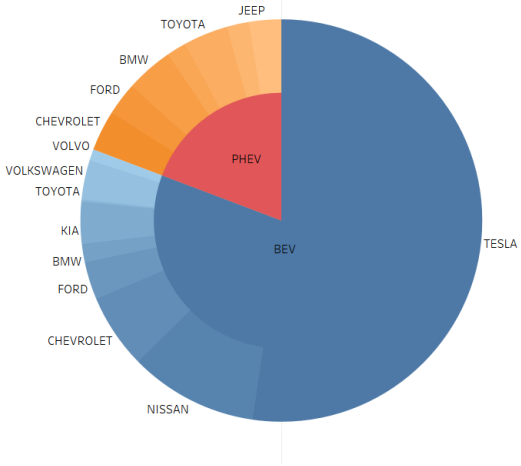

Fig. 17. Sunburst Visualization showing distribution of BEV and PHEV

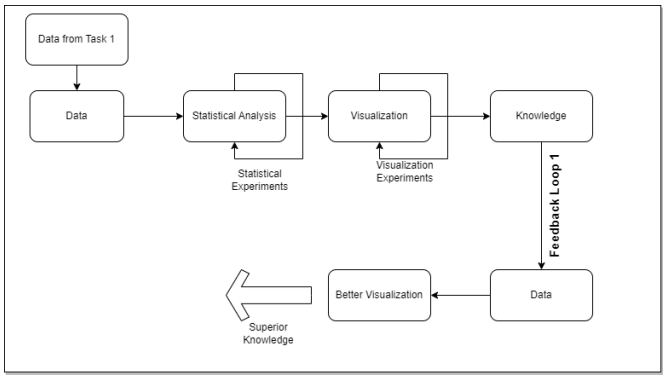

Fig. 18. Unrolled workflow diagram for Visual Analytics Workflow - 2

analysis holds significant value for EV manufacturers as it sheds light on the market penetration and regional preferences for EVs. Rather than opting for a conventional bar chart, we opted for a more visually engaging approach by crafting a circular bar chart (19). The difference between the two is that, in a bar chart the value of the attribute was determined by the length of the bar. In case of circular bar chart, we instead use angle to compare the values.

The dataset used for this task is the one provided by Shridhar, in which he filled the missing values for 'Sale Price' column using Machine Learning techniques. Also, the previous plot was drawn only for the top 15 cities (in terms of Sales Price), in order to avoid clutter.

B. Feedback/Knowledge

If we notice the previous plot, we can see that apart from the first city (innermost), it is difficult to distinguish the rest from each other as they subtend a very similar angle at the center. We will look as to how we can improve this visualization, to produce a more visually intuitive plot showing the distribution of sales price across various cities.

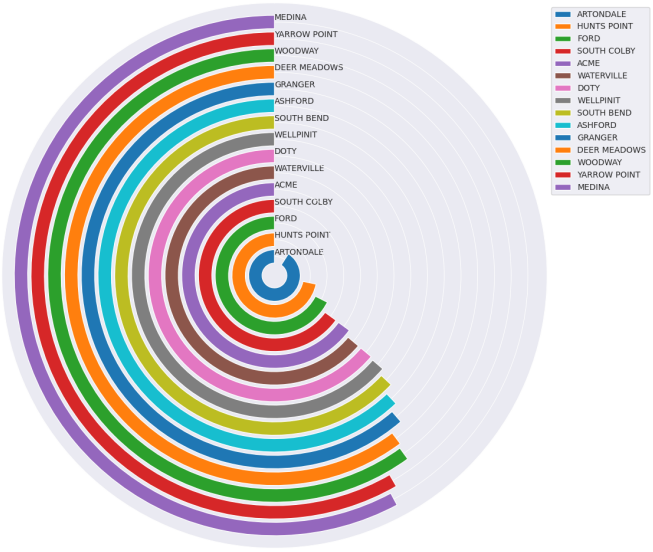

Fig. 19. Circular Bar Chart showing sales distribution across various cities

C. Data Mining

We tried various different machine learning methods. In the end, we stuck with K-means clustering, an unsupervised technique. K-means clustering helped group states based on how similar their electric vehicle sales were. This technique divided the cities into clusters, each group having cities with sales that were alike. This way, we could see which cities were similar in their sales numbers, giving us a better picture of how different regions performed in selling electric cars.

D. Improved Visualization

The new way of showing the data didn't just display how sales differed in various places. It also pointed out groups of areas with similar sales. This made it easier to see which places were alike in selling electric cars. By combining where these cars were sold with how many were sold, it gave a better overall picture of how things were going in different parts of the country. (20)

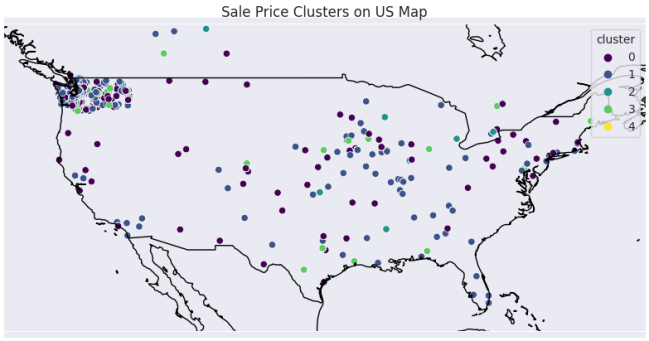

Fig. 20. Improved Visualization

E. Unrolled workflow diagram

The complete analytics workflow pipeline can be visualized by the image (21)

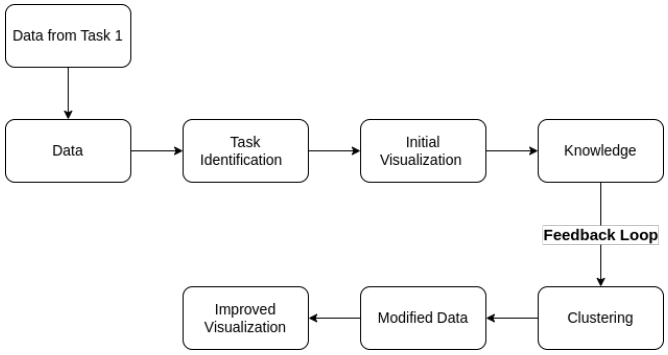

Fig. 21. Unrolled workflow diagram for Visual Analytics Workflow - 3

VI. Work Distribution

This assignment required seamless collaboration and equal contributions from all three team members. Each member actively engaged in various aspects of the assignment. Speaking roughly, Visual Analytics Workflow 1 was done by Shridhar, Visual Analytics Workflow 2 was done by Mayank, Visual Analytics Workflow 3 was done by Harsh.

References

[1] Build a Scatter Plot
[2] Electric Vehicle Population Data
[3] Electric Vehicle Title and Registration Activity
[4] Creating a Candlestick chart
[5] Onion Chart in Tableau
[6] Creating Stories in tableau
[7] Add a Tableau Data Story to a Dashboard
[8] Boxplot of Multiple Columns of a Pandas Dataframe on the Same Figure
[9] Principal components analysis using pandas dataframe
[10] pandas.DataFrame.plot.density
[11] How to calculate correlation between all columns and remove highly correlated ones using pandas?
[12] Plot Latitude and Longitude from Pandas DataFrame in Python
[13] What are the pros and cons of plug-in hybrid electric vehicles (PHEVs)?
[14] Electric Vehicle Population Data
[15] Electric Vehicle Title and Registration Activity
[16] Nissan Leaf Wikipedia
[17] Tesla Wikipedia
[18] Chevy Volt discontinued
[19] Model Y wikipedia

Appendix A
Assignment 1

A. Dataset

For this assignment, we worked with Electric Vehicle Population Data [14] [15]. This dataset shows the Battery Electric Vehicles (BEVs) and Plug-in Hybrid Electric Vehicles (PHEVs) that are currently registered through the Washington State Department of Licensing. The major variables in our dataset are -

- **Clean Alternative Fuel Vehicle Type** : BEV or PHEV
- **Make** : The manufacturer of the vehicle
- **Model** : The model of the vehicle

- **Model Year** : The model year of the vehicle
- **Base MSRP** : MSRP of the model
- **Electric Range** : The range of the vehicle (in miles)
- **City & County** : Residence of vehicle owner
- **Transaction Year** : The year upon which the transaction was recorded with Department of Licensing.

Please be aware that **Base MSRP** of most data points was NULL. We have taken this into consideration when visualizing this variable.

B. Visualization Tasks

Our objective is to explore the transformation and development of the Electric Vehicle (EV) market over time through data visualizations. This overarching goal is divided into three tasks -

- **Task 1** : Identify and analyze the major contributors that have played a significant role in shaping the EV landscape.
- **Task 2** : Spot temporal trends and anomalies over the years. Provide insights into the factors driving these changes, whenever possible.
- **Task 3** : Compare and analyze the trends between Battery Electric Vehicles (BEVs) and Plug-in Hybrid Electric Vehicles (PHEVs).

All visualizations were created using Tableau. We also used Tableau Prep and Pandas for data processing and cleaning.

C. Task 1

We began by plotting the total number of sales of each manufacturer to gain insight about the market share within the electric vehicle (EV) landscape. We observed from a simple bar graph that a single manufacturer holds a significant majority of the market share. A bar graph is not an ideal representation of such a skewed distribution data, so we experimented with alternate visualization options such as bubble charts and Tree Maps. Ultimately, we decided to go with a Tree Map (Fig 1) as it effectively portrayed the data's skewness and made optimal use of the available space.

Over the past few years, Tesla has become synonymous with electric vehicles. As anticipated, Tesla stands out as the dominant player in the electric vehicle industry, commanding a substantial 46.6% market share. In contrast, traditional automobile giants such as Ford, Chevrolet, and Toyota trail far behind, each holding only a single-digit market share.

In order to understand Tesla's dominance in the EV market, we turned our attention to two pivotal factors that significantly influence buyers: Electric Range and the Retail Price (MSRP).

To gain a better insight, we superimposed a line graph depicting the average Electric Range across all models from a manufacturer with a bar graph representing that manufacturer's market share (Fig 2). Tesla offers an impressive average range of 240 miles per charge, surpassing its competitors comfortably. The next two top manufacturers, Nissan and Chevrolet, also offer comparatively better electric ranges. It's worth noting that electric range is the most influential factor for a model's success, primarily due to the lack of electric

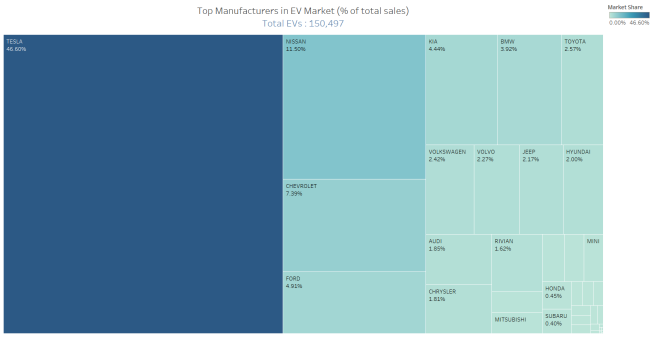

Fig. 22. TreeMap : Visualizing the market share of manufacturers

charging stations compared to conventional petrol/gas stations. Tesla's Supercharger infrastructure has played a significant role in driving the popularity of electric vehicles. Introduced in 2012, as of September 2023, Tesla operates a network of 5,500 Supercharger stations worldwide. Still, it's important to acknowledge that the charging infrastructure has a long way to go before it can provide competition to conventional fuel vehicles.

We made a similar visualization for the base MSRP, plotting the average selling price of top manufacturers alongside their market share (Fig 3). Once again, we observe that, on average, the top three manufacturers offer more cost-effective alternatives than their competition.

Succeeding in the EV market depends on striking a balance between price and electric range. Tesla offers the best of both factors. Toyota, while offering a highly competitive price, suffers due to its very low electric range (Toyota deals with mostly PHEV's, which have less electric range. We will explore this factor in the third task).

It's important to note here that both these variables in our dataset contained a lot of NULL values, indicating missing data for many data points. We filtered out these data points while making these visualizations. For base MSRP, there were very few data points, so we used another variable Selling Price, which should yield approximately similar results for new vehicles. Nevertheless, our visualizations make sense and gives the results we expected, barring some outliers.

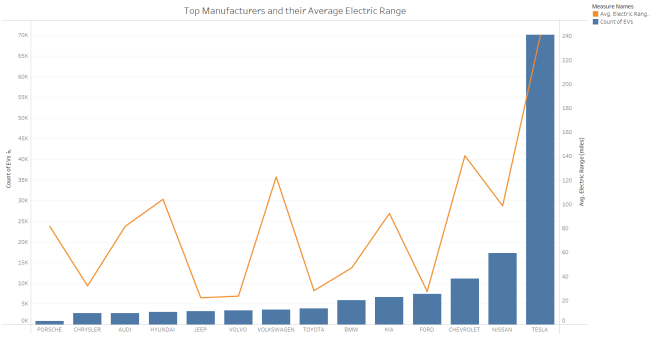

Fig. 23. BarChart and Line graph: Top manufacturers & avg. electric ranges

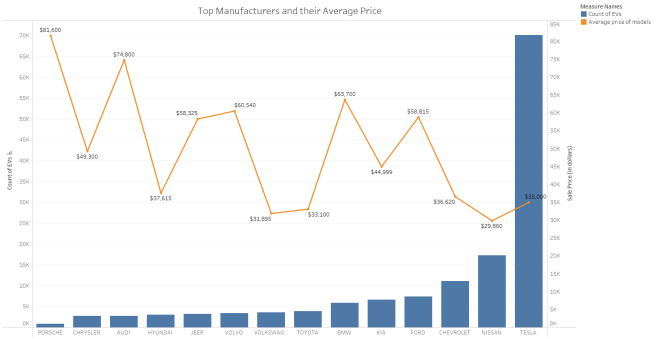

Fig. 24. BarChart and Line graph: Top manufacturers & avg. MSRP

Finally, we also explored the distribution of electric vehicles across counties in Washington State. We visualized the count of EVs in each county on a map (Fig 4). Remarkably, 75% of the market share is concentrated within just four out of the total 39 counties in Washington. King County dominates with 52% stake, due to the presence of major urban centers like Seattle, Redmond and Bellevue.

For a more granular view at the city level, we created a bubble chart (Fig 5) where the size of each bubble corresponds to the market share, and the color denotes the county of the city. Unsurprisingly, Seattle, being the most populous city, is the home of highest number of electric vehicles. Vancouver and Olympia, the capital, are other notable cities with significant influence on their respective counties.

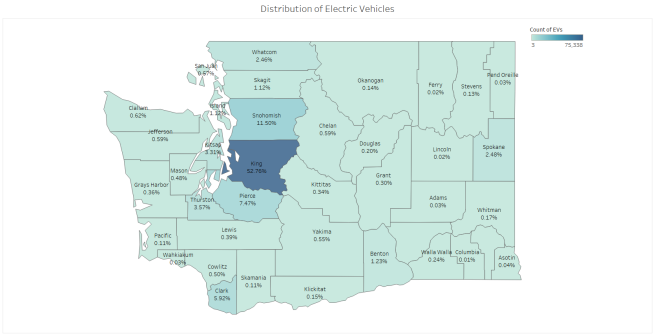

Fig. 25. Map of Washington which illustrates the distribution of EVs

D. Task 2

Our second task aims to uncover trends, anomalies, and significant milestones in the electric vehicle (EV) market over the years. We began by creating a time series graph illustrating the annual count of new EVs sold (Fig 6). To provide further context, we included labels indicating the percentage difference from the previous year. Another visualization we utilized to analyze trends was the evolution of market share over time. We visualized this by plotting the sales figures for the top 5 manufacturers each year from 2011-2022 (Fig 7).

Now, let's delve into the evolution of the EV market year by year.

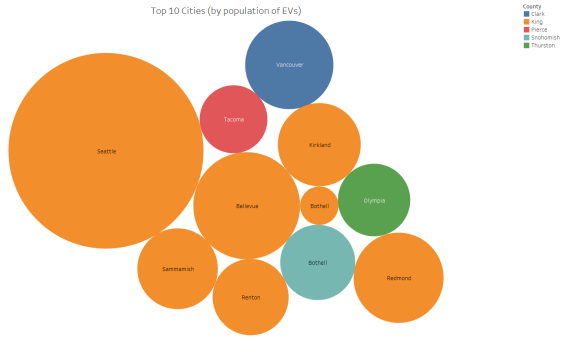

Fig. 26. Bubble Chart: Cities dominating the EV Market

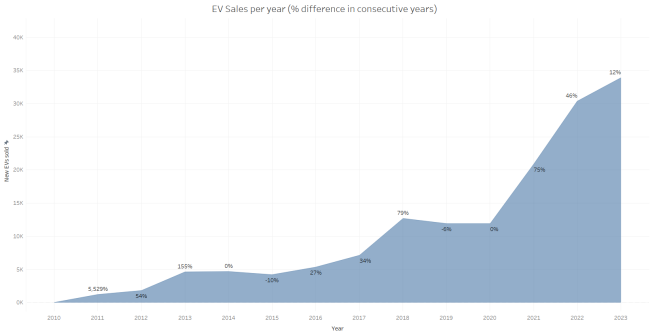

Fig. 27. Area Graph with percent difference in EV sales in consecutive years

The initial breakthrough in the EV market occurred in December 2010 when Nissan introduced the LEAF, the world's first mass-market electric vehicle. The LEAF held the title of the world's all-time best-selling electric car until it was surpassed by the Tesla Model 3 in early 2020 [16]. This event is evident in the sales spike observed in 2011 (Fig 6), surging from 21 to 1,182 units. A staggering 87% of all EV sales in 2011 were accounted for by the Nissan LEAF.

Following this, Tesla unveiled its second vehicle, the Model S luxury sedan, in June 2012. Simultaneously, Tesla introduced its Supercharger network. We discussed the importance of this network in Task 1. These developments, along with strong sales of Nissan's LEAF, contributed to a remarkable 155% increase in EV sales in 2013.

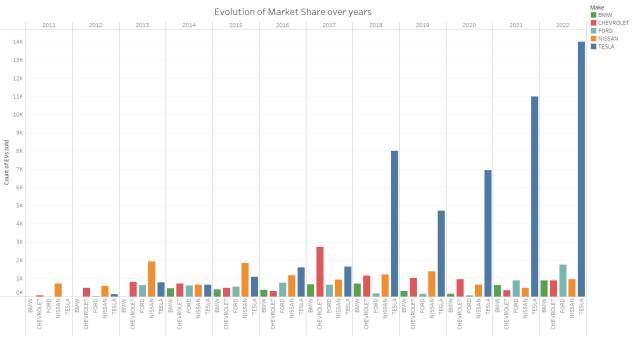

Fig. 28. BarChart showing top 5 manufacturers across years

Another visualization we will now use is the sale distribution of Top EV Models over years. We create a stacked area chart depicting the top 7 best selling EV models (Fig 8). This chart will provide valuable insights into the contribution of each model over time.

From fig 6, we observe a dip in EV sales by 10% in 2015. Tesla began shipping its luxury SUV, Model X, in September 2015, and EV sales saw a modest growth of 27% and 34% in the subsequent two years. Fig. 7 also reflects a period from 2015 to 2017 when market share among manufacturers was relatively evenly distributed, with no clear industry leader emerging. However, starting in 2018, Tesla established itself as the undisputed leader in terms of sales, effectively dictating industry trends from 2017 onwards.

In 2016, Tesla announced its first mass market vehicle, the Model 3 sedan. Compared to Tesla's previous luxury vehicles, the Model 3 was less expensive and within weeks the company received over 325,000 paid reservations [17]. After 2 years of delays and production issues (famously described as "Production Hell" by Elon Musk), Tesla began shipping the Model 3 in 2018 and it became the world's best selling electric car from 2018 to 2021. Fig. 6 demonstrates an impressive 80% surge in EV sales in 2018.

However, 2019 saw a surprising 6% decrease in EV sales, attributable to several factors. The Model 3's growth was more modest compared to the record-breaking year of 2018. General Motors also discontinued the Chevy Volt, a popular EV [18], and there were no new high-selling models introduced.

The COVID-19 pandemic adversely affected EV sales during the first half of 2020, although Tesla's introduction of the Model Y, an affordable SUV based on the Model 3, helped mitigate this impact. Nevertheless, overall EV sales remained stagnant in 2020 (Fig. 6).

Following the easing of COVID-19 lockdowns in 2021, the EV industry experienced another surge, driven primarily by the strong sales performance of the Tesla Model Y. This upward trend has continued. In the first quarter of 2023, the Model Y outsold the Toyota Corolla to become the world's best-selling car, the first ever electric vehicle to claim the title.

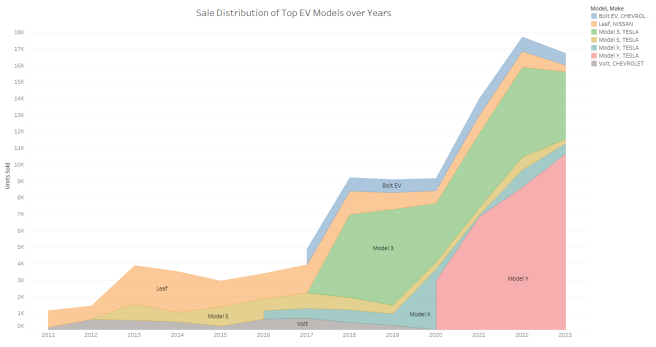

Fig. 29. Stacked Area Chart : Top 7 Best Selling EV models

In this task, through a series of insightful visualizations, we traced the growth of EV sales over the years, pinpointed key moments of transformations, and shed light on the influence of major players like Tesla. We observed how innovations like the introduction of Tesla's Model 3 and Model Y reshaped the market, along with external factors like the COVID-19 pandemic.

E. Task 3

Now, let's delve into an in-depth analysis of the electric vehicle (EV) landscape within the market, focusing on Battery Electric Vehicles (BEVs) and Plug-in Hybrid Electric Vehicles (PHEVs).

Our initial approach to visualizing the market share of BEVs versus PHEVs involved a bar chart. However, we opted for a pie chart instead, as it offers a more straightforward and intuitive representation of the market distribution. This pie chart visually illustrates the proportion of BEVs and PHEVs in the market, making it easier to grasp at a glance.

In addition to the pie chart, we've created an area graph to provide a dynamic view of the sales performance of BEVs and PHEVs over the years. This area graph presents a year-by-year comparison of BEVs and PHEVs, allowing us to observe how they have competed and evolved over time. We chose the area graph for its effectiveness in facilitating comparisons when dealing with only two distinct categories.

The Pie Chart vividly demonstrates that BEVs have established a dominant presence in the market [Fig 30]. This prevalence can be attributed to the fact that PHEVs tend to incur higher ownership costs due to their lower efficiency and increased susceptibility to maintenance issues, stemming from their more intricate design with multiple moving parts. Opting for a BEV can lead to substantial long-term savings, encompassing both maintenance and fuel expenses. Meanwhile, the Area Graph unveils a clear trend of rising BEV popularity over the years, with expectations of continued growth in the foreseeable future, while PHEVs lag behind [Fig 30]. This shift is primarily driven by the inherent advantages of BEVs, including simplicity, cost-efficiency, positive environmental impact, and superior efficiency. In contrast, PHEVs come with complex and costly components like batteries and electric motors, often necessitating the installation of charging stations, which adds to the initial financial outlay. For those seeking an economical and environmentally friendly option, BEVs emerge as the preferred choice. [13]

Let's now look at the top 15 manufacturers and their market shares. Initially, we developed two different graphs, one concentrating on BEVs and the other on PHEVs. However, in our pursuit of a more comprehensive analysis, we decided to incorporate a Stacked Bar Chart. This decision was motivated by the fact that, when comparing data points, a stacked bar chart provides a clearer and more intuitive way of comparison [Fig 31].

Tesla has undoubtedly had a significant impact on the EV market. Tesla has clearly intentionally committed a major percentage of its resources in BEVs. Nissan, the second candidate on our list, has shown a similar commitment to BEVs [Fig 31]. This reinforces the premise that BEVs can

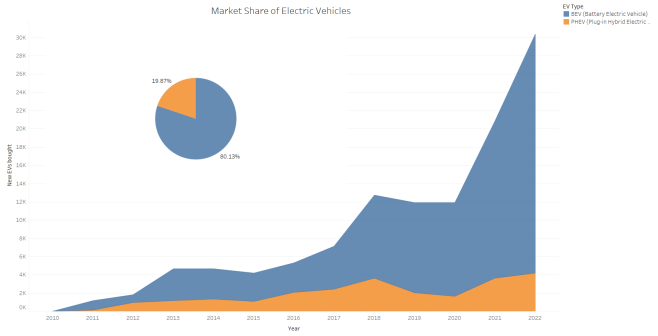

Fig. 30. Area Graph & Pie Chart: Market Capture by Different Types of EVs among the years

play a critical part in a manufacturer's road to success if they invest intelligently.

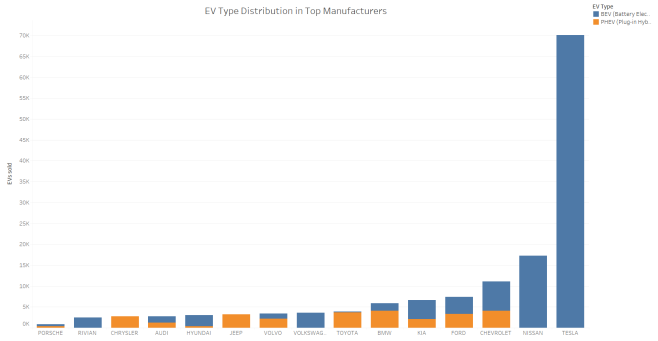

Fig. 31. Stacked BarChart: BEV vs PHEV in different manufacturers

Next, we compared the avg. electric range of BEVs and PHEVs from 2011 to 2023 for this task we chose a line graph [Fig 32] for this visualization because it provides a clear and effective way to compare the numeric values of different EV types.

The graph confirmed our expectations: BEVs have been steadily increasing their average electric range each year, highlighting the significant research and development focus on improving BEV range. In contrast, the line representing PHEVs showed a flat slope, indicating limited progress in the development of PHEVs.

F. Work Distribution

We initially brainstormed and established a list of tasks together. Following that, we worked together to create visualizations and dashboards. Instead of assigning specific duties to each other, we discovered that when we worked as a unified team, our productivity and creativity increased. Every team member contributed significantly to every aspect of the assignment. However, roughly speaking, Task 1 was done by Harsh, Task 2 by Shridhar and Task 3 by Mayank.

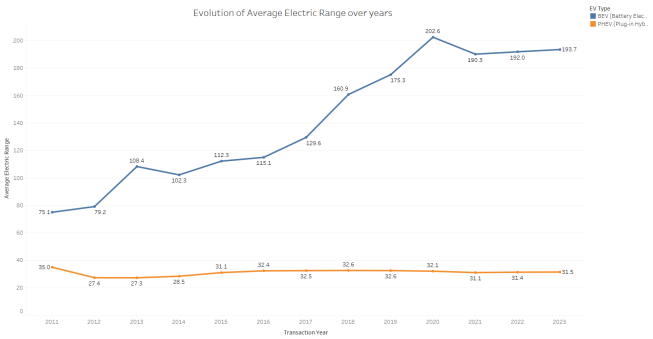

Fig. 32. Line Graph: Avg Electric Range of BEVs vs PHEVs