**Consumer Behavior Analysis for Electric Vehicle Adoption using Digital Twins**

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**Problem statement:**

* As the world progresses toward more sustainable modes of transportation, electric vehicles (EVs) have emerged as a viable alternative to traditional gasoline-powered automobiles.
* However, high prices, limited range, and a lack of charging infrastructure keep preventing widespread EV adoption.
* As a result, understanding consumer behavior surrounding EVs is critical for manufacturers, policymakers, and marketers.
* Traditional methods of investigating consumer behavior, including as surveys and focus groups, are limited in their ability to capture real-time data and dynamic changes in consumer preferences.

**Dataset:**

* The dataset encompasses a wide range of features, including 'Postal Code', 'Model Year', 'Make', 'Model', 'Electric Range', and 'Base MSRP'. Using these features, the primary objective is to develop predictive models capable of accurately forecasting the 'Electric Vehicle Type' that consumers are most likely to choose when making a purchase decision.

**Exploratory Data Analysis(EDA):**

1. Top Vehicle makes:

Tesla dominates the market with a substantially higher share than other manufacturers. The data includes popular electric vehicle brands such as Nissan, Chevrolet, Ford, and BMW. This data can help guide targeted marketing techniques and infrastructure development activities based on consumer preferences.

1. Electric range by model year:

Newer model years tend to have longer electric ranges, with some exceptions. Over time, electric car range has improved, removing a major barrier to adoption. This trend emphasizes the rapid technological improvements in the electric car industry, which might influence consumer decision-making.

1. Popular Electric Vehicle Makes and Model:

Tesla's dominant market share is reflected in the popularity of its Model 3 and Model Y variants. Other popular models are the Nissan LEAF, Chevrolet Bolt EV, Ford Mustang Mach-E, and Volkswagen ID.4.

This data can help advocacy groups customize their marketing efforts and infrastructure development to the region's most popular models.

1. Correlation Analysis:

The 'Postal Code' characteristic has no link with other numerical features, indicating that the geographic distribution of electric vehicles is influenced by factors not reflected in the dataset.

'Model Year' has a moderately negative correlation (-0.48) with 'Electric Range', implying that earlier model years have shorter electric ranges.

'Base MSRP' has a weak positive association (0.11) with 'Electric Range', indicating that higher-priced electric vehicles typically have longer ranges.

**Modelling:**

* Building on the EDA findings, we applied a range of machine learning models to predict the 'Electric Vehicle Type' that consumers are most likely to choose based on the available features. The following models were investigated, and their scores are displayed below:

1. Naïve Bayes:

Accuracy: 0.8963998575685451

ROC AUC Score: 0.819275183987384

Precision: 0.92

Recall: 0.96

F1-Score: 0.94

1. Logistical Regression:

Accuracy: 0.8342735058752975

ROC AUC Score: 0.6880596785827632

Precision: 0.86

Recall: 0.95

F1-Score: 0.90

1. Random forest classifier:

Accuracy: 0.9999062950954853

ROC AUC Score: 0.9998155689989119

Precision: 1.00

Recall: 1.00

F1-Score: 1.00

1. Gradient Boosting Classifier:

Accuracy: 0.9999625180381941

ROC AUC Score: 0.9999449127947211

Precision: 1.00

Recall: 1.00

F1-Score: 1.00

The Random Forest Classifier and Naive Bayes models scored the best, with R-squared scores better than 0.90 indicating good predictive ability. These models can be used to guide future EV development and infrastructure design, resulting in a more informed and data-driven approach to helping the state transition to sustainable transportation.

**Recommendations:**

* Based on our analysis and conclusions, we propose the following measures for electric car advocacy groups to promote widespread use of electric vehicles:

1. Urban Focus: Concentrate efforts on promoting the use of electric vehicles in urban areas, where there are more EVs and the impact on lowering emissions and congestion can be greater.

2. Collaboration with Electric Utility Companies: Work with electric utility companies to guarantee that charging infrastructure is in place and to promote the use of renewable energy sources to power electric vehicles, which aligns with sustainability objectives.

3. Public Charging Station Advocacy: Promote the establishment of more public charging stations to alleviate range anxiety and improve the convenience of owning an electric vehicle.

4. focused Marketing and Incentive Promotion: Use the data gained from the make, model, and pricing study to create focused marketing campaigns and raise awareness of clean alternative fuel vehicle incentives in locations with low adoption rates.

**Conclusion:**

By utilizing the prediction models created in this study and executing the proposed techniques, electric car advocacy groups can effectively aid in the transition to a more sustainable transportation system. The broad use of electric vehicles will not only reduce carbon emissions, but will also help to create a cleaner, more environmentally friendly future.