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Prescriptive Analytics

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Tesla Superchargers Location Optimization

Impact

In an era marked by an accelerating shift towards sustainable transportation, the EV industry has emerged as a vanguard for innovation and environmental consciousness. Central to the success and widespread adoption of electric vehicles is the infrastructure that supports them. Among the frontrunners in the EV landscape, Tesla's Supercharger network stands as a cornerstone, providing essential charging infrastructure for Tesla vehicle owners across the globe. This report delves into Tesla's Supercharger network, employing a dataset comprising 11 comprehensive columns.

Our team's analysis aims to unravel geographic and temporal trends, offering insights into the evolving landscape of EV support infrastructure. Through an assessment of accessibility in diverse regions, tracking Tesla's network growth, and pinpointing potential charging infrastructure gaps, this report seeks to contribute valuable perspectives to the ongoing discourse on sustainable mobility. Our goal is to navigate through the data, uncovering the intricacies of Tesla's Supercharger network and shedding light on their challenges.

Dataset

Supercharger	This feature represents the name or identifier of the Tesla Supercharger location.
Street Address	This feature contains the specific street address where the station is located.
City	This feature represents the city where the station is situated.
State	This feature indicates the state or province where the station is located.
Zip	This feature represents the postal code associated with the station's address.
Country	This feature indicates the country where the station is situated.
Stalls	This feature represents the number of charging stalls available at the station. A station can accommodate multiple vehicles simultaneously.
kW	This feature represents the power capacity or kilowatt rating of the station. It indicates the charging speed or power output available at each station.
GPS	This feature provides the GPS coordinates (latitude and longitude) of the station.

Elev(m)	This feature represents the elevation or altitude of the station above sea level. It provides information about the station's height relative to the surrounding area.
Open Date	This feature indicates the date when the station was opened or made available.

Dataset: [Tesla Superchargers Dataset]

Data Pre-Processing

To enhance our dataset for robust analysis, we focused on key refinements. We filtered the supercharge_data DataFrame to the United States, addressing geographic relevance. Addressing missing values, we ensured dataset completeness. For temporal analysis, the Open Date column was converted to DateTime, with missing values imputed for consistency.

Recognizing geospatial importance, the GPS column was split into Latitude and Longitude for float conversion, aiding geospatial analyses. Standardizing the Zip column to a string ensures uniformity. These refinements fortify the dataset, providing a solid foundation for nuanced exploration of Tesla's Supercharger network in the United States.

Formulate Optimization Models

Problem Statement 1: Minimizing Geographical Distribution of EV Charging Stations

Objective 1: Minimize the total distance between newly built EV charging stations.

Decision Variables: Let x_i be a binary variable representing whether a charging station is newly built at location i (using `Open_Date` to filter the most recently built charging stations). Let d_{ij} be the distance between locations i and j.

Objective Function 1: $Minimize \sum_{i=1}^{N} \sum_{j=1}^{N} D_{ij} * x_i * x_j$

Where $D_{ij} = Distance\ between\ station\ i\ and\ j$

Station Constraint: For each station i selected in the route, the number of stations Xi, should be between the minimum and maximum number of charging stations.

Before running the model, we need to calculate the prerequisites. When assessing the following factors to determine the required range of stations, we are estimating that a Telsa supercharger station, on average, serves 70,000 unique vehicles per day, and the average charging time is 30 minutes. If you want to ensure that each charging station is operating for 24 hours and to handle at least two cycles of charges during peak times, we are estimating there are 60 numbers of charging stalls per station. Our final assumption is a constant annual population growth rate of 1% in the US market.

Requirement Calculations

$Minimum\ Charging\ Stations\ =\ \frac{Current\ Demand(Per\ State)}{Cycles\ Per\ Station}$

$Cycles\ Per\ Station = \frac{Total\ Charging\ Time}{Charging\ Time\ Per\ Cycle}$

$Total\ Charging\ Time\ =\ Number\ of\ Charging\ Stalls\ Per\ Station\ *\ Operational\ Hours\ (24)$

$Charging\ Time\ Per\ Cycle\ =\ Average\ Charging\ Time\ (30\ minutes)$

$Current\ Demand\ =\ Estimated\ Number\ of\ EVs\ (700,000\ EVs)$

Minimum Station: Calculate the minimum number of stations by dividing the current demand by the cycles per supercharger station. $MIN\ Stations\ =\ \frac{Current\ Demand}{Cycle\ Per\ Station}$

Maximum Station: Calculate the future demand for supercharger stations and the growth rate in demand for supercharger stations. Then, using the minimum stations, we can calculate the maximum number of stations. $MAX\ Stations\ =\ MIN\ Stations\ *\ (1\ +\ \frac{growth\ rate}{100})$

Binary Constraint: Ensure each location is either selected or not. There is no non-binary constraint for our decision variable.

Results

Objective 1: Due to the model's size, it's currently running with a **10% optimality gap** for a subset of the US dataset. The preliminary results focus on California, indicating a need for over 80 new supercharging stations to meet the estimated demand in the state.

References

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