Tesla Super Charger Network Growth Model and Decision Support System

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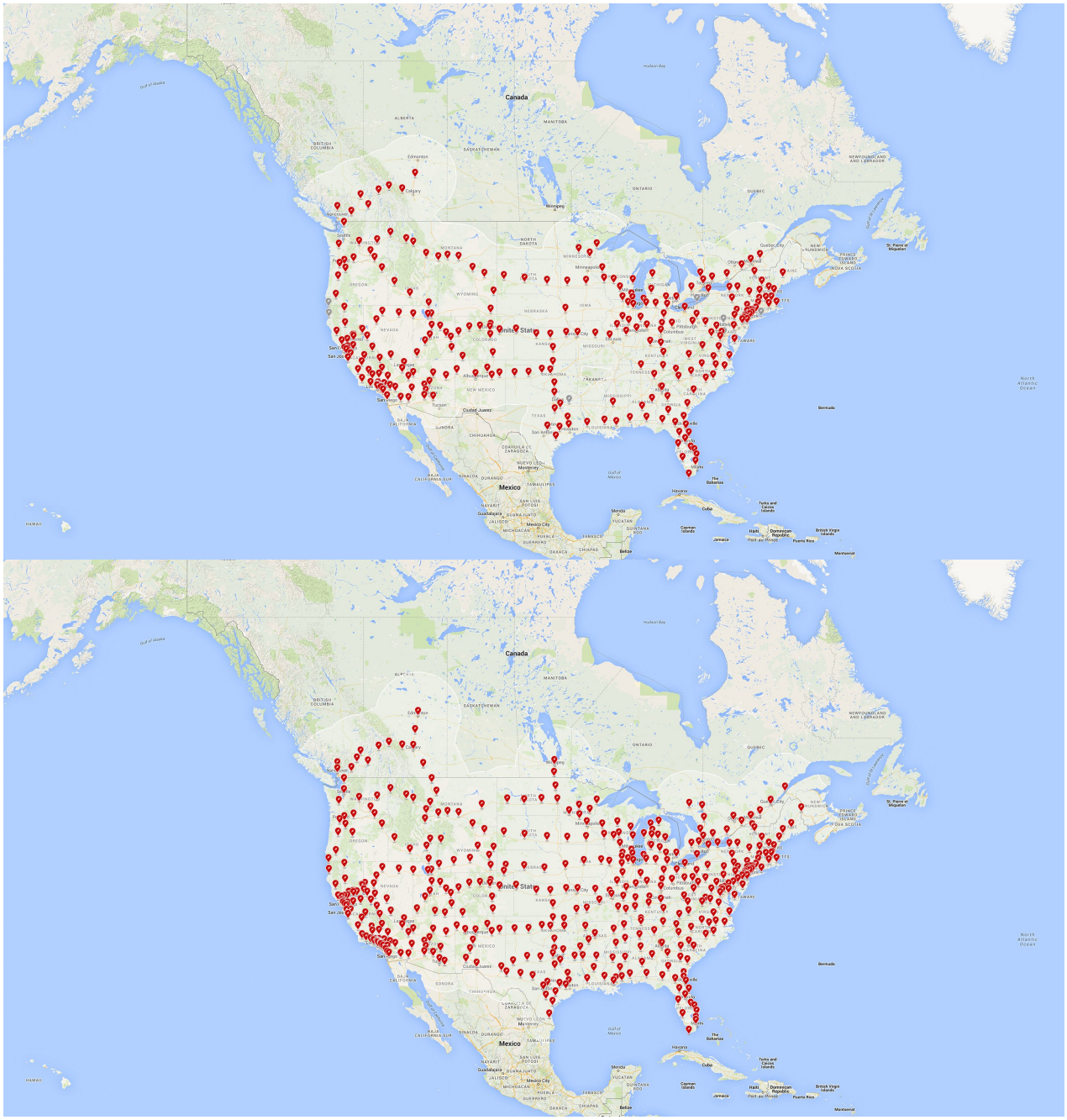
Introduction

With the recent unveiling of Tesla's Model 3 and pre-orders approaching 400,000, the internet has been buzzing with Tesla discussions and analysis. One of Tesla's key differentiators from other proposed mass market Electric Vehicals (EVs) is its Super Charger (SC) network that provides 170 miles of range in 30 minutes source. (https://www.teslamotors.com/supercharger) With Elon Musk stating plans to double the size of the SC network by the end of 2017, a large amount of planning, resources and investment are being allocated to this network expansion.

Tesla 2016 Planned North America Network Growth



source (https://www.teslamotors.com/supercharger)

Project Overview

The goal of this project is to build an intelligent decision support system to provide recommendations for where Tesla should expand their Super Charger (SC) network to maximize its effectiveness in creating a robust charging infrastructure for EVs in North America. This notebook is an extension of the Exploratory Data Analysis performed on the compiled Supercharger network data set and attempts to use the insights and intuition developed in that analysis to guide the development of an intelligent network growth model. The full EDA analysis can be found here.
(https://lab.beakernotebook.com/#/publications/6451bcd8-096e-11e6-8b45-2b70e59230e5)

Assumptions

This analysis brings many assumptions along with it, which are documented here to highlight and clarify potential (and highly probable) sources of error. Statements throughout the analysis that contain inherent assumptions listed here are denoted by @# where # represents the numbered assumption in this list.

Project Plan

The development of the decision suppport system will require a few distinct pieces of the puzzle to build an adequate model of the decision process performed in extending the Tesla Super Charger network. These steps are listed and briefly summarized here.

1. Development of the SCNetwork object - A python class that extends the functionality of a networkx's Graph object to provide abstracted infrastructure and utility functions used in this anaysis.
2. Expansion node search space hueristics - In order to make a decision on where to expand the network to next, we first need a set of expansion possibilities. Search hueristics are built to establish and reduce the search space to produce a robust but tractable subspace of potential expansion locations that we can analyze further and ultimately pick the ideal expansion node. There will be 2 parts to the search hueristics:
   i. First, the search space is reduced to searching for new cities the are reachable (ie. within 346km) of each node in the current network with populations greater then 99% of the last Supercharger added to the network.
   ii. The network growth utility functions developed in the EDA are analyzed for these cities, and the results are used with the ELECTRE Outranking Method (https://en.wikipedia.org/wiki/ELECTRE) to further reduce the search space by selecting the top 10 performant next nodes.
3. Venue Search - Once the short list of potential next cities to expand to is generated, we need to search for suitable venues in each potential city. Using the most common venues (ie. Starbucks, McDonalds, etc.) for each Supercharger attribute discovered in the EDA analysis, the google maps API is used to produce a list of potential venue locations in each city. The resulting list of venues is the list of potential next SC locations that can now be optimized with Utility based MCDA techniques.
4. Learn Network Growth Utility Function - Using the existing network expansion data, the network expansion utility features and the above search space definition, we can attempt to model the underlying utility function of the existing network expansion growth to new cities. This model will provide an accurate representation of the weights each Network Growth feature should have within the larger MCDA model.
5. Incorporating User Feedback - In order to ensure a robust system is developed that captures all potential options and end-user biases, a means of incorporating user preference data is included. Using a dedicated subreddit on reddit, and reddits API to capture upvotes and populatiry, users are providing a platform to suggest and vote for new Supercharger locations, which can then be incorporated into the MCDA model.
6. Building the MCDA Model - With the 3 meta categories compiled above, namely: Network Expansion Utility, Venue Satisifaction and Convienience, and User Preference, an MCDA utility model can be develop to calculate and ultimately sort/optimize the list of potential network expansion locations which can recommend the "best" next location for the Tesla Super Charger network.
7. Bringing it all together - in order to visualize and interact with the above model, the d3.js network graphic here (http://cole-maclean.github.io/MAI-CN/) will need to be expanded to include extra information and interaction capabilities to allow users to better use and understand the developed network expansion model.