



Segmenting and Clustering Tesla Superchargers

Applied Data Science Capstone

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Introduction

- Electric vehicles (EVs) are the future of ground transportation
- EVs are better for the environment, faster, quieter, less expensive to power, accelerate more smoothly, and are more reliable than their internal combustion engine (ICE) counterparts
- One non-trivial EV drawback: charging time
- Charging time is not a concern when charging overnight at home, but can be inconvenient on a trip requiring a charge before returning home
- Leveraging charging time by exploring nearby shops or attractions while charging can mitigate or eliminate the inconvenience of EV charging time
- Categorization of charging stations according to nearby locations can be useful when planning a road trip, enabling selection of routes or of charging stations along the route which have amenities of interest
- Such a categorization may be useful to entrepreneurs interested in opening a business near chargers which do not already have a similar business nearby

Data

- Level 2 chargers are slower chargers
 - Typically found in the home or at other final destinations (such as a hotel or shopping mall)
 - Provide 20-40 miles of range per hour of charging
 - Ample for an overnight charge, but far too slow when on a road trip
- DC fast chargers include CCS, CHAdeMO, and Tesla Superchargers
 - Charge up to 80% of the battery's capacity in roughly 30 minutes
 - Only feasible option for charging between the origin and final destination on a road trip [1]
- Intended beneficiaries of this project are EV drivers on a road trip, or potentially entrepreneurs wishing to cater to them
 - Data will be limited to DC fast chargers
 - In order to keep the project to a reasonable scope, data will be further limited to Tesla Superchargers within the United States

Data Sources

Charging Station Data

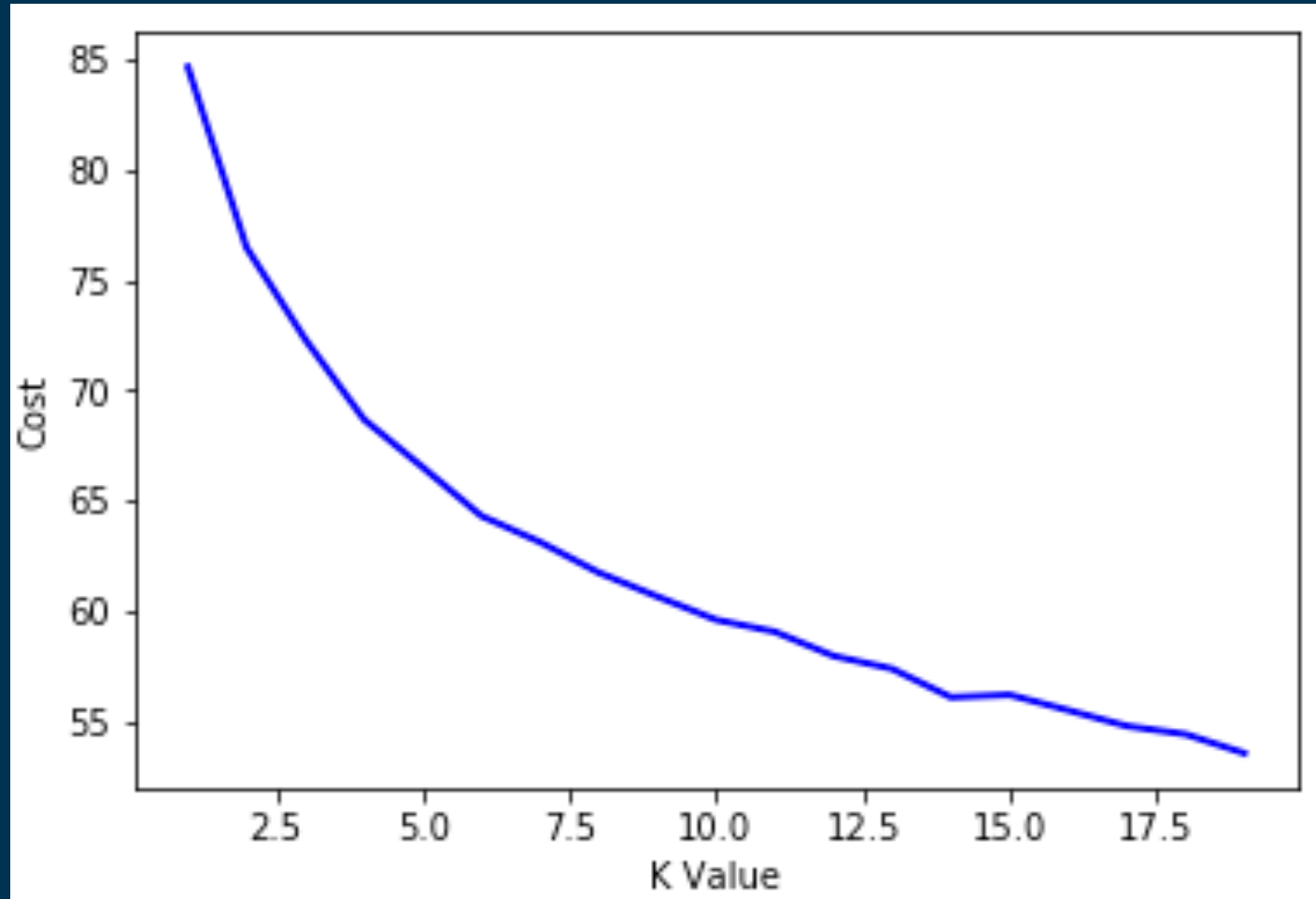
- Source of charging station data will be the National Renewable Energy Laboratory (NREL) Developer Network Alternative Fuel Stations API [2][3]
- NREL API returns 63 features per charging station (id, id, cards_accepted, open_date, station_name, station_phone, ...)
- Using only the following 8 features for each station (shown below with sample data from one station)
 - 'id': 101972
 - 'station_name': 'FAIRFIELD INN - Tesla Supercharger'
 - 'latitude': 34.785416
 - 'longitude': -86.942864
 - 'city': 'Athens'
 - 'state': 'AL'
 - 'street_address': '21282 Athens-Limestone Blvd.'
 - 'zip': '35613'

Location Data

- Source of location data will be the Foursquare API [4]
- Foursquare API returns a total of 27 features per venue (e.g., id, name, city, state, ...)
- Using only the following 4 features for each venue (shown below with sample data from one venue)
 - 'name': 'Fairfield Inn by Marriott Athens'
 - 'lat': 34.78587188328971
 - 'lng': -86.9428607460327
 - ('categories')'name': 'Hotel'

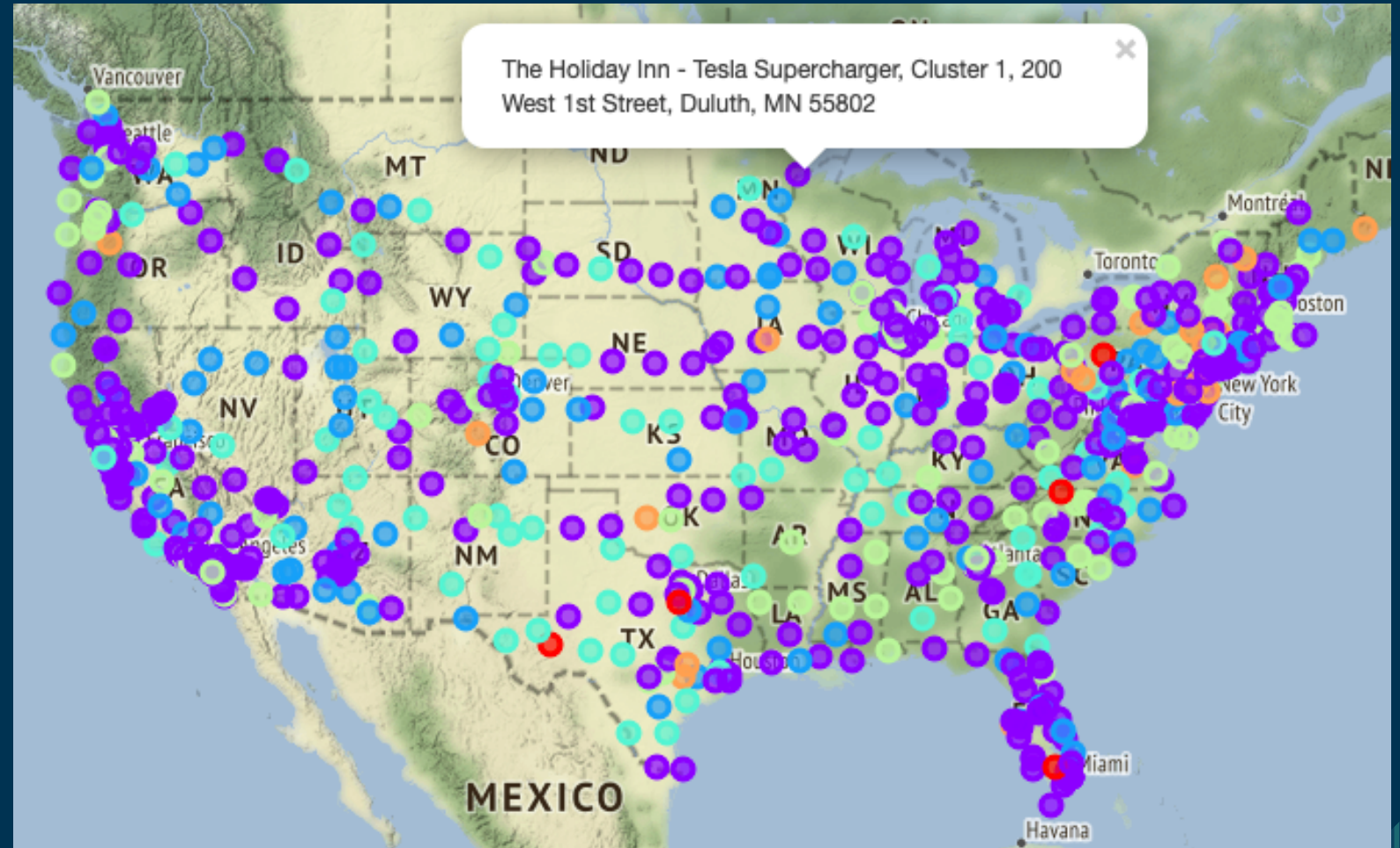
K-means Clusters

- Elbow method to select number of k-means clusters
- No distinct elbow, but absolute slope (or rate of decrease in cost) does begin lower trend at K value of 6
- Charging stations will be grouped into 6 clusters



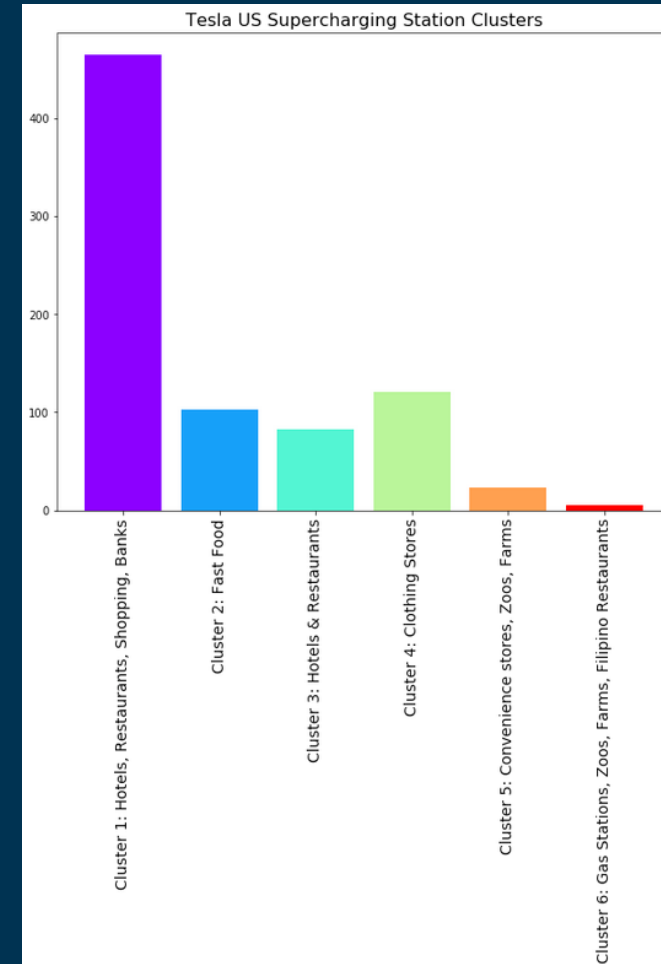
Tesla US Charging Stations by Cluster

- 798 charging stations with nearby venues
- Each filled circle colorized according to corresponding cluster
- Clicking a charging station displays charging station name, cluster number, and address



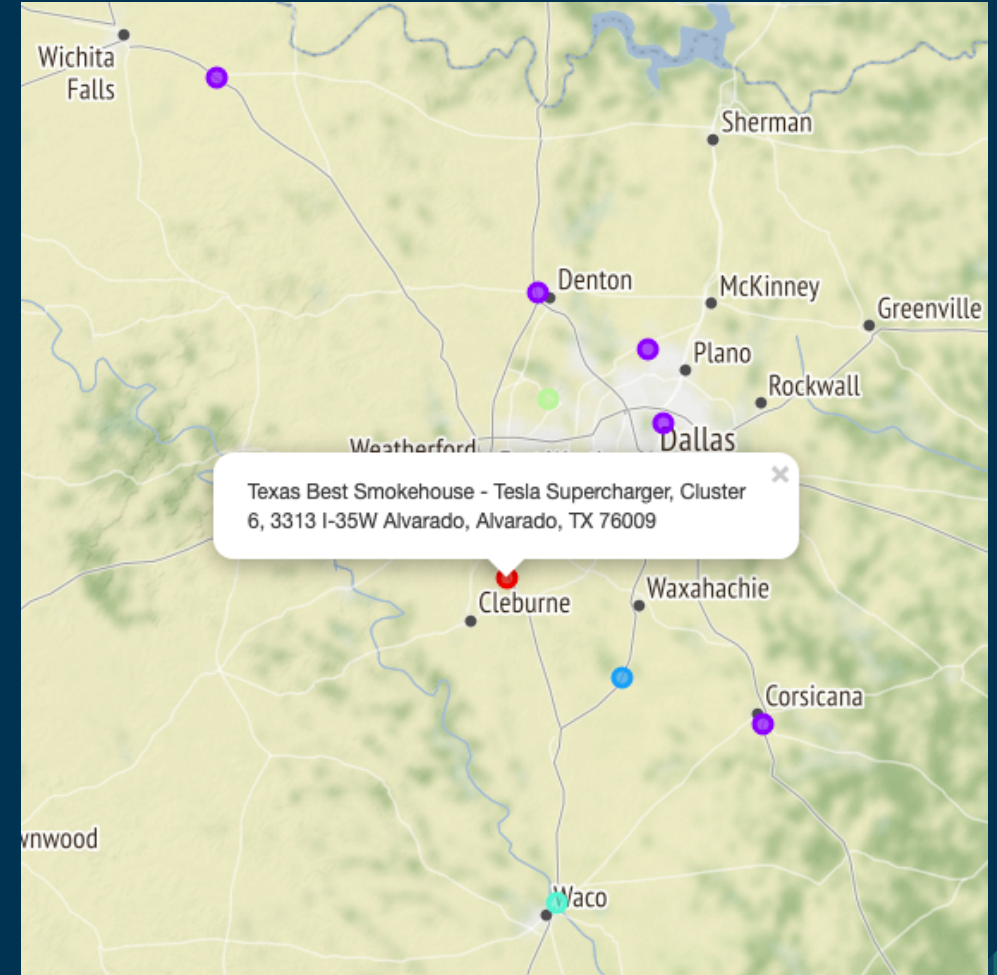
Cluster Descriptions

- Cluster analysis yielded descriptions along x-axis
- Bar colors correspond to cluster circles on map
- Bar lengths indicate number of members within cluster



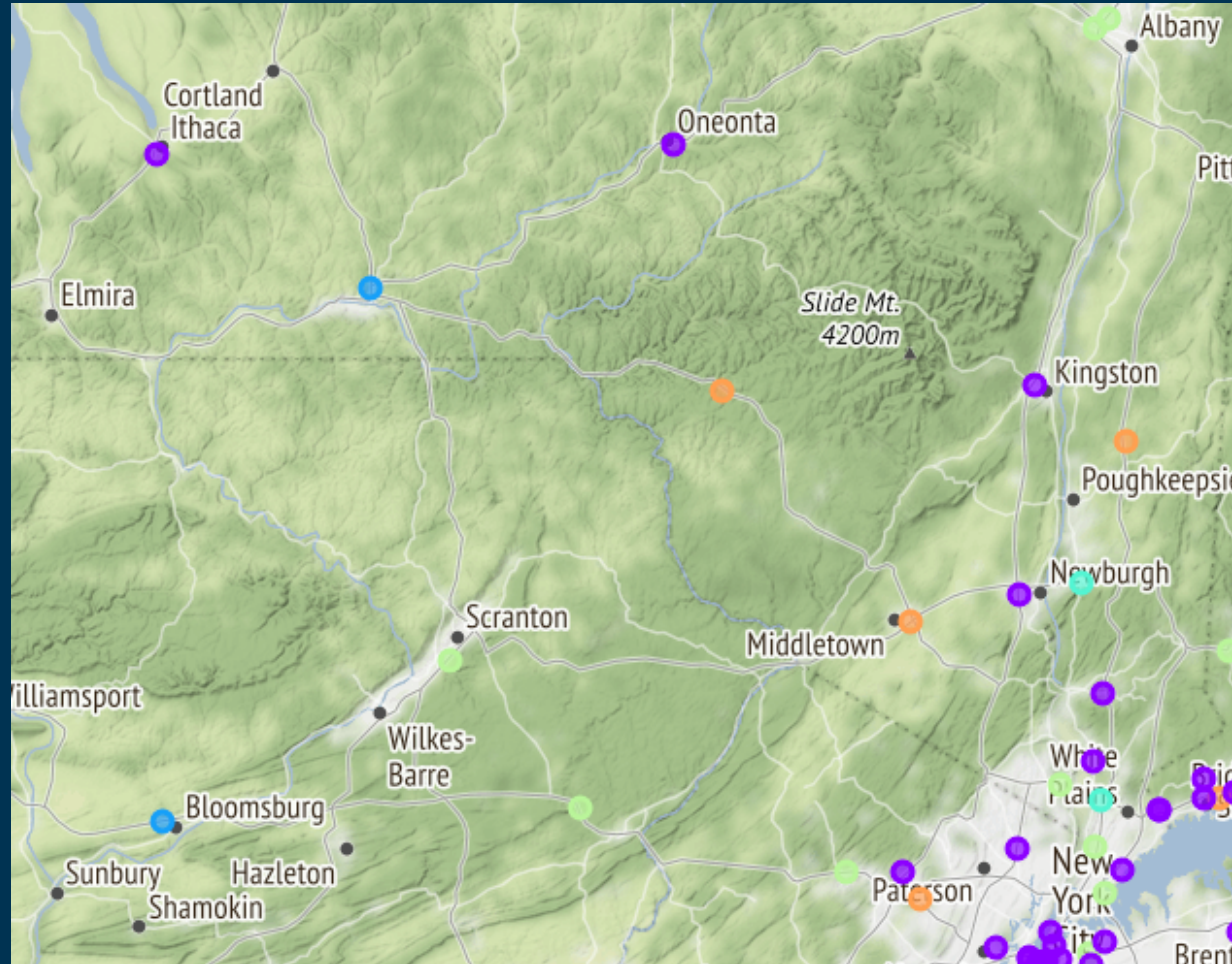
Charging Station Selection with Clusters

- Origin: Oklahoma City, OK
- Destination: Waco, TX
- Mid-route charging station options: Denton (Cluster 1) or Alvarado (Cluster 6)
- Cluster 6 chargers have predominance of Filipino restaurants
- Driver selects Alvarado charger to expand her culinary experience to include Filipino food



Destination Selection with Clusters

- Origin: Elmira, NY
- Destination: New York City or NY state capital (Albany)
- Driver wishes to visit zoo on way to destination
- Charging stations within clusters 5 and 6 contain predominance of zoos
- Route to NYC has 2 Cluster 5 charging stations
- Route to Albany has no Cluster 5 or 6 charging stations
- Driver selects NYC as weekend getaway destination and visits zoo(s) en route



Conclusion

- Charging station clustering useful for route and destination planning
- Certainly other use cases
 - Caravanning with Internal Combustion Engine vehicle
 - Choose route with charging stations in Cluster 6, containing predominance of gas stations within walking distance
 - Entrepreneur wishing to sell merchandise catering to electric vehicle owners
 - E.g., Tesla t-shirt, coffee mug with EV slogan, ...
 - Approach convenience stores near Cluster 5, which has charging stations with numerous convenience stores nearby
 - ...
- Project Enhancement
 - Included only Tesla US superchargers in this project
 - For further flexibility in selection of routes or en route charging stations, expand to also include non-Tesla DC fast chargers
 - For use outside of US, expand to include chargers worldwide

References

- [1] EV Charging Stations: <https://www.caranddriver.com/news/a30031153/ev-charging-guide/>
- [2] Alternative Fuels Data Center: <https://afdc.energy.gov/>
- [3] NREL Developer Network API: <https://developer.nrel.gov/docs/transportation/alt-fuel-stations-v1/all/>
- [4] Foursquare API: <https://developer.foursquare.com/>