C2SMART
CONNECTED CITIES WITH SMART TRANSPORTATION

Research Brief: Designing and Managing Infrastructure for Shared Connected Electric Vehicles

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Introduction

Electric free-float carsharing (eFFCS) represents the convergence of two major trends in urban mobility: electrification and shared mobility. Electric vehicles and carsharing are becoming increasingly popular, and both have potential positive impacts for city environments. However, while eFFCS offers the benefits of both EVs and FFCS, it also suffers from the challenges of both, specifically the need for rebalancing and recharging. EVs present the added complications of shorter ranges than conventional cars, longer charging times, and sparser charging infrastructure. Because of these challenges, it is critical for eFFCS systems to have a robust decision support system to minimize costs and maximize revenue-producing operations.

This project will investigate the potential for making electric free-float carsharing systems more efficient to operate by optimizing charging station locations. The research team developed a demand modeling framework for eFFCS based on the historical trip data of an operator in the City of Seattle. The model consists of two parts: a destination model to probabilistically predict the destination of a trip based on the origin and time of day, and a duration model to predict how long a vehicle is expected to stay parked or “dwell” at a particular location. Together, these models allow for simulation and mapping of trajectories of eFFCS vehicles throughout the city.

Methodology

Figure 1: (Left) Clusters showing trip generation density (Right) Hazard ratios from the Cox proportional model

For destination modeling, trip data from a carsharing fleet in Seattle were analyzed to extract any temporal patterns. Trip origins and destinations were then spatially clustered into zones using k-means cluster analysis, with the time variable split into four sections. The accuracy of destination zone predictions, given the origin zone and time of day as a categorical variable, is compared using multinomial logistic regression and naïve Bayes classification.

The destination model can help predict where a vehicle is likely to end up given the time of day and start cluster. However, to completely define a vehicle’s trajectory, the dwell time, i.e. the time a vehicle is parked between trips, needs to be modeled as well. A Cox proportional hazard model is used to predict the dwell duration using the location and time of day as covariates. As seen in Figure 1, clusters with high trip generation density match clusters with shorter dwell times.

Overview

- This project investigated the potential for making electric free-float carsharing systems more efficient to operate by optimizing charging station locations
- The researchers developed a demand modeling framework for eFFCS based on historical trip data of an operator in Seattle consisting of a destination model and a duration model
- The destination model is used create a trajectory synthesizer as an interactive web app. The trajectory synthesizer allows a selection of a number of trips and a time block and predicts a vehicle’s trajectory based on an initial click location

Project Personnel

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Results & Conclusions

The percentage of destinations correctly predicted declines with the number of clusters used, for both the MNL and NB approaches. Even if the city is divided into just four zones, the destination model predicts the destination correctly in about 55% of cases. With 20 clusters, the destination is predicted correctly about 20% of the time.

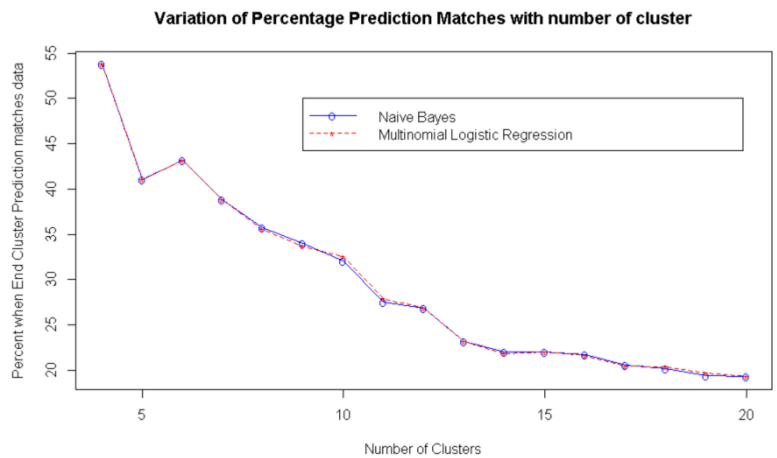

Figure 2: Change in percentage of predictions matching the data as the number of clusters is increased

The duration model indicated shorter dwell times during the afternoon and evening time blocks. Including the number of cars in the cluster and the number of cars within 500m of a vehicle starting a trip did not have much impact on the vehicle dwell times.

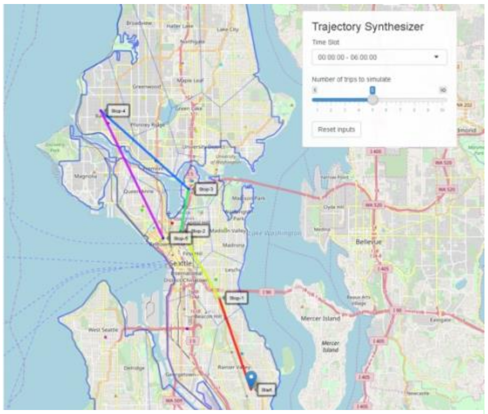

Figure 3: Sample trajectory synthesizer model run showing five trips

The research team used the destination model to create a trajectory synthesizer as an interactive web app. The trajectory synthesizer allows a selection of a number of trips and a time block and predicts the trajectory based on an initial click position in the Seattle region.

This project produced a destination model and a duration model that model usage patterns in a free-float carsharing system. Together, these two models can be used to probabilistically simulate trajectories for FFCS vehicles. Next, the modeling framework can be used to predict the optimal locations of charging stations by finding locations that are frequent destinations for cars with a low SOC and have longer dwell times. This would allow for minimum car relocation efforts and that they are charged where they are likely to stay parked for longer.

For more information and to read the project's full report, visit the C2SMART website.

- → **Project Webpage**
- → **Final Report**
- → **Web Application**

About C2SMART

C2SMART is a USDOT Tier 1 University Transportation Center taking on some of today's most pressing urban mobility challenges. Using cities as living laboratories, the center examines transportation problems and field tests novel solutions that draw on recent advances in communication and smart technologies. Our consortium includes New York University, Rutgers University, University of Texas at El Paso, University of Washington, and City College of New York.

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