Research Brief: Integrated Analytics and Visualization for Multi-Modality Transportation Data
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Introduction

The field of urban informatics is growing, attracting increasing interest from academia, government and industry. One particular area of interest is in modeling movement of people and goods around cities. A city model should allow for analytical approaches to answer questions like: How do cities evolve? How can cities be compared, clustered, and distinguished?

This research project aims to develop a data-driven approach for modeling cities. This requires the identification of areas in the city that have similar characteristics, such as a similar urban fabric, type of building facade, or even a specific item of interest, such as broken curbs or pedestrians. New data sets consisting of dense collections of images are now becoming available, which open up new possibilities for modeling and analyzing cities.

For this project, the research team leveraged a new data set composed of tens of millions of images from New York City captured over a period of a year by cameras mounted on top of cars. This data, by providing both spatially and temporally dense coverage of city streets, has the potential to provide users with a visual perspective that was not possible before. The team used this data to construct a model of pedestrian density in Manhattan and to create a tool, named Urban Portfolio, which allows users to interactively query, explore and analyze visual elements of the city over space and time.

Methodology

The team constructed a framework that leverages recent advances in computer vision to efficiently handle such a large collection of complex images, which was then used to create a spatiotemporal map of relative pedestrian density in Manhattan. Due to the limitations of state-of-the-art computer vision methods, automatic detection of pedestrians is inherently subject to errors. These errors were modeled as a probabilistic process, for which a theoretical analysis is provided. Through numerical simulations, it was demonstrated that, within the assumptions of this project, the methodology used can supply a reasonable estimate of pedestrian densities and provide theoretical bounds for the resulting error.

To create the interactive visual analysis tool, the research team used an approach that computes a set of feature vectors for each image in the collection at multiple resolutions using a convolutional neural network. They then designed a lightweight feature index allowing for memory and computationally efficient interactive querying. A visual interface consisting of a query interface and an exploration interface was designed, which allows users to query the dataset using spatial and temporal constraints.

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

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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.

![Variation of Percentage Prediction Matches with number of cluster](image)

*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.

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](#)

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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