C2SMART
CONNECTED CITIES WITH SMART TRANSPORTATION

# Research Brief: City-Scalable Destination Recommender System for On-Demand Senior Mobility

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## Introduction

Mobility-on-demand (MOD) services—rideshare, car- and bike-share, e-hail taxis, microtransit, and more—have been on the rise due to advances in information and communications technologies (ICTs). Despite their increasing popularity, many operational challenges make them hard to sustain. One of the biggest contributing factors to high operating costs is incidents that disrupt the planned route, such as non-recurring traffic delays, customer rescheduling, or cancellations. MOD services can be smarter by interacting with users and recommending destinations to them.

What is needed is an efficient learning mechanism for MOD services so that destinations they recommend can help the service efficiently learn the users' preferences over time. The learning problem of selecting options under repeated trials of those options is called a contextual bandit problem. The fundamental trade-off is to balance an option selection that could efficiently learn the uncertainty (exploration) associated with that option while still providing users with rewarding choices (exploitation). A good learning mechanism is one that, over multiple trials, minimizes its expected regret.

This project set out to better understand the mobility needs of seniors in El Paso and New York City through surveys to help inform the development of the recommender system. The research team also sought to implement a proof-of-concept recommender system that considers routing constraints and can be readily adapted to MOD services. Lastly, the researchers conducted computational experiments with the developed system to investigate the effect of routing constraints on its performance.

## Methodology

The research team conducted a survey in a joint effort with researchers at University of Texas at El Paso to gain better insight on elderly mobility needs in the context of mobility-on-demand services in smart cities. To develop the recommender system, the research team separated the system into recommendation and route generation parts. The problem of recommending destinations is formulated as a contextual multi-armed bandit. The route generation part is modeled as a dynamic traveling salesman problem with pickups and drop-offs (TSPPD).

Having developed a prototype of the recommender system, the researchers devised an experiment to see how it performs when considering routing constraints versus ignoring it. The experiment uses a simulated dataset containing people's choice to visit or not visit one of three restaurants, with the goal being to learn to suggest restaurants based on user's previous

## Overview

- This project sought to develop and implement a proof-of-concept recommender system that could be used by mobility-on-demand services to provide more efficient, smarter service
- The researchers also aimed to better understand the mobility needs of seniors in El Paso and New York City to inform the development of the recommender system
- The prototype recommender system was evaluated through computational experiments that revealed the impact of routing constraints on its performance

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history. In the experiment, an agent has to choose from a set of possible restaurants, and then receives a reward of 1 or 0 depending on whether it chose the system-recommended restaurant or not.

## Results & Conclusion

The survey found a few key differences in the needs, preferences and challenges of seniors in these two different cities. In El Paso, 62% of participants reported that traffic, parking and construction was their greatest commuting challenge, while waiting time was most frequently cited as the greatest challenge for New York residents. The top three concerns from both surveys – cost, on-time departure, and protection from extreme weather - were the same, just in different orders. One common insight between the cities was that public transit information and navigation are key features desired in smartphone apps.

The experimental results showed that the recommendations become fairly stable when relying only on routing cost per individual and location rating for the destinations. The recommendations also generally matched the trendy destinations in the dataset, showing the effectiveness of the algorithm in recommending highly rated locations while accounting for routing costs.

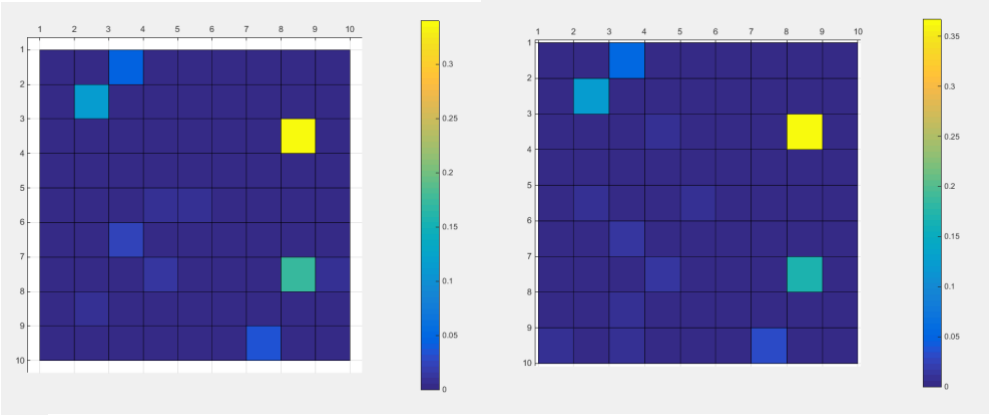

*Figure 1: Distribution of recommended zones after (left) 500 trials and (right) 2000 trials.*

The researchers also calculated the average regret for this case, along with an alternate scenario with increased travel time costs. Regret performance improves slightly with increased travel time cost, suggesting that the higher costs mean the algorithm has to do less exploration to hone in on the best destinations. This is promising because it suggests that the benefit of using such a recommender system increases when the need is greater.


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.

## Disclaimer