STRIDE | Southeastern Transportation Research, Innovation, Development and Education Center

Technology Transfer Final Report

STRIDE Project B3

Micro-Mobility as a Solution to Reduce Urban Traffic Congestion

Xilei Zhao, PhD

University of Florida

March 2023

THE STRIDE CENTER

The STRIDE Center is the 2016 USDOT Region 4 (Southeast) University Transportation Center (UTC) housed at the University of Florida Transportation Institute (UFTI). Our mission is to develop novel strategies for Reducing Congestion. The Center has nine partners, representing seven states in the Southeastern U.S. The UFTI and its partners in the STRIDE Center are recognized leaders at state, regional, national, and international levels. The STRIDE Center is focused on assembling and integrating research projects throughout the region in a way that maximizes contributions to solving current and future transportation problems as well as strengthening expertise and developing new technologies. For more information see https://stride.ce.ufl.edu/.

DISCLAIMER

ACKNOWLEDGEMENT OF SPONSORSHIP AND STAKEHOLDERS

This work was sponsored by a contract from the Southeastern Transportation Research, Innovation, Development and Education Center (STRIDE), a Regional University Transportation Center sponsored by a grant from the U.S. Department of Transportation's University Transportation Centers Program.

1. Project Overview

Micromobility is an innovative transportation strategy that has demonstrated a great potential for congestion mitigation. However, the research on micromobility is very limited in the field of transportation. This project aims to conduct a comprehensive study to analyze, quantify, and understand the impacts of micromobility on congestion reduction and recommend corresponding intervention strategies for stakeholders.

We firstly inferred origins and destinations of e-scooter trips in Washington, D.C. based on the General Bikeshare Feed Specification (GBFS) data and modeled the trip origin demand of e-scooter services. The Ordinary Linear Squares (OLS), Lasso, Decision Tree (DT), Random Forest (RF), and Boosting models were used to predict the trip origin demand in census block group level. The RF model had the best performance among the five models regarding root mean squared error (RMSE) and mean absolute error (MAE). Then we used feature importance (FI) and partial dependence plots (PDP) to interpret the RF model. The results showed that the most important category of variable was built environment variables. From PDPs, we also observed nonlinear relationships between the dependent variable and independent variables.

After that, we developed an extended module for shared micromobility simulation in MATSim by applying modifications to its carsharing module. We also developed an effective pipeline to generate synthetic student plans by using different real data sources. The updated MATSim framework was utilized to generate realistic day plans for travelers in a case study that considered 500, 750 and 1000 e-scooters on and around the UAB campus. The case study results confirmed that the simulated traffic volumes are lower and travel speeds are higher when e-scooters are available, compared to the base case scenario.

Then we discussed the policy related to shared micromobility operation and developed a decision-support tool that can collect and analyze the e-scooter-related data. Lastly, we created a new decision-support tool to assist cities to better monitor and analyze e-scooter usage and gather inputs from residents. We also presented policy recommendations on regulatory structure, general terms and conditions, operations oversight, public engagement, data, and infrastructure.

This project provided rich insights of key factors associated with micromobility demand, examined the potential impact of deployment of e-scooters and other micromobility options on traffic operations, and generated new knowledge for stakeholders to facilitate planning micromobility policies and practices.

2. Research Goals

This project aims to conduct a comprehensive study to analyze, quantify, and understand the impacts of micromobility on congestion reduction and recommend corresponding intervention strategies for stakeholders.

3. Findings

This project provided rich insights of key factors associated with micromobility demand, examined the potential impact of deployment of e-scooters and other micromobility options on traffic operations, and generated new knowledge for stakeholders to facilitate planning micromobility policies and practices.

4. Performance Metrics

Metric	# Completed
OUTPUTS	
Product(s): Number of new or improved tools, technologies, products, methods, practices, and processes created or improved	4
Technical Report: Number of client-based technical reports published	STRIDE Final Report
OUTCOMES	
Body of Knowledge: Number of trainings for transportation professionals	6
Professionals Trained: Number of professionals participating in trainings	~478
IMPACTS	
Stakeholders: Number of stakeholders you met with to encourage adoption or implementation of product(s)	7
Adoption/Implementation: Number of incidences outputs of research have been implemented or adopted	1

5. Product(s)

1) Developed new methodologies in interpretable machine learning to model and interpret travel demand of micro-mobility.

Problem

Micromobility is flexible, convenient, affordable, accessible, environmentally friendly, and is a good solution to the "first mile/last mile" problem (the problem of public transit being unable to get passengers to their doorstep) that has long troubled public transit. Among all the micromobility options, e-scooters are growing at the fastest pace (NACTO, 2019). While e-scooter as a travel mode can greatly enhance urban mobility, it has two key limitations. Firstly, the demands of e-scooter trip origin and destination are unbalanced spatially and temporally. For example, the spatial distribution of commuter trip origins and destinations are significantly unbalanced during the morning peak and the afternoon peak. The operators need to rebalance the vehicles to meet the high demand of e-scooter use in some areas. Therefore, accurate spatiotemporal e-scooter demand predictions are needed to help the operators generate optimal rebalancing strategies. Secondly, the e-scooters need to be recharged when they are at a low power level. Under normal usage conditions, a typical e-scooter must be recharged at least once within 24 hours. To accomplish this, the operators pay citizens to recharge e-scooters on their private property. Participants are instructed to pick up scooters with low power levels and drop them off at specific locations when finishing recharging. Accurate e-scooter demand predictions are needed to determine the optimal scooter drop-off locations. However, few existing studies focus on the e-scooter demand prediction problem.

Product

A methodology was developed to use machine learning methods to model the e-scooter demand and explore effects of different factors**.**

The independent variables include socioeconomic and demographic variables, built environment variables, and transit supply variables. The linear regression, Lasso, decision tree, random forest, and boosting trees models are used to predict the trip origin demand in census block group level. The in-sample and out-of-sample performance of these five models are compared. The results of the best performed model, the random forest model, are further interpreted using feature importance and partial dependence plots.

Application

Using data from Washington, DC as a case study, the most important variable is WalkScore and the most important category of variable is built environment variables. From partial dependence plots, we can observe nonlinear relationships between the dependent variable and independent variables. For example, when WalkScore increases from 85 to 95, there is a sharp increase in trip origin demand. The results and insights regarding the trip origin demand found in Washington D.C may not be directly transferable to other cities with different characteristics. Therefore, transferability requires further research in the future.

2) Invented new algorithms to infer e-scooter trips from GBFS data

Problem

Public application programming interfaces (APIs) are the main data source for the public to understand micromobility. As a part of the micromobility permit requirement, cities often require micromobility providers to share data through APIs prescribed by standard formats, including the General Bikeshare Feed Specification (GBFS). GBFS was initially developed as the open data standard for bike share system availability back in 2015, but now it is applicable for nearly all shared micromobility systems in the North America (NABSA, 2020). GBFS data only reports real-time information about available vehicles, which typically includes vehicle location, vehicle type (bike or scooter), and battery level. We need to infer trip origins and destinations from the raw data.

Product

Three algorithms are developed to deal with different types of GBFS data, including static vehicle ID, resetting vehicle ID, and dynamic vehicle ID. These algorithms can produce accurate inference of shared micromobility trip origins and destinations to help researchers and decision-makers understand the travel demand of shared micromobility across time and space with high granularity.

3) Improved the activity-based traffic simulator

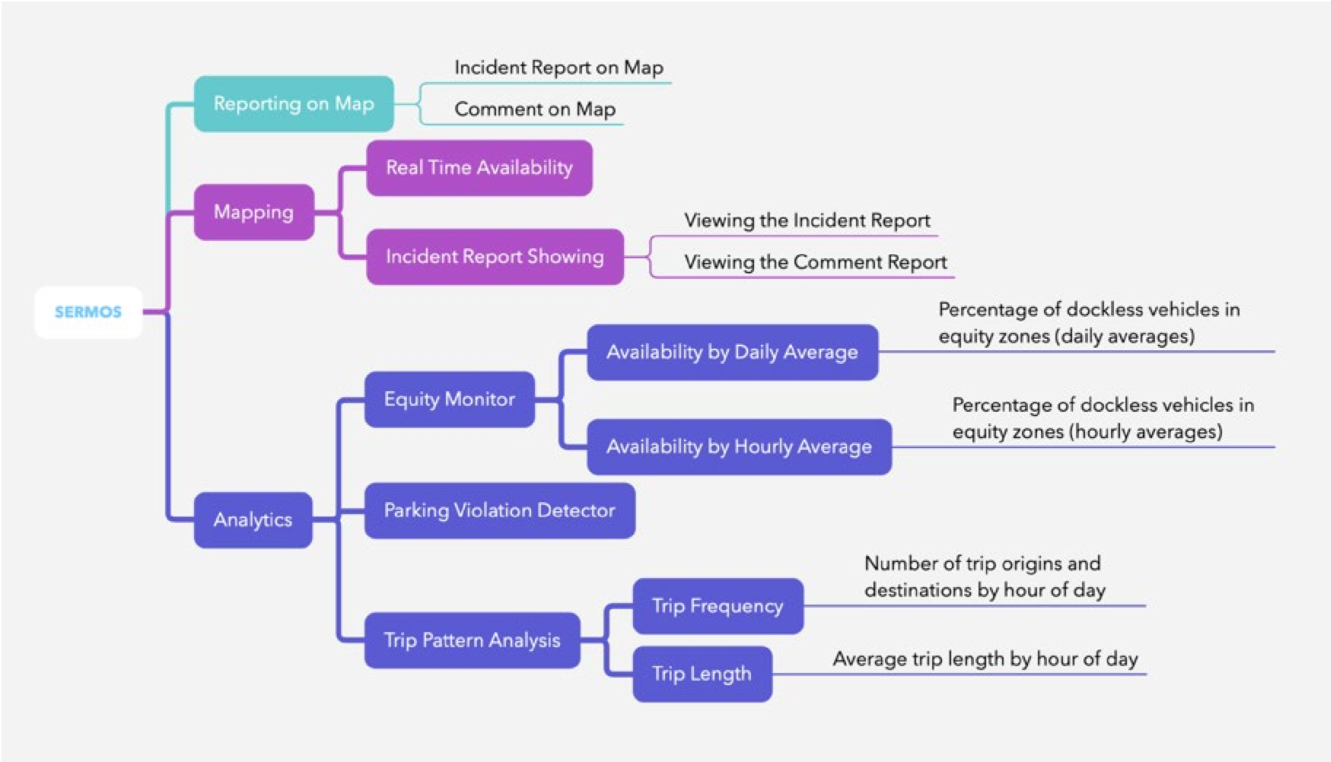
In any MATSim model, each MATSim job is associated with a configuration file, which defines job parameters. In our study, in order to allow proper simulation with e-scooters as a mode of shared mobility, we made the following changes to the configuration file:

1) MATSim uses a FIFO queue on each road link for vehicle traffic simulation by default, but this will cause the slower e-scooters to block the faster cars following them. We configured the job to use MATSim's "PassingQueue" instead, which allows e-scooters to use a designated lane so that they will not block the cars. This aligns better with the real situation around UAB where dedicated bike lanes are available, and
2) MATSim's "subtourmodechoice" strategy for replanning was enabled, so that MATSim can change modes between iterations. This would allow a more reasonable mode setting to be explored by the co-evolutionary framework of MATSim, so that the best plan (using e-scooters or not) can be retained and selected due to its better score.

4) Decision-Support Tool for Stakeholders: SERMOS

SERMOS collects and analyzes the e-scooter-related data (e.g., GBFS data, e-scooter equity zone data, e-scooter parking zone data, among others), which is expected to benefit various stakeholders. For example, cities can use the tool to monitor and regulate micromobility operations. MPOs can use the tool to assist long-term planning of multimodal transportation systems. For the SERMOS system, there are three modules, including reporting module, mapping module, and analytics module.

The reporting module provides the functionality that users can click any location on the map to report an e-scooter incident or just leave a comment. After the report is submitted, the reported location and the reporting time will also be recorded. All of this information will be then stored and maintained in the database to serve as the input for the mapping module. The analytics module includes equity monitor, parking violation detector, and trip pattern analysis. The analytics module will be fully developed if additional funding is available.



6. Who benefits/will benefit from your product(s)?

- Transportation researchers
- DOTs
- Industry partners

7. Body of Knowledge & Professionals Trained

1) A webinar on transportation data analytics for professional training was held Oct 2020. (20 Attendees)
2) A workshop presentation on real-time forecasting of micromobility demand using a context-aware recurrent multi-graph convolutional neural network approach was held in 2021 TRB workshop sponsored by AED50. (300 Attendees)
3) Dr. Xilei Zhao gave an invited lecture, entitled "Planning micromobility for future smart cities," for the course "Miami 2030 – from smart transportation to urban transformation" at the University of Miami School of Architecture. (10 Attendees)
4) Dr. Xilei Zhao gave an invited talk, entitled "Planning innovative mobility systems with machine learning," at the Transportation Data Science Seminar Series, hosted by Texas A&M University. (50 Attendees)
5) Yiming Xu gave an invited talk, entitled "Real-time forecasting of dockless scooter-sharing demand: A spatio-temporal multi-graph convolutional network approach," in the UF AI Research Catalyst Fund Seminar Series. (40 Attendees)
6) STRIDE Webinar: "Micro-Mobility as a Solution to Reduce Urban Traffic Congestion" presented by Xilei Zhao, University of Florida (UF), Virginia Sisiopiku, University of Alabama at Birmingham (UAB),

and Ruth Steiner, University of Florida (UF) on April 20, 2022. (58 Attendees) Recording: https://youtu.be/j3nnO5szJgI

8. Journal Publications, Conference Presentations, & Posters

Date	Type of Accomplishment	Detailed Description
1/2020	Conference Paper	Zhao, X., Liu, X., Yan, X. (2020). Modeling demand for ridesourcing services in the City of Chicago: A direct demand machine learning approach. Proceedings of Transportation Research Board 99th Annual Meeting, Washington, DC.
1/2020	Conference Presentation	Xu, Y., Yan, X., Liu, X., Zhao, X. (2020) Applying Interpretable Machine Learning to Identify Key Factors Associated with Ride-Splitting Adoption Rate and to Model Their Nonlinear Relationships. Transportation Research Board 99th Annual Meeting, Washington, DC.
2/2020	Publication	Yan, X., Liu, X., Zhao, X. (2020). Using machine learning for direct demand modeling of ridesourcing services in Chicago. Journal of Transport Geography, 83, 102661.
2/2020	Publication	Zhao, X., Yan, X., Yu, A., Van Hentenryck, P. (2020). Prediction and behavioral analysis of travel mode choice: A comparison of machine learning and logit models. Travel Behaviour and Society, 20, 22-35.
6/2020	Conference Presentation	Elefteriadou, L., Du, L., Zhao, X. (2020). Autonomous vehicles and micromobility in a disruptive society and transportation system. The 5th Conference on Sustainable Urban Mobility.
8/2020	Conference Presentation	Sisiopiku, V., Zhao, X., Xu, Y., Yan, D., Steiner, R. (2020) Can Micro-mobility Reduce Urban Traffic Congestion?. ITE Annual Meeting.
10/2020	Conference Paper	Zhang, X., Zhao, X. (2020). A Clustering-aided Ensemble Method for Predicting Ridesourcing Demand in Chicago. Proceedings of Transportation Research Board 100th Annual Meeting, Washington, DC. (Paper accepted for presentation)
10/2020	Conference Paper	Noei, S., Zhao, X. (2020). Longitudinal Dynamics in Traffic Microsimulation. Proceedings of Transportation Research Board 100th Annual Meeting, Washington, DC. (Paper accepted for presentation)

10/2020	Conference Paper	Xu, Y., Yan, X., Sisiopiku, V. P., Merlin, L. A., Xing, F., Zhao, X. (2020). Micromobility Trip Origin and Destination Inference using General Bikeshare Feed Specification (GBFS) data. Proceedings of Transportation Research Board 100th Annual Meeting, Washington, DC. (Paper accepted for presentation)
12/2020	Conference Presentation	Zhao, X. (2021). Micromobility for smart cities: Planning, design, and operations. Interstate Transit Research Symposium.
01/2021	Publication	Xu, Y., Yan, X., Liu, X., Zhao, X. (2021). Identifying key factors associated with ride-splitting adoption rate and modeling their nonlinear relationships. Transportation Research Part A: Policy and Practice. https://doi.org/10.1016/j.tra.2020.12.005
01/2021	Publication	Merlin, L. A., Yan, X., Xu, Y., Zhao, X. (2021). A segment-level model of shared, electric scooter origins and destinations. Transportation Research Part D: Transport and Environment. (Accepted)

9. Stakeholder Engagement

STRIDE rep.	X. Zhao	X. Zhao met with the Transit Director of RTS and discussed our STRIDE project and the potential to integrate micro-mobility with public transit to facilitate first/last-mile problem.
Date of Activity	11/18/19	
Type of Activity	in-person meeting	
Location	RTS	
Stakeholder(s)	Jesus Gomez	
STRIDE rep.	X. Zhao	X. Zhao met with program managers of FDOT and discussed our STRIDE project to seek their input.
Date of Activity	12/18/19	
Type of Activity	in-person meeting	
Location	FDOT	
Stakeholder(s)	Darryll Dockstader	
STRIDE rep.	X. Zhao	X. Zhao met with industry partner to seek feedback on our findings and explore collaboration opportunities.
Date of Activity	2/12/20	
Type of Activity	phone meeting	
Location		
Stakeholder(s)	Laurence Wilse-Samson, Sr. Manager, Policy Research @ Bird	
STRIDE rep.	X. Zhao	X. Zhao met with industry partner to seek feedback on our findings and explore collaboration opportunities.
Date of Activity	3/25/20	
Type of Activity	phone meeting	
Location		
Stakeholder(s)	Andrea Broaddus, Sr. Research Scientist @ Ford Mobility	

STRIDE rep.	V. Sisiopiku	V. Sisiopiku met with key stakeholders listed below to seek feedback on our work.
Date of Activity	2/13/20	
Type of Activity	in-person meeting	
Location	UAB	
Stakeholder(s)	Darrell O'Quinn, City Councilor, City of Birmingham Cory Pettway, Community Liaison, City of Birmingham Colin Alexander, City of Birmingham Brian Atkinson, Programs Manager, Parking and Transportation, UAB Andre Davis, Director of Transportation, Parking and Transportation, UAB	
STRIDE rep.	X. Zhao	X. Zhao presented our work in I-STREET stakeholder meeting to seek their feedback.
Date of Activity	09/23/20	
Type of Activity	other - please describe	
Location	Zoom	
Stakeholder(s)	FDOT central office officials and location district officials (around 30-40 people attended the meeting)	

10. Adoption/Implementation

Dr. Zhao has been actively working with the City of Gainesville for the product adoption.

11. Broader Impacts

This project can positively impact the transportation system in terms of improving mobility and reducing congestion. This project provided insights of key factors associated with micromobility demand, examined the potential impact of deployment of e-scooters on traffic operations, and generated new insights for key stakeholders to facilitate planning micromobility policies and practices. The products have been shared with multiple stakeholders, including government agencies and industry partners, for feedback and/or potential adoption.