User Characteristics, Spatiotemporal Patterns, and Spatial Access in a Dockless E-Scooter Service in Puerto Rico

Daniel Rodríguez-Román, Andrés G. Camacho-Bonet, Gabriela Yáñez-González, Fernando A. Acosta-Pérez, Lina M. Villa-Zapata, Charmelis A. Reyes-Cruz
Carlos A. del Valle-González, Benjamín Colucci-Ríos, Alberto M. Figueroa-Medina | University of Puerto Rico at Mayagüez

NATIONAL INSTITUTE for CONGESTION REDUCTION

NATIONAL INSTITUTE FOR CONGESTION REDUCTION

National University Transportation Center (UTC) for Congestion approved by the U.S. Department of Transportation in October 2019.

Mission Emerge as a national leader in providing multimodal congestion reduction strategies through real-world deployments that leverage advances in technology, big data science and innovative transportation options to optimize the efficiency and reliability of the transportation system for all users.

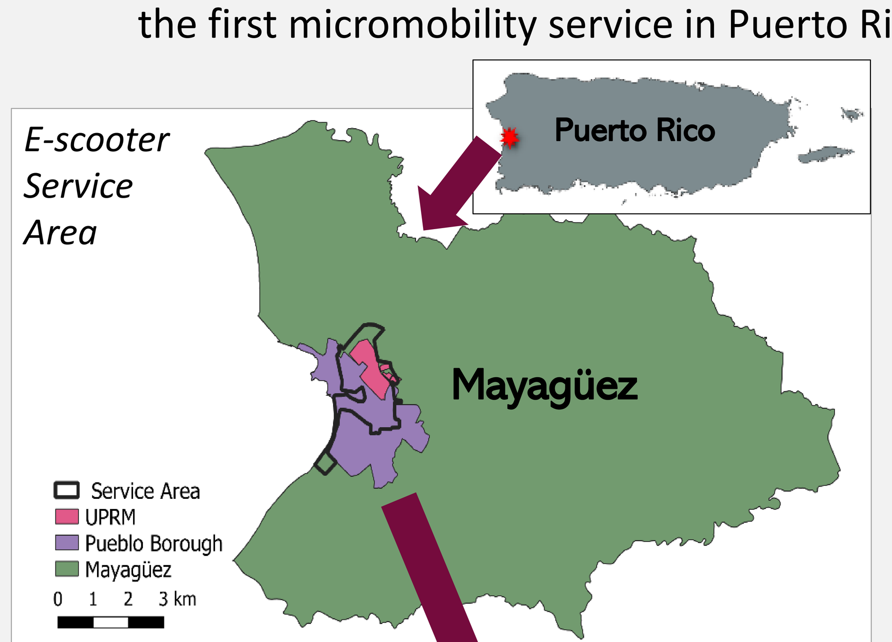
Projects
- Pricing Mechanisms for Managed Lanes
- Corridor Wide Surveillance Using Unmanned Aircraft Systems
- Influencing Travel Behavior Via an Open-Source Platform
- Enhancing Equity and Access

INTRODUCTION

1. Case study of a dockless e-scooter system in Mayagüez, Puerto Rico.
   - Attributes and opinions of users and non-users of the e-scooter service are explored.
2. Methods are proposed for quantifying spatial access to dockless micromobility systems and for measuring the regularity of their spatiotemporal patterns
   - Spatial access measured in terms of network-level proximity to the e-scooter fleet.
   - Pattern regularity measured using a similarity measure approach.

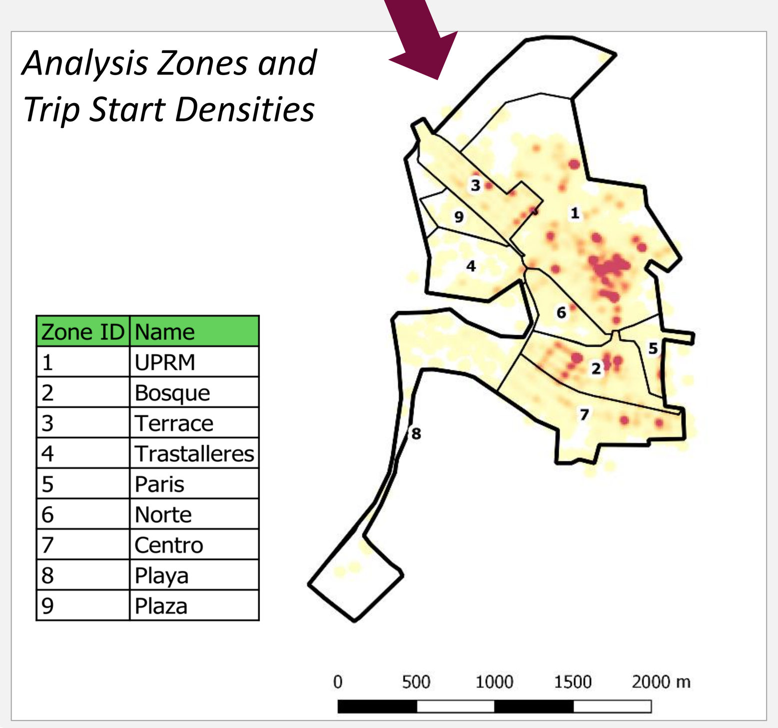
DESCRIPTION OF MAYAGÜEZ AND E-SCOOTER SERVICE

- College town with 77,000 residents and substantial floating student population that lives around the University of Puerto at Mayagüez (UPRM).
- Skootel, a micromobility startup, operates a dockless e-scooter service in the city, the first micromobility service in Puerto Rico.



Mayagüez City Characteristics

Characteristic	Value
Median age	40
Female population	52%
Bachelor's degree or more	25%
Median household income	$14,120
Population below the federal poverty line	53%
Unemployment rate	27%
Drive alone or carpool	91%



Service Characteristics

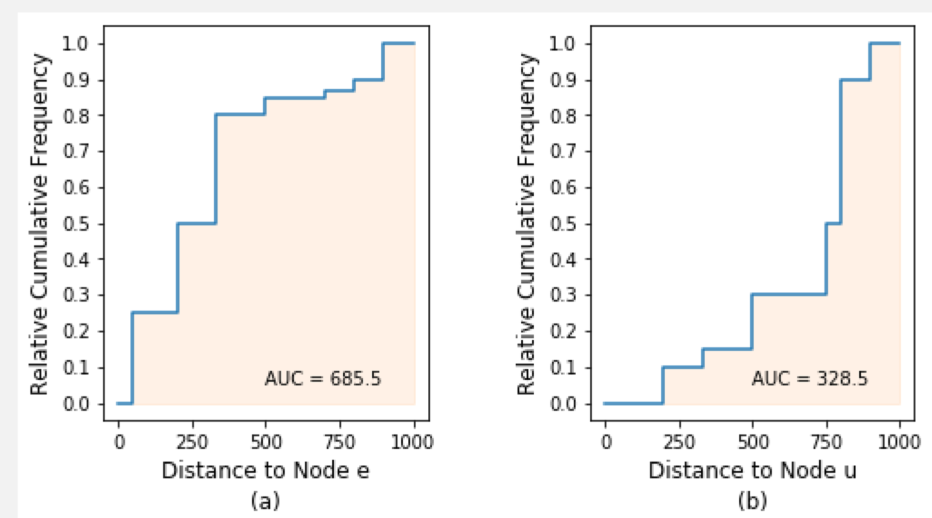
Characteristic	Value
Service Area	3.5 km²
Trip cost	$1 + 0.20/travel minute
Operation hours	6:00 AM to 8:00 PM
Fleet size	About 100 scooters
Rebalancing	Midday operations
Opening date	August 3, 2019

DATA

- Skootel data of 66,000 e-scooter trips during the 2019-2020 academic year.
- US Census block group data from the 2014-2018 American Community Survey.
- Online survey from March to May 2020 with 417 responses.

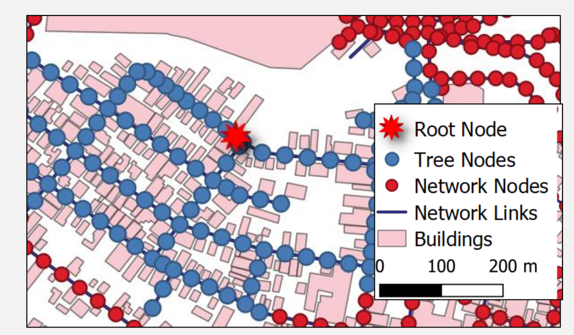
METHODS

- Two spatial access indicators are proposed:
  - average distance to the K-nearest e-scooters.
  - area under scaled cumulative relative frequency curve (AUC).
- AUC is computed for each node $\boldsymbol{i}$ by determining the area under the cumulative relative frequency curve constructed with shortest path distances from a node $\boldsymbol{i}$ to all e-scooters on day $\boldsymbol{d}$ at period $\boldsymbol{p}$.



AUC values for e-scooter distances of nodes e and u
(as AUC increases, the "closer" a node is to the e-scooter fleet)

E-scooters were mapped to network nodes to compute spatial access.



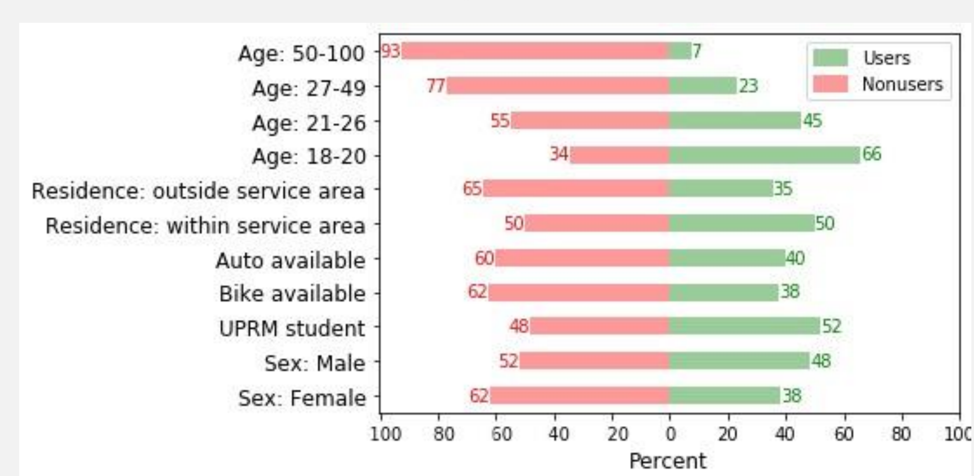
- Nodal e-scooter density: number of e-scooters in node's graph tree divided by the number of people (e.g., residential nodes) connected to the tree.
- Indicator of patter regularity: Quantify degree to which observed spatiotemporal e-scooter distribution repeats itself during a given period

$$s_{dh} = \frac{\sum_{p\in P}\sum_{g\in G}\min(m_{dpg}, m_{hpg})}{\sum_{p\in P}\sum_{g\in G}\max(m_{dpg}, m_{hpg})}$$

- s_{dh} = Ruzicka similarity index for observed trip patterns in days d and h.
- m_{dpg} = # e-scooters in cell g on day d and period p (computed after service area is split by grid).

RESULTS – ANALYSIS OF SURVEY RESPONSES

Characterization of Users and Non-users

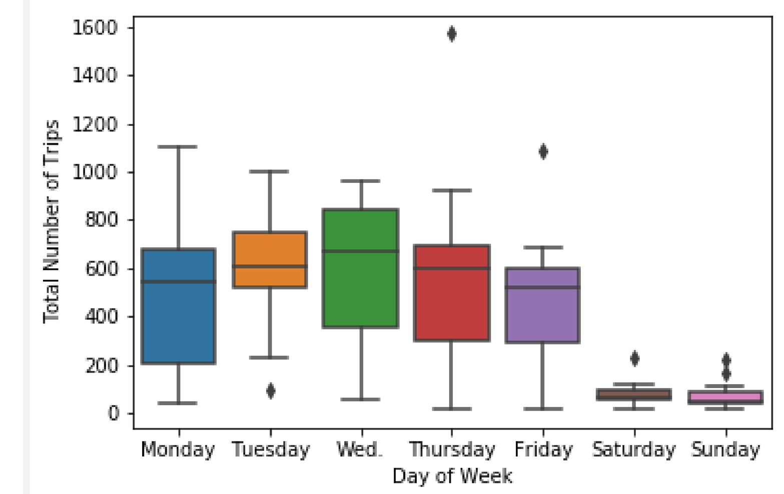


Main reasons for using e-scooters:
- travel time savings (58%)
- avoid traffic congestion (37%)
- lack of auto parking spaces (34%)

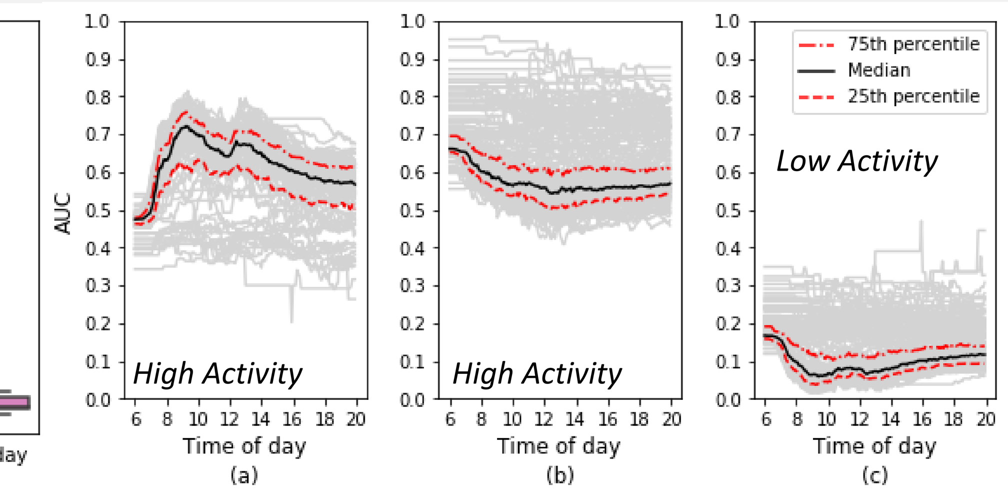
Main reasons for NOT using e-scooters:
- lack of space in streets (40%)
- cost of e-scooter trips (35%)
- safety concerns (23%)

RESULTS – SPATIOTEMPORAL PATTERNS, SPATIAL ACCESS

Daily trips by day of week

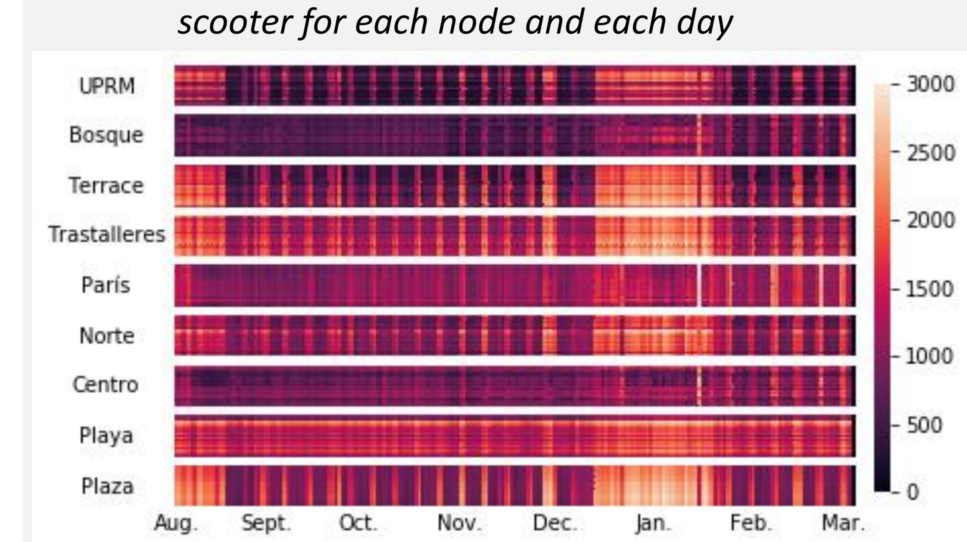


AUC for nodes in high- and low-activity zones

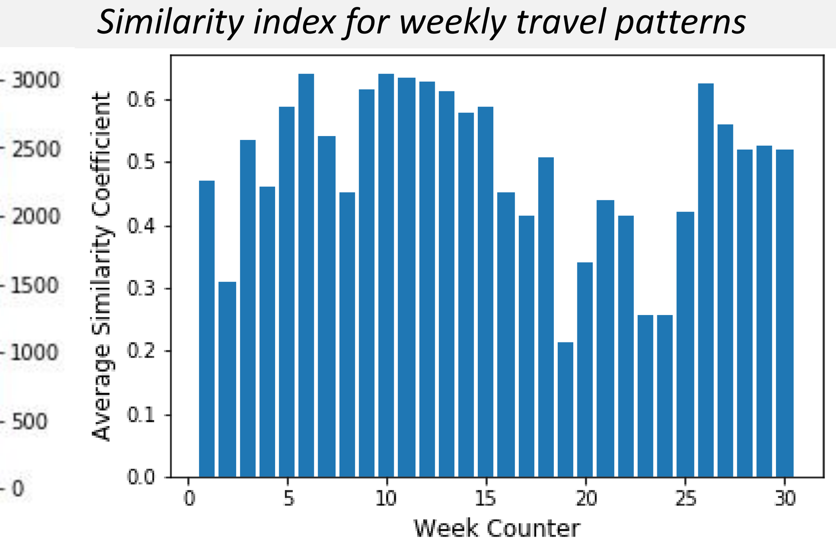


- Demand is driven by students; when students leave the city (weekends, holidays, semester break) demand for e-scooter trips is reduced significantly.
- Spatial access indicators suggest that access to the system varies significantly even in within zones and by time of day.
- Similarity index drops in transition periods (e.g., end of semester, start of semester); it is sensitive to cell size; could be an approach for comparing dockless micromobility patterns between cities.

Average minimum walking distance (meters) to an e-scooter for each node and each day



Similarity index for weekly travel patterns



CLOSING REMARKS

- E-scooter trip generation is higher for UPRM and large student neighborhoods.
- Usage of e-scooters was found comparable to other cities:
  - Users primarily young and male.
  - Peak hours do not match those of the auto mode.
  - Main motivation of e-scooter trips are university-related activities.
- Trips appears to be contributing to reduction of auto trips, but the magnitude needs to be studied.

ACKNOWLEDGMENTS

- Thanks to Skootel for providing e-scooter trip data and information about their system.
- Study supported by the National Institute for Congestion Reduction (NICR); funded by the US-DOT Office of the Assistant Secretary for Research and Technology UTC Program under Grant 69A3551947136.

RECOMMENDED LITERATURE RELATED TO PROJECT

1. Bai, S., and J. Jiao. Dockless E-Scooter Usage Patterns and Urban Built Environments: A Comparison Study of Austin, TX, and Minneapolis, MN. Travel Behaviour and Society, 2020. 20:264–272.
2. Caspi, O., M. J. Smart, and R. B. Noland. Spatial Associations of Dockless Shared E-Scooter Usage. Transportation Research Part D, 2020.
3. Mathew, J., M. Liu, H. Li, S. Seeder, and D. Bullock. Analysis of E-Scooter Trips and Their Temporal Usage Patterns. ITE Journal, 2019. 89(6):44–49.
4. Mooney, S.J., K. Hosford, B. Howe, A. Yan, M. Winters, A. Bassok, and J.A. Hirsch. Freedom from the Station: Spatial Equity in Access to Dockless Bike Share. Journal of Transport Geography, 2019. 74:91–96.