Why Do People Take E-scooter Trips? Big Data and Unsupervised Machine Learning Insights on Temporal and Spatial Usage Patterns

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Background

- 86 million e-scooter trips in 2019, which is over a 120% increase in trips compared to 2018 (NACTO, 2020)
- Emerging and disruptive technology
- Policy-level questions
  - Safety
  - Sustainability
  - Parking
  - Mode shift
- **When, where, and why people use e-scooters**

Photo credit: https://www.irishtimes.com/business/technology/tech-review-electric-scooter-is-fun-portable-but-not-that-light-1.3951480

Research approach

- Survey-based and/or observational studies
  - Pilot project evaluation: City of Austin (2019)
- Micromobility trip data analysis
  - Descriptive statistics: McKenzie (2019) and Liu, Seeder, and Li (2019)
  - Discrete choice model: Reck, Guidon, Haitao, and Axhausen (2020)
  - Regression models: Bai and Jiao (2020) and Younes, Zou, Wu, and Baiocchi (2020)
  - Spatial regression models: Caspi, Smart, and Noland (2020)

Research objective:

To identify e-scooter usage patterns using spatiotemporal analysis of micromobility data

Data

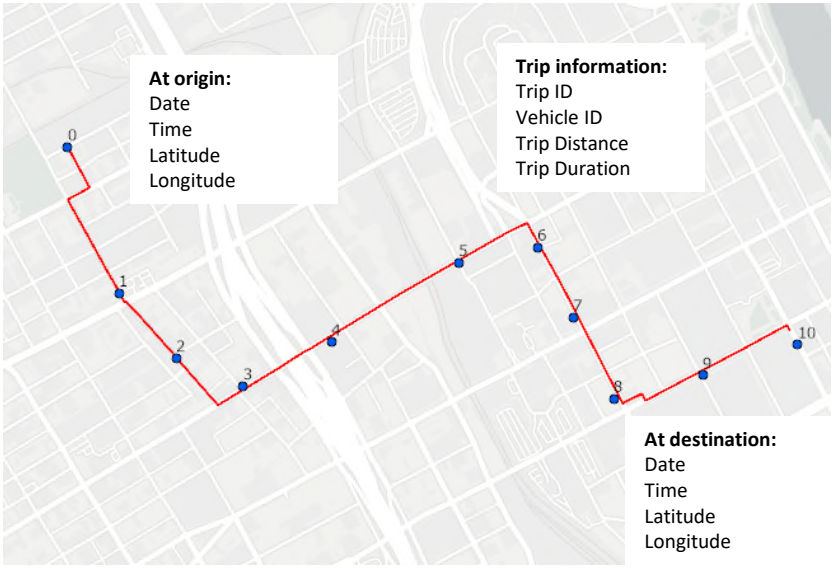
- **Study Area:** Nashville, Tennessee
- **Trip data source:** Shared Use Mobility Device (SUMD)

Trip Summary

Device Availability

Parking Compliance

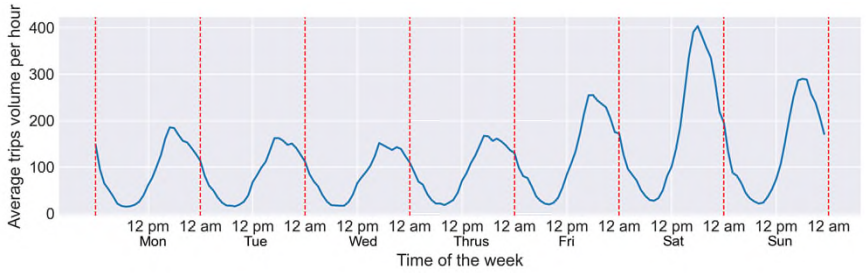
- **Study period:** September 1, 2018 to August 31, 2019
- **Number of trips:** 1,072,430



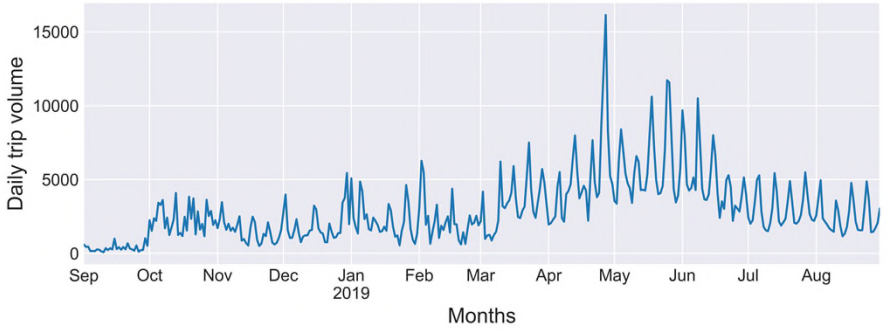
Sample trip summary data from Nashville's SUMD

Basic usage information

- One daily peak in the evening
- Weekend (Friday-Sunday) has higher usage than weekdays
- Saturday evening has highest e-scooter usage in the week
- Summer months have higher e-scooter usage
- Average trip distance: 0.72 miles
- Average trip duration: 17 minutes

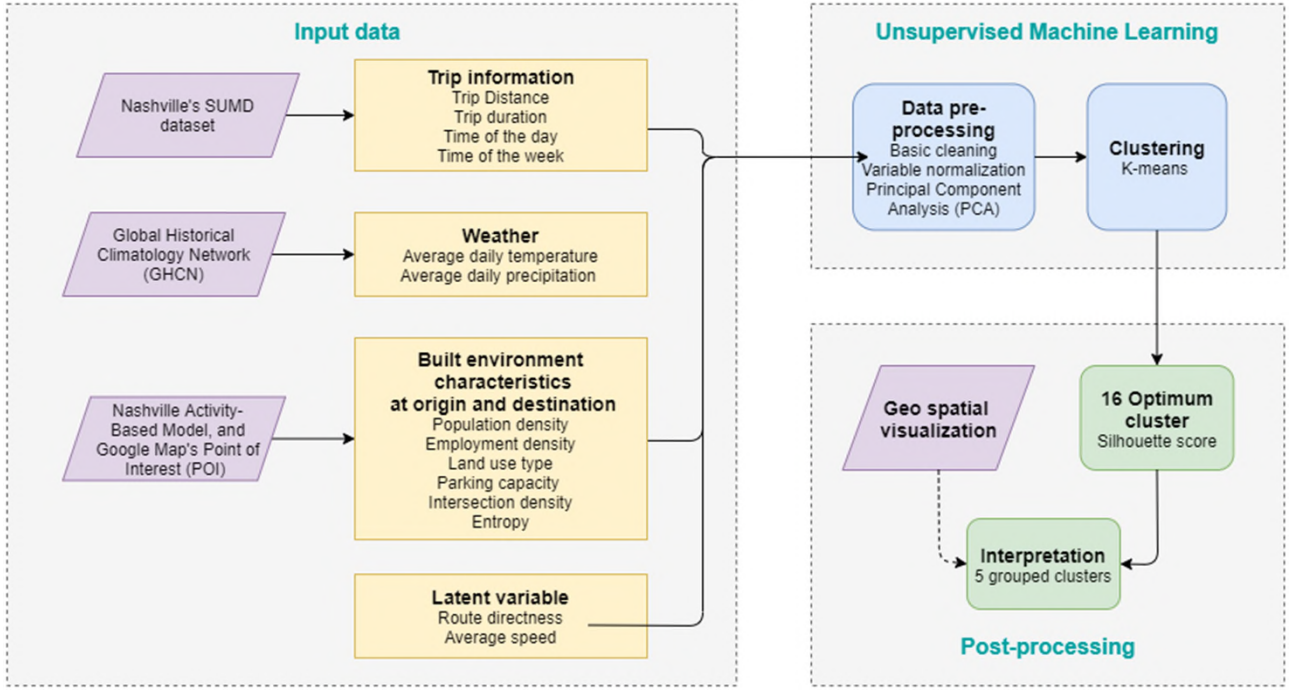


E-scooter usage by time of day and week



E-scooter usage over a year

Methodology

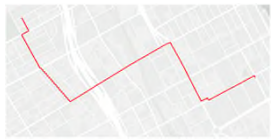


Analytical framework

Route directness

$$= \frac{Euclidean\ distance\ between\ O\&D}{Actual\ path\ distance\ between\ O\&D}$$

which varies between 0 an 1

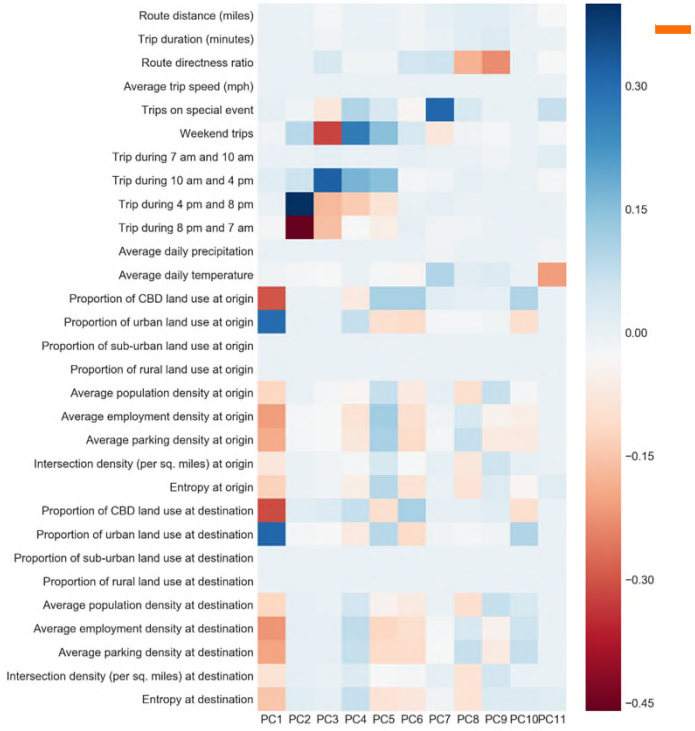


Value towards 1:
shorter path between O&D

Value towards 0:
longer path between O&D

Factors influencing e-scooter trips

- Principal Component Analysis (PCA) for dimension reduction
- The color scale in the figure indicates the loadings, which is positive or negative correlation between PCs and variable
- Strong correlation between start time, land use variables, temperature, and route directness



Loadings of first 11 Principal Components (PCs)

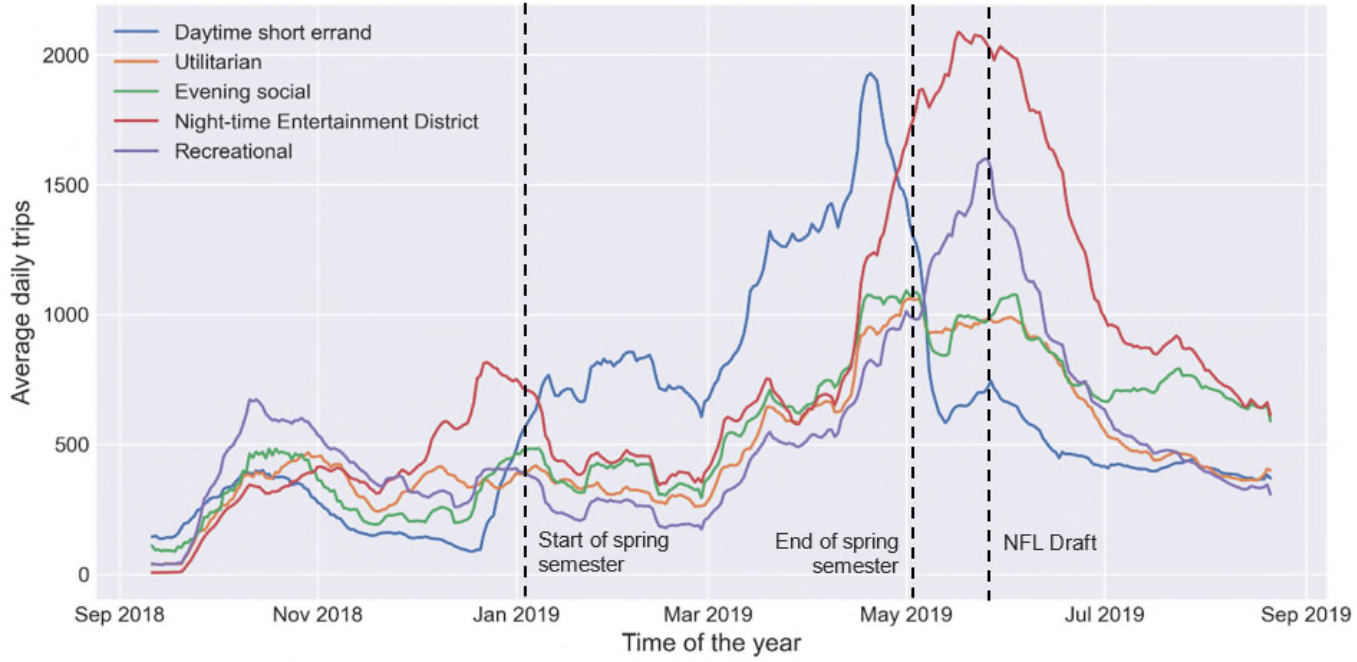
Usage-grouped clusters

We combined 16 K-means clusters into five usage-grouped clusters based on trip attributes like start time, land use of trip origin and destination, and route directness ratio

	Daytime short Errand	Utilitarian	Evening social	Night-time Entertainment District	Recreational
Percentage of trips by count	20.4	16.8	18.9	26.1	17.8
Percentage of trips by Vehicle-Miles Travelled	13.3	20.5	20.9	25.4	20.0
Percentage of trips by travel duration	19.0	16.9	20.5	25.2	18.5
General Attributes (mean)					
Route distance (miles)	0.47	0.88	0.80	0.71	0.81
Trip duration (minutes)	15.2	16.5	17.8	15.9	17.0
Route directness ratio	0.58	0.64	0.53	0.54	0.48
Percentage of weekend trips within the cluster	17	4	56	35	48

Note: Red color indicates lower values while blue color indicates higher values among clusters

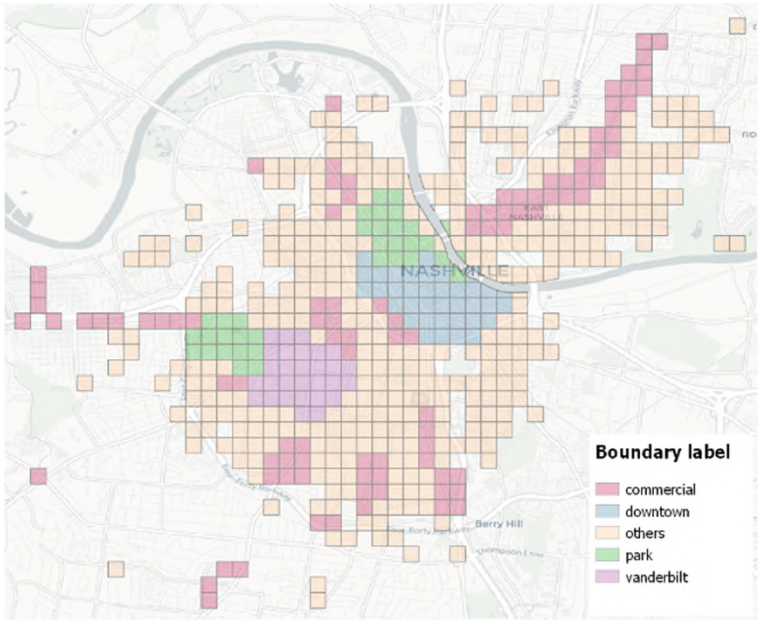
Temporal Distribution



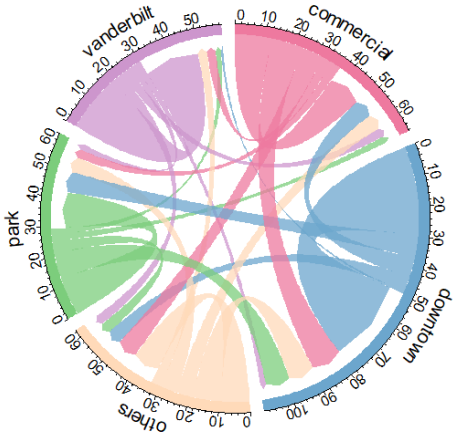
Trip distribution of usage-grouped clusters over months

- Daily average trips increased during the summer months for all usage-grouped clusters
- E-scooter usage was influenced by events in Nashville
- Overall usage of all usage-grouped clusters increased over a year

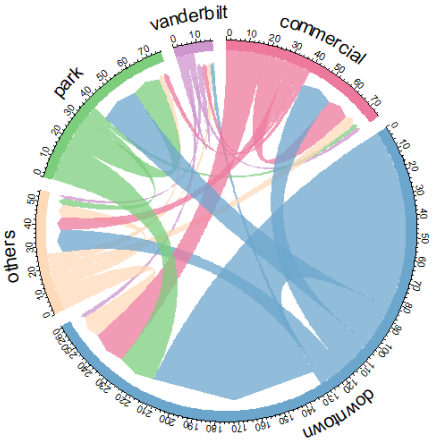
Spatial Distribution



Boundary for chord diagram



Daytime short errands



Nighttime Entertainment District trips

The flow of e-scooter trips among usage-grouped clusters show spatial variation. Daytime short errands trips are distributed among all land use types, while nighttime entertainment district trips are predominantly in downtown area.

Key takeaways

- We identified five distinct purpose-oriented e-scooter usage patterns in Nashville
- ¾ of e-scooter trips were NOT tourist-oriented nighttime entertainment trips
- E-scooter usage pattern doesn't resemble commuting pattern in Nashville
- The number of e-scooter trips of each five distinct patterns increased over a year
- E-scooter ridership increases during weekends and summer months in general
- Future research
  - Validation using survey results; semi-supervised learning methods
  - Include built environment information at route level for clustering
  - Comparative analysis of e-scooter usage patterns from other cities

References

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Questions?

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