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Data-driven methods for effective micromobility parking

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1. General Problem and Context

Proliferation of shared urban mobility devices (SUMDs), particularly dockless e-scooters, has created opportunities for users with efficient, short trips, but it has raised management challenges for cities and regulators in terms of safety [1], infrastructure, and parking. There is a need in some high-demand areas for dedicated parking locations for dockless e-scooters and other devices. We propose the use of data generated by SUMD trips for establishing locations of parking facilities and assessing their required capacity and anticipated utilization [2]. The problem objective is: find locations for a given number of parking facilities that maximize the number of trips that could reasonably be ended and parked at these facilities. Posed another way, what is the minimum number and best locations of parking facilities needed to cover a desired portion of trips at these facilities? In order to determine parking locations, areas of high-density trip destination points are found using unsupervised machine learning algorithms. The dwell time of each device is used to estimate the number of devices parked in a location over time and the necessary capacity of the parking facility. The methodology is tested on a dataset of approximately 100,000 e-scooter trips at Vanderbilt University in Nashville, Tennessee, USA. We find DBSCAN [3] to be the most effective algorithm at determining high-performing parking locations.

2. Description of the Specific Human-Cyberphysical System Problem

There is an obvious demand for cities to adopt forms of SUMD parking management, but there needs to be an effective process by which the locations of this parking are determined. Observations and empirical evidence are insufficient in the placement of this infrastructure. In most proposals for SUMD parking, use of these parking locations would not be mandatory; they would be placed conveniently to collect trips ending near high-volume destinations, and their use would be encouraged for riders. This calls for a rigorous, data-based solution calculated over months of micromobility trips. A large dataset has the potential to reveal patterns that may not be obvious to observation and effectively provide governments with the tools to make these infrastructure decisions.

3. The Challenges of Reaching a Functional System

It is incredibly difficult to reach a functional system with new forms of dockless micromobility. The technology is constantly evolving, and policy has not evolved with it at the same rate. Urban environments are learning how to accommodate the change by giving trial periods to companies focused on micromobility. Many issues have arisen that will take more experimentation and regulation to truly solve. Once we can manage issues such as clutter and safety concerns, cities will be able to come closer to a truly functional system.

4. The Technical Problem and the Research Setting

The technical problem was initially posed as an optimization problem to find the most efficient places to locate scooter parking spots. We aimed to minimize the distance between scooter historical drop-off spots and the potential parking locations to locate the best parking spots. We formulated the problem as a facility location problem [4] but found that the solution algorithm was computationally too expensive to solve city-scale placement problems. We then turned to clustering the trip dataset, which approximates the optimal solution but is scalable to large SUMD datasets. The algorithm we found to be most effective was DBSCAN, a density-based clustering algorithm implemented in Python. The parameters of this algorithm were then tuned to our dataset to achieve our objective of highest trip capture.

The research environment was the Work Lab at the Institute for Software Integrated Systems at Vanderbilt University. There we ran all our tests and analyzed the large datasets of scooter trips. We ran through many preliminary plans before figuring out our final direction of proposing a solution to dedicated parking infrastructure. Together with my colleagues, we found what we believe to be the most efficient and scalable way to find data-based locations for forms of dockless micromobility.

5. Future Research

The research done thus far can be extended to many different aspects affected by micromobility. The current project that the initial research is being extended to deals with violations of the Americans with Disabilities Act. Analysis is being done on the sidewalks of Nashville to determine how scooters can affect these violations. The goal is to have estimates of what sidewalks are consistently in violation and explore options on how to mitigate these issues.

Bibliography

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