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E-Scooters in Tucson, AZ: Modeling Placement, Charging, and Rebalancing

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Are e-scooters just the first sign of a shared-mobility revolution? If they are, then researchers at the University of Arizona intend to make sure that the emerging transportation system has functional models on par with other modes of transportation. In 2018, approximately 100 U.S. cities had already launched shared e-scooter programs, accounting for 38.5 million trips. However, the models to manage e-scooter sharing are only recently being developed. In a project funded by the National Institute for Transportation and Communities (NITC) and led by Dr. Jianqiang Cheng, the research team set out to develop data-driven, decision-making models for shared-mobility system design and operation in Tucson, Arizona.

> "The decision making process for e-scooter companies is complex. One of the first questions is where to locate the scooters – In the transportation network, where do e-scooters need to be placed to meet demand? The second question is how to distribute them. It gets more complicated when you introduce different electric charging methods, so that some scooters are being collected by paid contractors and others are being charged by customers, through incentives," Cheng said.

As the researchers see it, the main benefits of shared mobility are threefold:

1. It's an affordable first/last mile option for people who cannot afford to own a vehicle;
2. It's environmentally friendly, using fewer resources more efficiently;
3. It offers a novel solution to the problem of traffic congestion.

The model they created can provide decision makers with a robust solution that enables low cost and high service quality.

WHAT DOES THE MODEL DO?

Cheng, along with Dr. Xiaofeng Li, Dr. Yao-Jan Wu, and doctoral student Abolhassan Mohammadi Fathabad, created a two-stage stochastic programming model, for the planning and operation of large shared mobility networks in the presence of demand uncertainty.

The model, using a random probability pattern, can answer several questions that arise at the company and policy-maker levels:

- In the face of uncertain demand, how many e-scooters should be placed in the network and in which locations?
- How many charging facilities are needed, where and at what capacities?
- How should the network be evaluated and adjusted daily, to continue to meet demand while minimizing costs?

The model, developed using data from the City of Tucson, allows for optimal placement, charging, and rebalancing of unused (idle) scooters to meet demand in the most efficient manner possible.

Successful operation of a shared mobility system requires both careful planning and strategies that minimize operational costs for the company while also increasing the customer satisfaction rate (i.e., an e-scooter is available when it is wanted).

From a longer-term planning perspective, it is necessary to consider e-scooter demand patterns on a seasonal basis and plan accordingly for long-term economic benefits.

The final report offers a detailed walk-through of the computational model.

POSSIBILITIES FOR FUTURE RESEARCH

By predicting scooter rentals, relocations, idle periods, and charging times, the model offers e-scooter management companies a ready-made decision-making system to to effectively design and operate shared e-scooter systems, and thus help to ensure system reliability and cost-effectiveness.

In the future, this research could be extended in several directions. First, to increase the robustness in uncertainty modeling, researchers could develop a distributionally robust optimization framework (a modeling framework for decision-making under uncertainty).

Another possible direction is to develop new approaches to solve the e-scooter planning problem when more variables are introduced that would require the model to be capable of solving more complex problems.

ABOUT THE AUTHORS

The research team consisted of Jianqiang Cheng, Xiaofeng Li, Yao-Jan Wu, and Abolhassan Mohammadi Fathabad of the University of Arizona.

ABOUT THE FUNDERS

This research was funded by the National Institute for Transportation and Communities, with additional support from the Arizona Board of Regents and the University of Arizona.

THE REPORT and RESOURCES

For more details about the study, download the full report **Data-Driven Optimization for E-Scooter System Design** at nitc.trec.pdx.edu/research/project/1382

Photo by Cait McCusker

The National Institute for Transportation and Communities (NITC) is one of seven U.S. Department of Transportation national university transportation centers. NITC is a program of the Transportation Research and Education Center (TREC) at Portland State University. This PSU-led research partnership also includes the Oregon Institute of Technology, University of Arizona, University of Oregon, University of Texas at Arlington and University of Utah.