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Optimizing the location of bike-sharing stations using GPS-based trip data

Shared micro-mobility services (e-scooters, e-bikes, bikes) are increasingly embraced by cities around the world in recent years. Their environmental, economic, and social benefits over other transportation modes encourage traffic/urban planners, public authorities to establish such systems in urban areas. A docked bike-sharing scheme allows users to rent bicycles from a station and drop it at the same or another station within the duration that a user is willing to ride. Optimal placement of shared-bike stations is a key factor to comply with the most potential user demand in the area of interest. Therefore, planning a docked micro-mobility service is a vital issue before an infrastructure investment. Designs of the schemes involve the placement and capacity of the stations and the operation of the service. Understanding users' needs and travel characteristics is an essential investigation to determine the basis for the structure of the stations. Findings from the user demand lead to the setup of objectives and constraints for the optimization process.

This master thesis aims to develop a framework for an optimal design of bike station locations and capacities. The mathematical model was created with the determined objectives and constraints to be used in the optimization script, which was developed using Python. An optimization script was developed with a genetic algorithm, and different parameters of the algorithm were tested to determine ideal parameters. In the two-stage optimization framework, following the optimization of the stations' location, the lockers' capacity of the stations was optimized based on the trajectory data of a dockless bike-sharing system. Additionally, prior to the optimization process, rider patterns (location and time of the trips) and behaviour on bicycle trips from a 2-week GPS trajectory dataset was investigated. Accordingly, thresholds for actual bike use were determined and the major origin-destination flow was obtained by performing data cleaning from insignificant trips.

The implementation in the real-world scenario demonstrates that it can finely optimize the placement and the capacity of the bicycle sharing stations in Shanghai, China. The assessment part also proved that the suggested model performs better coverage of user demands concerning coverage scores of the proposed model and two other optimization methods (point of interest based and population density based). The framework developed in this study can be implemented in the GPS trajectory dataset, and some objectives and constraints can be also re-tuned according to the user needs and behaviour. Results from this optimization model can assist decision-makers on the station placement and capacities.

Keywords: Geomatics, Bike-sharing, Genetic algorithm, Location allocation, Site selection, Optimization

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