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Optimizing the locations of bike-sharing stations using GPS-based trip data: A Spatio-temporal demand coverage approach

Shared micro-mobility services are increasingly embraced by cities around the world in recent years. Their benefits over other transportation modes in certain frames encourage traffic/urban planners, public authorities to establish such systems in urban areas. However, planning the placement, size and operation of such beneficial micro-mobility mode is a vital issue that concerns designers. Several approaches have been attempted to design such schemes in a spatio-temporal space with the integration of geographical information system (GIS).

This master thesis aims to develop a framework for an optimal design of bicycle sharing locations and capacities. Objectives and constraints for an ideal bicycle sharing system were determined and formulated as a mathematical model. This model was programmed to develop an optimization framework using a genetic algorithm in Python. The proposed two-stage framework aims to achieve optimized placement and size of bike-sharing stations by maximizing spatio-temporal demand coverage of bicycle trips. Prior to the optimization process, spatio-temporal rider patterns and behaviour on bicycle trips from a 2-week GPS trajectory dataset was investigated. Accordingly, thresholds for statistical indicators of actual bike use were determined and the major origin-destination flow was obtained by performing data cleaning from insignificant trips. Additionally, optimal parameters of the genetic algorithm were investigated to determine ideal inputs.

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).

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

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