Master thesis of *Yu-Ting Liang*

A Study on the Optimal Vehicle Deployment for Public Electric Scooter Sharing Systems

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Green transportation has aroused more and more attentions recently, especially by the introduction to the concept of vehicle sharing that promotes shared vehicles to conserve energy, reduce carbon emissions, and improve traffic congestions. The bicycle sharing system has become the most poplar vehicle sharing systems so far. However, for some places with bad weather or topography not so convenient for biking, electric scooters (e-scooters) may serve better than bicycles as shared vehicles, since they are as mobile as bicycles, and can move even faster with ease.

This thesis focuses on the initial vehicle deployment at each rental site for a public e-scooter sharing system so that service requirement can be achieved with minimum total cost. In particular, we would like to put optimal number of e-scooters at each rental site in the beginning of each day so that the number of satisfied Origin-Destination demands attains specified service level requirement with minimum number of e-scooters. Two linear mixed integer programming models are proposed based on different ways of recharging batteries: one using the charging stations, and the other using the battery exchange stations. Both models assume uncapacitated rental sites, and available e-scooters are distributed fairly in proportion to their historical OD profile. They differ in how the battery power level changes, where an idle e-scooter recharged in a charging station model gains some battery power within a time period, whereas an idle e-scooter in a battery exchange station model does not gain any battery power, unless the power level is insufficient for one time period in which case the battery will be directly swapped to one with full power level.

We first solve these models by the Gurobi optimizer, and learned that models asking for lower service level requirements take longer time. We then design two particle swarm optimization algorithms, named PSOCP and PSOBE, respectively for eeach model. These proposed PSO algorithms can calculate good solutions in much shorter time than Gurobi. Finally, we conduct analyses on the effects in the service level requirements and total costs caused by different battery recharging models, as well as the effects caused by different battery consumption and recharging rates.

***Keywords*:** Electric scooter, Vehicle sharing, Charging station, Battery exchange station, Mixed integer programming, Vehicle deployment strategy, Particle swarm optimization

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