

Research on Shared Bicycle Parking Point based on Robust Optimization Model

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Abstract. With the widespread use of shared bicycles, when sharing bicycles brings us convenience it also brings many disadvantages to urban management. This paper studies the location of shared bicycle parking spots in shared bicycle management problems. Firstly, a robust optimization method is introduced for the practical problem of shared bicycles in Xi'an. Secondly, the optimization model is derived under the uncertainty of the need to use shared bicycles.

Keywords: robust; location planning; turnover rate; constraint.

1. Introduction

Since the emerge of the shared bicycle, it has brought great convenience to the citizens by virtue of its lack of piles and borrowing, intelligent technology, low price and green environmental protection. At the same time, it also exposed a lot of problems: such as occupying urban public space, disorderly management, disordered management, and management department monitoring. How to solve the urban management problem brought by shared bicycles in the city has become an important issue at present. This paper focuses on the problem of setting the corresponding parking point location in the management of shared bicycles.

The core of the shared bicycle parking point planning problem is the facility location problem is a resource allocation optimization model. The main problem is to select the optimal facility location and related resource allocation based on different optimization objectives and constraints, which has always been a classic decision-making problem that people face in all aspects of production and life.

Due to the volatility of the shared bicycles in the use demand, based on the urban slow-moving traffic network, the parking location selection and traffic distribution model are constructed, and the shared bicycles and parking stations are rationally distributed and configured. Minimize the total cost of the system, including the total construction operating expenses of the planner and the total travel cost of the user.

2. Robust Optimization Methods

The classic example of mathematical programming is to build a model under the assumption that the input data is accurately known and equal to some nominal values, and the existing mathematical programming method is used to obtain the optimal solution. This approach does not take into account the effects of data uncertainty. Therefore, when the value of the data is different from the nominal value, some constraints may not be satisfied, and the original optimal solution may not be optimal or even become infeasible. Therefore, it is necessary to find an optimization method to make the optimization solution immune to data uncertainty. This method is a robust optimization method.

The purpose of robust optimization is to find a solution that satisfies all conditions that may occur and makes the function value of the worst-case objective function optimal. The core idea is to transform the original problem into a convex optimization problem with polynomial computational complexity with a certain degree of approximation. The key to robust optimization is to establish a corresponding robust peer-to-peer model. Then it is transformed into a solvable "approximate" robust equivalence problem by using the relevant optimization theory, and the robust optimal solution is given.

3. Model Preparation

Assuming there are m alternative parking spots and n travel demand points, each alternate parking point can be used by multiple travel demand points, but each travel demand point can and can only use one alternate parking point. By determining the location of the shared bicycle parking spot, the capacity of each parking spot, and the demand points it covers, the total system cost is minimized, that is, the fixed cost of the parking point construction, the variable cost of the station accommodating bicycle parking, and the general cost of the user travel. The sum is the smallest. During the discussion, we assume that the travel demand of each travel demand point is divided into vehicle demand and parking demand, all of which are uncertain, and the uncertainty is expressed by the fluctuation range of the travel demand value; Any travel demand point travel needs can be met by one or more parking spots.

4. Model Establishment

Objective function: Established to minimize system cost, including: fixed cost of parking point construction, variable cost of station parking for bicycles, and user travel cost. Denote as

$$\min[\sum w_i x_i + p v_i + q_i u_i + \mu(\sum_{i=1}^m \sum_{j=1}^n d_{ij} y_{ij} v_i + \sum_{i=1}^m \sum_{j=1}^n s_{ij} z_{ij} u_i)]$$

Among them: $W_i, i \in M$: the total fixed cost of setting parking spots at the place i , mainly including signage, vehicle files, hard isolation facilities, management fees, etc.; $x_i, i \in M$: Whether to select the decision variable for the point i , if the parking point is set at the point i , $x_i = 1$, otherwise $x_i = 0$; $v_i, i \in M$: The bicycle volume decision variable at the point i when the point is selected as the parking point; p : the cost for each bicycle; $q_i, i \in M$: When setting a parking spot at the place i , the variable cost per unit capacity mainly includes the rent per unit area and the parking cost per unit capacity;

$u_i, i \in M$: The parking design capacity decision variable for the point i when the point is selected as the parking point; μ : The conversion factor of the travel distance converted into cost; $d_{ij}, i \in M, j \in N$: Travel demand point j distance from the parking point i ; $y_{ij}, i \in M, j \in N$: Assign the demand at the point j for the car to the point i , $y_{ij} = 1$, otherwise $y_{ij} = 0$; $z_{ij}, i \in M, j \in N$: Assign parking demand at the point j to the point i , $z_{ij} = 1$, otherwise $z_{ij} = 0$.

Consider the following constraints:

(1) The demand for car and parking for each travel demand point must be met, and there is only one parking spot serving each travel demand point. Meeting the car and parking needs may not be the same parking spot.

$$\sum_{i=1}^m y_{ij} = 1, \forall j \in N;$$

$$\sum_{i=1}^m z_{ij} = 1, \forall j \in N.$$

(2) In the process of actually using shared bicycles, even if there is a certain fluctuation in travel demand, it can still maintain normal operation with a certain probability, without the phenomenon that no car is available and no parking space can be stopped, assuming that the fluctuation of travel demand is uncertain random variables, the information of the probability distribution is not completely known. The known data is the upper and lower bounds of its fluctuation. Assume:

$$\bar{\varepsilon}_j = \varepsilon_j \alpha_j \bar{\varphi}, \forall j \in N$$

$$\bar{\eta}_j = \eta_j \beta_j \bar{\psi}, \forall j \in N$$

$\bar{\varepsilon}_j$ and $\bar{\eta}_j$ respectively represent fluctuations in random vehicle demand and parking demand, α_j , β_j are the level of uncertainty in the demand for vehicles and the demand for parking at the point j . The higher the value, the higher the level of uncertainty of the two requirements; The maximum absolute deviation between vehicle demand and parking demand is obtained when the stochastic variable $\bar{\varphi}$ and $\bar{\psi}$ are 1.

$$\hat{\varepsilon}_j = \varepsilon_j \alpha_j, \hat{\eta}_j = \eta_j \beta_j$$

For the travel demand points allocated to the same parking point, the total demand for vehicles or parking should not exceed the total number of bicycles put in the parking points for serving these demand points and the planned parking capacity.

$$\sum_{i=1}^m v_i y_{ij} F_b \geq (1 + \alpha_i) \varepsilon_j, \forall i \in M, j \in N.$$

$$\sum_{i=1}^m u_i z_{ij} F_t \geq (1 + \beta_i) \eta_j, \forall i \in M, j \in N.$$

(3) The number of shared bicycles at each parking point should not exceed the planned parking capacity.

$$v_i \leq u_i, \forall i \in M.$$

(4) Only the selected parking point can be used to serve the travel demand point.

$$x_i \geq y_{ij}, x_i \geq z_{ij}, \forall i \in M, j \in N.$$

(5) The planned capacity of the selected parking point should not exceed the maximum available capacity of that point.

$$U_i x_i \geq u_i, \forall i \in M$$

(6) Values of v_i can only be taken within a given range.

$$v_i \in [V_{\min}, V_{\max}], \forall i \in M$$

(7) u_i has nonnegativity.

$$u_i \geq 0, \forall i \in M$$

5. Conclusion

The purpose of this paper is to establish a robust optimization model with minimum system cost as the objective function and other constraints such as vehicle and parking requirements at the demand point must be satisfied when the user's travel demand is uncertain. In the follow-up study, we intend to use Python to obtain the use data of Xi'an shared bicycles, and then verify the reliability and validity of the model.

References

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