Application of heuristic algorithm in parking location of shared single car

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Abstract-With the development of sharing economy and the advocacy of green travel, shared bicycles came into being and are rapidly popularized in major cities. Due to the large number of mountains in Chongqing, the popularity of bike sharing is not very high. However, as a frontier municipality with numerous colleges and universities, its future market is considerable. However, the popularity of bike sharing will also bring many problems, especially in vehicle management. If not handled properly, it will affect traffic and travel. In this paper, the problem of parking location for shared bicycles is studied, and it is suggested that the shared bicycles operating enterprises should build a fixed parking location. By analyzing the influencing factors of location selection and establishing relevant indicators, the feasibility of scientific location selection is verified based on an example of heuristic algorithm with the goal of minimizing the cost of capital consumption on the premise of ensuring the convenience of users. The experimental results show that the algorithm is effective.

1. INTRODUCTION

The emergence of the sharing economy platform under the Internet wave is changing the traditional consumption concept. In recent years, sharing bicycles has become a new hot spot of China's sharing economy, and is deeply loved by college students. As of the end of 2016, the 2016 China Shared Bicycle Market Research Report released by the third-party data research institution BIDA Consulting shows that the overall number of users in China's shared bicycle market has reached 18.86 million. It is estimated that in 2017, the number of users in the shared bicycle market will continue to grow significantly, reaching 50 million users by the end of the year. With the launch of a large number of bike sharing vehicles, there are many "urban diseases" in the management of bike sharing vehicles, such as the failure of bike sharing enterprises and the inability to return users' deposits, the obstacle to traffic due to random parking of bike sharing vehicles, the rapid damage of vehicles and the increase in the number of damaged vehicles, and a series of problems. With regard to the parking of shared bicycles, Beijing, Shanghai, Changsha, Shenzhen and other places have successively issued regulations on the parking of shared bicycles, but not all of these regulations have designated special parking areas for shared bicycles.

As the shared bicycles generally use the pile free parking mode, they can only be parked in the public parking area marked with white lines. In order to avoid the problem of shared bicycles parking as much as possible, the fixed parking place should be selected without affecting users' use and traffic. It is stipulated that the used vehicles must be parked at the specified place and locked. Such a regulation may not be accepted by some people, so it involves whether the parking position of shared bicycles is convenient for most users to implement this regulation. However, the parking problem is greatly affected by the level of public moral quality, so the problem cannot be completely analyzed quantitatively. Therefore, this paper uses heuristic algorithm to model and analyze the parking location problem of shared bicycles.

Nowadays, in many theoretical planning problems, people always tend to use firefly algorithm, simulated annealing, genetic algorithm, ant colony algorithm, etc. to find the optimal solution, but in reality, many problems are complex systems involving many influencing factors, and can’t accurately find the optimal solution to the problem. Heuristic algorithm is a technology that can find one or more comprehending solutions within the scope of problem constraints. In most cases, the solution obtained by this algorithm can’t describe its similarity to the optimal solution.

Although the rise of shared bicycles in China is relatively short, the public bicycle system appeared in the Netherlands as early as 1965, and even has designated a driving road for shared bicycles. Domestic scholars also have a lot of theoretical research on bike sharing. Tian Yu (2017) modeled and simulated the safety problem of shared bicycles in his article, classified the obstacles and environments to avoid during the driving process of shared bicycles, used the BP neural network technology model, and verified the good simulation effect of the model with real data.

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Xianzhen Tian and Baoxia Jin (2017) analyzed the problem of sharing bicycles using matrix multiplication, matrix eigenvectors and eigenvalues according to the data in MathorCup 2014 Mathematical Modeling Challenge Question B. Nuozhou Ding (2017) studied the history and current situation of shared bicycles in Japan and put forward some suggestions on the operation of shared bicycles in China. He believed that operators should use the relevant deposit money for the long-term development of their business. The government should formulate industry norms for the operation and management of shared bicycles and create a road traffic environment suitable for the development of shared bicycles, so as to realize the synchronous development of social services and economy.

To sum up, bike sharing cannot be developed blindly. If bicycles are parked disorderly, it will bring great trouble to urban management. In order to make shared bicycles park reasonably, this paper will analyze the main parking places and surrounding environment of shared bicycles, comprehensively consider the feasibility and cost of shared bicycles parking, and find a reasonable parking address.

2. SHARED BICYCLE PARKING LOCATION MODEL

2.1 Problem description and indicator selection

2.1.1 Problem description

Due to the special terrain of Chongqing, bike sharing has not been fully popularized. However, Chongqing is 470 kilometers long from east to west, 450 kilometers wide from south to north, covering an area of 82,402.95 square kilometers. It has 23 districts, 11 counties and 4 autonomous counties under its jurisdiction, of which the built-up area of the main city is 647.78 square kilometers. There are 55 colleges and universities in Chongqing, and there are more than 200000 college students in the university town alone. To meet the needs of college students, the main places for sharing bicycles in Chongqing are near the school and the places with more people in the main urban area. According to the principle that the location setting is easy to identify, easy to maintain, and does not hinder the public space, the shared bicycle parking address with low cost and considerable benefits is sought. This paper believes that the Adlan heuristic algorithm can consider the main influencing factors, which has certain guiding significance for parking location.

2.1.2 Indicator selection

As a means of transportation beneficial to the people, the relevant factors affecting the location of shared bicycle parking are users, convenient location, demographic characteristics, scalability, vehicle maintenance and recovery costs.

Because the characteristic of the heuristic algorithm is the selection of indicators, on this basis, this paper selects new indicators. Target to minimize the cost of shared bicycle parking address

Table 1: The index symbols in the model

Index name	Symbol
Population flow	$P_i(i=A,B,C)$
Sharing rate of single vehicle	V
Fixed cost of parked address	M
Total cost of parked address	Y
Damaged vehicles	$t(t=1,...,X_i)$
Maintenance cost of damaged vehicles	$a(a=1,...,n)$
Population weight	W
The distance from the door to the parking address	d

2.2 Basic assumptions of the model and establishment of mathematical model

(1) Basic assumptions

Assumption 1: The bike sharing users are of good quality. After using the bike, they will all park at the designated place and lock it.

Assumption 2: 80% of the passenger flow near the parking place of shared bicycles will be used, and the utilization rate of shared bicycles and the damage amount of bicycles are linear functions of the passenger flow.

Assumption 3: The capacity and number of parking places for each shared bicycle are limited, there are “n” alternative parking places, and the maximum capacity is Xi (i=1,2,..., n). Due to the limitation of the operating cost of shared bicycles, the fixed parking place for bicycles is Y at most.

Assumption 4: The variable cost of a shared bicycle parking place is a convex function of its flow.

Assumption 5: The scheduling level of shared bicycles is unrestricted, and the instantaneous weight distribution of vehicles among parking points with unbalanced demand can be completed.

(2) Location model based on VRP theory

Dantzig and Ramser first put forward the Vehicle Routing Problem (VRP) in 1959, which means that a certain number of users have different demands for goods. The distribution center provides goods to customers, selects appropriate driving routes, and a fleet is responsible for distributing goods. The goal is to meet customers' needs, and achieve the goals of shortest distance, minimum cost, and shortest time under certain constraints. The VRP model in this paper is defined as: assuming that the functional relationship between the number of users, the distance between parking places, fixed costs and variable costs is known, it is required to select an appropriate parking address for shared bicycles on the premise of meeting constraints, so that the sum of costs of users and operators is minimized.

According to the above hypothesis, it can be obtained:

$$V=k2P_i+b2 \quad V=k2P_i+b2 \quad (k1>0,k2>0)$$

The objective function can be expressed as:

$$\min Y_i(\max V)=M+W*P_i*d+\sum_{t=1}^{Xi}\sum_{a=1}^{n}X_{at}$$

(3) Model Analysis Based on Adelan Heuristic Algorithm

Firstly, a n filter, consider the alternative address for each m combination, a total of nm options, each alternative address set by T , the maximum capacity of each group contained one by one to calculate the alternative address $X_i(i=1,\ldots,n)$. The filtration conditions are as follows: $\sum_{i=T} X_i \ge \sum_{j=1}^{i} D_j$ (D is the total demand for a single bicycle), If it is set up, the combination of T can be discussed; otherwise, the combination of T is filtered, not to be considered.

Then condition filtering can be carried out to obtain less than or equal to the feasible subset, and its corresponding sub-problems will also be simplified. At this time, there will be no 0-1 variable in the sub-problem, and the continuous variables will be greatly reduced. Except that convex functions are referenced in the objective functions, the rest are linear and constant functions. The number of sub-problems is reduced compared with the original number, and the difficulty of solving is greatly reduced.

Finally, the convex function can be separated and finally processed. The complex function can be converted into a simple cost oriented linear programming function by weight calculation. After the solution is completed, the value of the convex function can be added for qualitative analysis, that is, the total cost of single car location sharing.

3 EXAMPLE SOLUTION

Taking a university in Chongqing as an example, this paper studies the location of shared bicycles. Because some of the data are large and cannot be measured accurately, the simulated real proportional data is used. The school is connected to several other colleges and residential areas with a large number of people. The school has three doors that can be accessed, namely the main door A, the side door B, and the back door C. There are bus stops near the three doors, which are ranked as C, B, A according to the number of people from low to high. C is close to the residential area. Now it is planned to set up four shared bicycle parking places near the school, each with a fixed cost of 1000 ¥.

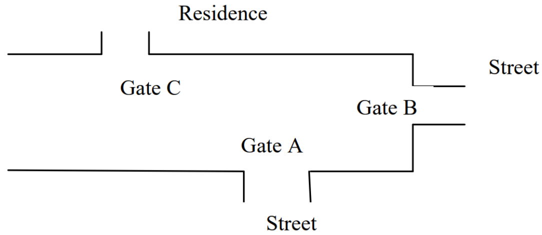

Fig.1. Sketch map of simple distribution in a university

Table 2: Initial assumption of related data

	Distance from parking point to each door				Nearby population (K)	Population weight
	Parking 1	Parking 2	Parking 3	Parking 4		
Gate A	0	2	16	6	20	0.8
Gate B	4	0	2	4	10	1.0
Gate C	30	20	0	25	4	1.2

Step 1: according to the data of the above table, the weighted distance of the population near the door is calculated. The formula is weighted distance = near population * distance * population weight. The results of the calculation are shown in the following table:

Table 3: Total weighted distance from each area to single car parking place

	Distance from parking point to each door			
	Parking 1	Parking 2	Parking 3	Parking 4
Gate A	0	20	100	60
Gate B	64	0	32	64
Gate C	144	96	0	120
$\sum$	208	116	132	244

Step 2: Calculate the sum of the figures in each column in the above table, and select the area with the smallest sum. This means that the weighted distance between users in each area and the shared bicycle parking place is the shortest, that is, the total cost of users (mainly students of the school) is the lowest, and the school gate B is selected.

Step 3: Compare the distance from door B to the single car parking point and the value in each row one by one. If the former is larger, the value will remain unchanged. If the former is smaller, replace the value in the table with the distance from door B to the single car parking point. The final results are as follows:

Table 4: Compare B gate distance and door distance and replace results

	Distance from parking point to each door			
	Parking 1	Parking 2	Parking 3	Parking 4
Gate A	0	20	20	20
Gate B	0	0	0	0
Gate C	96	96	0	96

Step 4: Repeat step 2, and door C is selected.

Step 5: Repeat steps 3 and 4, and finally determine the reasonable parking place sequence of shared bicycles as door B, door C and door A according to the traffic conditions near each door and the vehicle maintenance and recovery costs caused by the use of bicycles.

4 EXAMPLE SOLUTION

In this paper, through qualitative and quantitative analysis, a heuristic algorithm is used to model and analyze the location problem of shared bicycles. With the verification of examples, the scientific-city and effectiveness of the heuristic algorithm are confirmed laterally. With the development of the times, heuristic algorithms are also applied to all walks of life, especially in the logistics center location. This algorithm can be used in some complex system modeling to simplify the elements in the system. Its innovation mainly lies in the selection of indicators.

The starting point of popularizing bike sharing is not only to obtain economic benefits, but also to facilitate the public. In addition, bike sharing is also a form of green economy, which has made great contributions to the urban environment and is in line with the sustainable development strategy of the city advocated by the government. Chongqing, as a rapidly developing city, even if there are some obstacles in popularizing bike sharing, it cannot completely block the future bike sharing market here. If an emerging industry wants to develop healthily, its management system must be gradually followed up, and more efforts should be made in this regard.

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