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# An Automated Planning and Scheduling Method of Shared Bikes Based on Reward and Punishment Mechanism

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***Abstract*— In order to solve the problem that the geographic distribution of shared bikes does not match the geographical distribution of user needs, an automatic planning and scheduling method was established in this paper. Through effective rewards and penalties mechanisms, the motivation of users to participate in shared bike scheduling was motivated, and users were encouraged to regulate parking and optimize the overall state of typical areas, which in turn allows the shared bike to flee the "black hole" of the city, return to the hot spot area from the non-hot spots, and increase the utilization rate of the bike. In this paper, we have defined a new scheduling method and scheduling criteria, which distinguishes users into active scheduling users and passively scheduled users, thereby dividing different scheduling areas and seeking optimal scheduling points. The use of GPS positioning function to determine whether the user to regulate parking, ultimately through the reward and punishment mechanism for users to change the cost of riding so that the sustainable development of shared bikes benign.**

***Keywords- automatic planning and scheduling model; reward and punishment mechanism; Intelligent bike lock; shared bikes***

## I. INTRODUCTION

Shared bikes refer to the sharing of bikes by the company in a time-shared rental mode on campus, subway stations, bus stops, residential areas, and commercial areas. With the deepening of residents' concept of low-carbon life and the continuous expansion of the shared bike market, the shared bikes which have proved effective in filling the so-called last mile traffic gap for city commuters is widely implemented in China in recent years [1].

Research shows that shared bikes have effectively improved air quality, reduced the use of fossil fuels and congestion [2-3]. They have played a major role in building healthy green cities and enhancing urban image. The main mode of low-carbon transportation in the city is mainly based on public transport, subway, and light rail. Because of its lightness, flexibility, environmental protection, and comfort, bikes have also become an indispensable part of urban low-carbon travel. As of July 2017, the cumulative number of domestic shared bikes is about 16 million, and the number of users is 106 million.

Shared bikes themselves environmentally friendly. However, the social problems brought about by shared bikes are appeared. For example, high concentration in non-hot spots causes the idleness of bike resources, the shortage of supply in hotspots, and insufficient cycling resources [4]. At the present stage, the scheduling of shared bikes is still mainly in the charge of the enterprise scheduling specialist, which is time-consuming and costly.

Although the existing shared bike scheduling methods have demonstrated their superiority in some aspects, they all have a common deficiency: they need to invest a lot of manpower, material resources, and financial resources to schedule and cannot fully utilize shared bike users to participate in scheduling.

We believe that the above-mentioned phenomenon should be resolved through the participation of all citizens, using effective reward and punishment mechanisms to mobilize the enthusiasm of users to participate in shared bikes scheduling, using automatic planning and scheduling methods to carry out shared bikes scheduling, realizing parking management through precise latitude and longitude positioning, and promoting user specification. In this way, the sharing bikes can leave the urban "black hole" and return to the hot spot from the non-hot spot area, so as to improve the bikes utilization rate and to achieve the sustainable development of the shared bikes.

## II. MOTIVATION

After a large number of field visits, we analyze a number of data on the use of shared bikes at home and abroad, and summarizes the experience and deficiencies in a large number of papers, mainly to achieve the following goals:

### *A. Save on shared bike operating costs*

The scheduling system distinguishes the user according to whether the user inputs a riding destination to the scheduling system. The user who has the riding destination is a passive scheduling user, and the user who does not have a riding destination is an active scheduling user. The scheduling system divides the scheduling area for different types of users, and then traverses all the prescribed parking areas in the scheduling area, that is, the candidate scheduling points. Finally, all the candidate scheduling points are arranged in descending order according to the optimization degree of the overall status of the typical area.

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After the end of using bike, the user will be judged to reward or punish according to the behavior. This paper proposes an automated planning and scheduling method of shared bikes based on reward and punishment mechanism, which can effectively promote the participation of all citizens in shared bikes scheduling and encourage users to regulate parking. More importantly, it will greatly reduce the human resources of enterprises in the operation of shared bikes, as well as material resources and other expenses.

### *B. Make the overall status of a typical area as optimal as possible*

In this paper, the typical area is a region that needs to be optimized in a scheduling system and has a series of background conditions for the successful application of the scheduling system: there are several prescribed parking areas in the typical area, and the maximum parking capacity of the prescribed parking area meets the needs of residents in the area. The geographical coordinates of the various parking areas are known and so on. Typical areas can be divided according to administrative regions, and can also be divided according to geographical location.

### *C. Sustainable development of shared bikes*

The development of shared bikes requires shared management. In this paper, an automated planning and scheduling method of shared bikes based on reward and punishment mechanism achieves the sharing management of shared bikes. Studies have shown that incentives are effective for users in bicycle scheduling, therefore, our scheduling method will also make full use of this [5]. Through the participation of all citizens, effective incentives and penalties are used to mobilize the enthusiasm of users to participate in bike scheduling, and parking management is promoted through precise latitude and longitude positioning, and users are encouraged to regulate parking, so that shared bikes can leave the "black hole" of cities and return to hot spots from non-hot spots, the method can also improve bike utilization, reduce operating costs, and achieve sustainable development of shared bikes.

## III. AN AUTOMATED PLANNING AND SCHEDUDING METHOD OF SHARED BIKES BASED ON REWARD AND PUNISHMENT MECHANISM

In this section, we will give a specific implementation of this method.

### *A. Calibration prescribed parking area*

The prescribed parking area is a rectangular area. The intersection of the diagonal area of the prescribed parking area is recorded as the center point of the prescribed parking area. The latitude and longitude coordinates of the four vertices and the center point are calibrated. The prescribed parking area is depicted in Figure 1. The coordinate position information and the maximum parking capacity have been determined and stored in the database of the scheduling system.

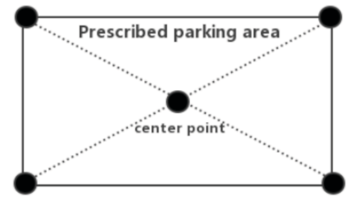


Figure 1. Example of a prescribed parking area

### *B. Differentiate users*

User scan the shared bike two-dimensional code for unlocking. If the user inputs a riding destination, the scheduling system determines that the user is a passive scheduling user; if the user has no destination, it determines that the user is active scheduling user.

### *C. Divide the scheduling area*

For passive scheduling user, the starting point is the central point of the prescribed parking area at the beginning and the terminal point is the central point of the prescribed parking area at the destination. The division method of the scheduling area is to multiplied the distance between the starting point and the terminal point by the tolerance coefficient, so we get the tolerance radius, then draw the circle with the terminal point as the center and the tolerance radius as the radius, this circle is the scheduling area, depicted in Figure 2. For the active scheduling user, the starting point is the central point of the prescribed parking area at the beginning. The division method of the scheduling area is to take the starting point as a center and to make a circle with a reasonable distance as a radius, thus the scheduling area is obtained, depicted in Figure 3.

The calculation method of the tolerance radius is:

$$r = \partial \cdot d \tag{1}$$

The tolerance coefficient $\partial$ is a reasonable value acceptable to most users in market research, $d$ is the linear distance between the starting point and the terminal point, $r$ is a tolerance radius.

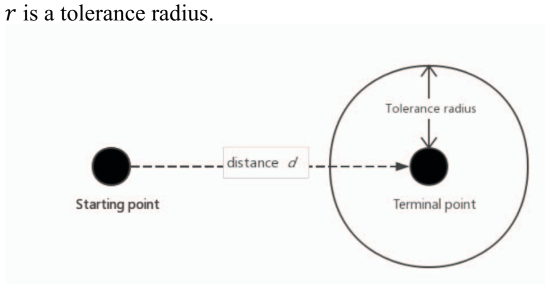


Figure 2. Passive scheduling user scheduling area division method

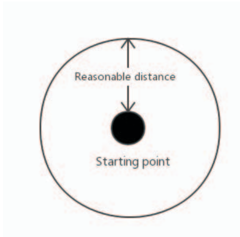


Figure 3. Active scheduling user scheduling area division method

### D. Finding the best scheduling area

The scheduling system successively traverses the ratio Q of the existing number of bikes to the maximum parking capacity in the prescribed parking areas in the scheduling area, and when traversing to a prescribed parking area where Q<1 (it means the area is not saturated) and the variance V of the Q value of the entire scheduling area can be minimized, it is considered that parking the shared bikes in this area will optimize the overall status of the scheduling area, at the same time, the whole typical area will be optimized to the maximum extent. After the end of the traversal, the scheduling system arranged all the prescribed parking areas in the scheduling area in descending order according to the overall state optimization of the typical area, the first is the optimal scheduling point calculated by the system. The system eventually sends the results to the user to select one of them as the scheduling point. Among them, data communication between scheduling system、 shared bikes and users is realized through wireless communication.

The method of traversing the prescribed parking areas in the scheduling area by the scheduling system is:

The total number of prescribed parking areas within the scheduling area is $n$, and the $n$ prescribed parking area should be traversed.

D0: the current traversal number is $i$, the current parking area number is $j$, $i$=1, $j$=1;

D1: start the $i$-th traversal;

D2: for the $j$-th parking area: get the number of existing bikes $a_j$, maximum parking capacity $b_j$;

D3: if $j = i$, then $Q_j = (a_j + 1)/b_j$; if $j \neq i$, then $Q_j = a_j/b_j$; Where $Q_j$ is the saturation of the $j$-th parking area in the $i$-th traversal;

D4: $j = j + 1$;

D5: if $j \neq n + 1$, return D2; if $j = n + 1$, enter D6;

D6: $\overline{Q_i} = \frac{1}{n}\sum Q_j$ ; $V_i = \frac{1}{n}\sum\left[(Q_j\text{-}\overline{Q_i})^2\right]$ ; $j$ =1; among them, $\overline{Q_i}$ is the average saturation of each prescribed parking area when traversing the $i$-th time; $V_i$ is the saturation variance of the prescribed parking area in the $i$-th traversal;

D7: $i = i + 1$;

D8: if $i \neq n + 1$, return D1;if $i = n + 1$, enter D9;

D9: The $n$ prescribed parking areas are arranged in ascending order of saturation variance and pushed to the user.

### E. Reward and punish user's behavior

The user stops using the bike and turns off the smart lock. The smart lock sends the GPS (Global Positioning System) position of the parking spot to the scheduling system. The scheduling system compares this position with the existing prescribed parking area data in the database. If the parking area is not parked within the prescribed parking area, it will not consider the positive impact of user scheduling on typical areas, but will increase the user's riding cost to punish the user for not parking the shared bikes in the prescribed parking area.; if the bike is parked in a prescribed parking area, and the final riding destination belongs to one of the candidate points, the user will be rewarded for the optimization of the entire typical area, such as reducing riding costs or giving cash rewards. Among them, rewards and punishments on riding cost are realized by multiplying the reward coefficient or penalty coefficient by the original cost. The reward and punishment coefficient is related to the distance between the starting point and the scheduling point, and is related to the variance V corresponding to the Q value of the prescribed parking areas in the scheduling area.

## IV. EFFECT EVALUATION

In order to evaluate the specific effects of the above methods for different situations, the following data was specially selected, three possible states are listed in this paper. The contribution rate CR of the Q value variance of the center point of each candidate region of the system after the use of this method was calculated by the MATLAB tool, and compare the contribution rate if we do not use this method, that is to say, the shared bike is directly parked in the parking area of destination.( In this evaluation, the tolerance coefficient $\partial$ we use is 0.5)

X is a set of coordinate positions formed by a prescribed parking area in a typical area, where the first two elements are the coordinates of the starting and ending coordinates respectively; BN is the collection of existing number of bikes in each area, and the first two elements are the starting and ending points' data. MBN is the set of the maximum parking capacity for each prescribed parking area, where the first two elements are the maximum number of bikes corresponding to the starting point and ending point; CR1 is the contribution rate value obtained without using the above scheduling method, CR2 is the set of recommended scheduling point values in the scheduling area sorted in descending order of contribution rate after the use of this scheduling method.

- State1: The prescribed parking areas in the typical area are not saturated, that is, the existing parking volume is less than the maximum parking capacity. (Data and results as shown in table I)

TABLE I. STATE 1 DATA AND RESULTS

| Parameter | Value |
|---|---|
| X | [(0,0),(6,6),(7,5),(5,6),(5,2),(2,4),(3,0)] |
| BN | [100,150,80,140,600,70,360] |
| MBN | [180,200,350,350,650,180,380] |
| CR1 | -5.06 |
| CR2 | [-2.85, -3.58, -5.06, -5.79] |

- State2: The prescribed parking areas in the typical area are basically saturated, that is, the existing parking volume exceeds or approaches the maximum parking capacity. (Data and results as shown in table II)

TABLE II. STATE 2 DATA AND RESULTS

| Parameter | Value |
|---|---|
| X | [(0,0),(6,6),(7,5),(5,6),(5,2),(2,4),(3,0)] |
| BN | [100,150,80,140,600,70,360] |
| MBN | [80,120,80,120,350,80,300] |
| CR1 | -4.81 |
| CR2 | [ -3.61, -4.41, -4.81, -7.04] |

- State3: The prescribed parking areas in typical areas are partially saturated, and some of them are still far from saturated. (Data and results as shown in table III)

TABLE III. STATE 3 DATA AND RESULTS

| Parameter | Value |
|---|---|
| X | [(0,0),(6,6),(7,5),(5,6),(5,2),(2,4),(3,0)] |
| BN | [100,150,80,140,600,70,360] |
| MBN | [60,20,30,400,950,280,600] |
| CR1 | -0.34 |
| CR2 | [0.02, -0.10, -0.34] |

According to the results, we can find that the contribution rate of the optimal scheme and the suboptimal scheme is increased by 2.21 and 1.48 in the state 1, by 1.20 and 0.40 in the state 2, and 0.35 and 0.34 in the state 3, compared with the case without the use of the scheduling method. In other words, if the user does not use the scheduling method, the contribution rate will be less than the contribution rate that the recommended parking point can obtain. Although the optimal scheduling point contribution rate obtained using this scheduling method may be negative, it is still significantly better than not using this scheduling method.

## V. CONCLUSION AND FUTURE WORK

In this paper, we study an automatic planning and scheduling method of shared bikes based on reward and punishment mechanism, which effectively solves the problem that the geographical distribution of shared bikes is not matched with the geographical distribution of users' needs. Through the reward and punishment mechanism, more people are dispatcher to participate in the scheduling and the regulate use of bikes, thus saving the operating cost of shared bikes and making the shared bikes can sustainable development. During the research process, we also found that the selection of prescribed parking areas for shared bikes will also affect the overall optimization of the typical area [6]. Therefore, we will continue to investigate and study the important factors that influence the scheduling system in the future, and make the method more suitable for the actual market and realize the value of use.


## ACKNOWLEDGMENT

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## REFERENCES


[1] Fu C, Guo Q. Road traffic injuries in shared bicycle riders in China[J]. 2018, 3:e111.

[2] Zhang J Y, Sun H, Li P F, et al. The Comprehensive Benefit Evaluation of Take Shared Bicycles as Connecting to Public Transit[C]// 2017:012018.

[3] Midgley P. The Role of Smart Bike-sharing Systems in Urban Mobility[J]. Journeys, 2009, 2(2):23-31.

[4] Jensen P, Rouquier J B, Ovtracht N, et al. Characterizing the speed and paths of shared bicycle use in Lyon[J]. Transportation Research Part D Transport & Environment, 2010, 15(8):522-524.

[5] Santoni M, Santoni M, Meenen M, et al. Incentivizing users for balancing bike sharing systems[C]// Twenty-Ninth AAAI Conference on Artificial Intelligence. AAAI Press, 2015:723-729.

[6] Hu S R, Liu C T. An optimal location model for a bicycle sharing program with truck dispatching consideration[C]// IEEE, International Conference on Intelligent Transportation Systems. IEEE, 2014:1775-1780.