Public bicycle rental problem based on large data analysis

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Keywords: large data analysis, Public bicycle rental, Optimal rent scheme

Abstract. As a low carbon, environmental protection, energy saving and healthy travel mode, public bicycles are being popularized and popularized in many cities all over the country. In the public bicycle service system, the location of the bicycle rental and the allocation of the number of bicycles, locks, and bicycles in each site have important influence on the operation efficiency and the satisfaction of the users. Taking the public bicycle rental in Hangzhou as an example, the newly introduced free bicycle system has been discussed in this paper, which can solve the rental scheme problem from the car rental perspective, and bicycle distribution considerations problem from the administrative perspective.

Introduction

In this paper, after proper analysis, the waiting time of changing trains is taken into account. After obtaining the respective formulas of time and money, they are given some weights, and the synthetic points are used as the criterion. Then, the best scheme of changing the car between two possible lines is found, and then the horizontal comparison is carried out to get the best route. Finally, the best routes and corresponding timetable for the 11 points of Hangzhou scenic spot are given. The following Table 1 shows the initial number of allocated vehicles for each site:

Table 1 The initial number of allocated vehicles for each site

Location	The number of bicycles
Children’s Palace	40
Liu Lang Wen Ying	97
Long Bridge Park	60
Su Causeway Nankou	91
The west gate of Hua Gang	63
Hangzhou flower nursery	62
Yue temple	43
Autumn Moon and Calm Lake	100
Zoo	58
Lingyin	85
Nine Creeks	24

Table 2 below shows the number of bicycles at the beginning and end of each hour:

Table 2 The number of bicycles at the beginning and end of each hour

Time	Number of original bicycles	Number of final bicycles
1	100	90
2	90	63
3	63	47
4	47	36
5	36	35
6	35	42
7	32	38
8	38	30
9	30	31
10	31	27
11	27	14
12	14	4
13	4	0
14	0	29

Problem analysis

In May 2008, the free public bicycle system for the first time is introduced in Hangzhou. There are 2800 public bicycles for visitors at 61 service points. The public bicycle service will adopt a combination of "fixed point standard service point" and "mobile convenient service point". At the same time, in line with the bicycle rental points rectification work, the bus group in the city, scenic spots, synchronous launch of about 30 "mobile convenient" service point". Convenient service points are mainly located along the sea route, bachelor road and other scenic spots. But the mobile convenience service point implements the original rent.

Public bicycle accounting method and accounting standards is this: public bike free for 60 minutes; 1 yuan bike rental service fee will be charged from 60 minutes to 120 minutes (including); 2 yuan rent bicycle service fee will be charged 120 minutes to 180 minutes (including) ; 3 yuan per hour over 180 minutes, accounting (by one hour less than one hour). Rental bike fare will be returned to the car, sub billing, from the rental car IC card in the settlement deduction.

According to the location of all service points, combining the public bicycle charges, a save time and money by bike rental scheme has been given in "designated service point distribution standard" scenic area, and taking the children's palace to Sir Georg Solti station of Nankou Railway Station as an example, the specific leasing plan has been given.

Model hypothesis. In order to create a system model, we make the following hypothesis:

(1) In the same service area, the speed of the bicycle in the process of fixed value, road and fatigue and other effects can be ignored.

(2)This model discusses the general situation, without taking into account the impact of holidays, climate and other unknown factors on the number of bicycle rental.

(3) The number of people arriving at each service point (including the arrival of various means of transportation) is equal to the number of rental cars at each service point in a given period of time.

Symbolic Convention. The symbolic conventions of the parameters used in the system model are as follows:

t_0-Time required for car rental procedures;

t_{wi}- The waiting time of each site, i=1... ..11, stands for individual sites;
t_{pi}- Total transfer time required;
v- Speed, it is set as 7km/h here;
M- Spend money (yuan);
M_k- The amount of money consumed by subsection (yuan);
T- Time consuming (if not specified, the unit is hour);
$f(t)$- Charge equation, take time as parameter;
L- Distance between two points (kilometre)
J- Discriminant value of problem 1
V- Initial number of bicycles
$A_j(t)$- The number of bicycles arriving at the service point j at time t
$P_{ij}(t)$- The probability of a bicycle going to location j from location i at time t
The number of instructions representing the site in each table:
1: Children's Palace, 2: Liu Lang Wen Ying; 3: Long Bridge Park; 4: Su Causeway Nankou; 5: The west gate of Hua Gang; 6: Hangzhou flower nursery ;7: Yue temple; 8: Autumn Moon and Calm Lake; 9: Zoo; 10: Lingyin; 11: Nine Creeks

The optimal rental scheme. 1. Factors affecting the rental program: total consumption time and money
2. Objective of the rental program: make both as small as possible

Details of influencing factors are discussed:

Ordinary tourists stay in range attractions is large, its impact on the total time of the immeasurable, so we believe that given the requirements in question is to reach another bike rental points is the main purpose of the program, the total time = travel time + bike rental time consumption, does not take into account the scenic sojourn time.

One of the original intention of public transport bicycles is to facilitate passengers and citizens to travel, so free rental (including the same site after the rental of another car) should be allowed. Excluding rent consumed bicycle waiting time and procedure time, the optimal solution is the first question is the rent a bike at every station, discusses the optimal scheme previously put under is equivalent to solving a shortest path problem, this setting is clearly not reasonable. Then we will discuss the time consumption into the car, including a bicycle rent amount calculated formalities in time and various attractions of rent a bike waiting time.

As a result, the total amount of time spent on a traffic route will increase as a result of increasing rental time. Because the amount of money spent and the number of hours have different effects on the quality of the program, we consider giving them a certain weight, and use the synthetic points to judge.

In any of the two bike rental points between the traffic, need to consider many possible paths of any of the two scene interval, we calculate each path optimal rental scheme, and then compare these schemes to obtain the overall optimal rental scheme.

Model establishment and solution

We measured the actual fixed standard service "scenic area adjacent the rental point between the shortest distance from the satellite map (rather than a straight line distance), calculated in accordance with the assumption of the speed of the bicycle, the adjacent driving time point are rent bicycles for less than an hour.

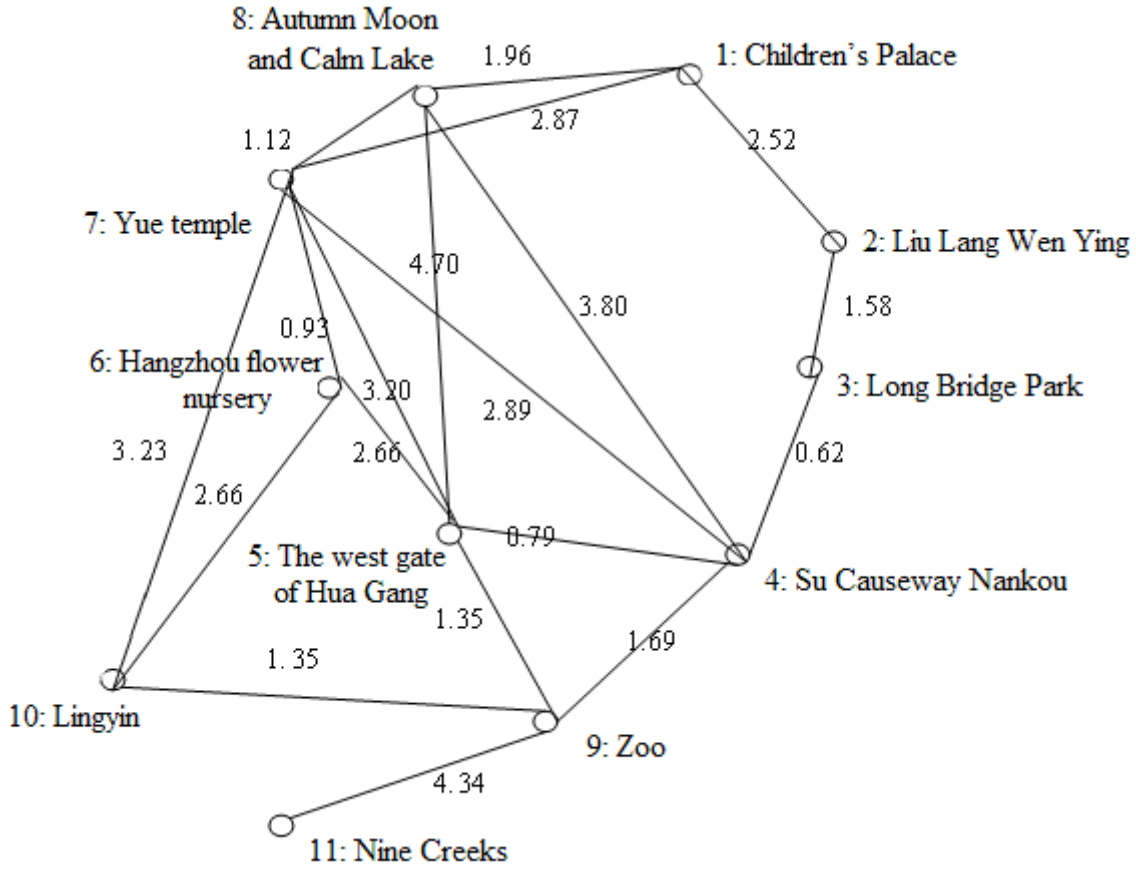

Fig. 1 Distribution of node in service point

Each of the nodes in Figure 1 represents a different service point. If the connection between two points is wired, the two service point is adjacent and can be reached without other sites. The numerical value beside the line is the shortest distance traveled by our range (unit: km).

If you do not take into account transfer, time and money is proportional to the number of consumption, consumption is less time, spend less, the question becomes the shortest path problem, you can use the Dijkstra algorithm or floyd_warshall algorithm. The optimal solution at this time is the children's Palace→Liu Lang Wen Ying→Long Bridge Park→Su Causeway Nankou. But in this question, we will discuss the transfer plan.

The additional time to consider in the transfer program is the change of rental time on the way. Taking into account the rental bike procedures should not be too cumbersome, rental cycling process time t_0 should also be shorter, not to the actual time consumption has too much impact. We add the waiting time t_w of each site to the equation and change the rent consumption time $t_p = t_0 + t_w$. Generally speaking, waiting time obeys exponential distribution, so we refer to the list of attractions in the day of car rental to get its expectations.

The following table 3 is the expected value of the waiting time:

Table 3 The expected value of the waiting time:

Location	Hourly population	Hour of t_{wi}	Minute of t_{wi}
Children's Palace	26.6	0.038	2.28
Liu Lang Wen Ying	27.6	0.036	2.16
Long Bridge Park	29.2	0.034	2.04
Su Causeway Nankou	34.5	0.029	1.74
The west gate of Hua Gang	25.6	0.039	2.34
Hangzhou flower nursery	27.6	0.036	2.16
Yue temple	26.4	0.038	2.28
Autumn Moon and Calm Lake	38	0.026	1.56
Zoo	25.2	0.040	2.40
Lingyin	30.7	0.033	1.98
Nine Creeks	19	0.053	3.18

According to the "public bicycle charging method and settlement standard", we get the actual expression of the price function.

$$f(t)=\begin{cases} 0 & t<1 \\ 1 & 1\le t<2 \\ 2 & 2\le t<3 \\ 3[t-2]+2 & 3\le t \end{cases} \tag{1}$$

By question analysis, we get the total time consumption $T=t_p\times n+L/v$, n is the change station number, L/v is the actual ride time, t_p is time for a single bike hire, the total cost of money needs to be considered separately, $M=\sum_{k\le n+1}M_k=\sum_{k\le n+1}f(L_k/v)$, $f(t)$ is the price function, actual segments is n+1.

We assign different weights to both, use the discriminant value as the evaluation of the merits of the standard, the weight is on multiple sets of data for reference to select the variables, the calculation method of *M* and *J* in the above formula have been described in detail.

If you change at each station of the road, the whole trip will be free by the distance table, which will also carry out the idea of the "free public bicycle system".

Conclusion

In fact, tourists usually stay in the country, or with more slow riding speed to the lake, may detour to visit several tourist attractions. Taking into account the actual public bicycle charge is rather low (through the data we know that before the opening of the bus, bicycle scenic area private bicycle rental business is generally 30 yuan per hour), some people will not be too concerned about the cost of. That's why we don't use the optimal amount of money when we talk about profit in the next question.

References

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