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Parking Space Reverse Selection Reservation Model and Reservation Platform Design

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Abstract

In view of the continuous increase in the number of motor vehicles and the unreasonable utilization of parking resources, the utilization rate and turnover rate of parking spaces are not high. In order to solve this parking problem, based on the existing parking reservation methods and algorithms, from the perspective of parking spaces, a parking space reservation model based on fuzzy comprehensive evaluation method is established. In the case of insufficient parking spaces, the optimal parking space is selected for the parking lot. Those who make an appointment, use MATLAB to write an application program to make the calculation model concretely realized. Finally, a WeChat and web parking reservation platform was designed to realize real-time parking reservations. This research is of great significance for improving the utilization rate of parking spaces, alleviating the current situation of road traffic congestion and improving the urban traffic travel environment.

Keywords

Parking Space Reservation; FAHP; Matlab Programming; Wechat Platform; Webpage.

1. Introduction

In recent years, the continuous improvement of the people's living standards in our country and the frequent introduction of preferential policies to encourage private car consumption by the automobile industry have resulted in an increase in the number of domestic cars.At the same time, parking spaces in parking lots are not properly used, the turnover rate of parking spaces is not high, and the contradiction between parking demand and supply has become increasingly prominent.With the development of the Internet and big data, drivers increasingly want to be able to park conveniently and efficiently. The way of making parking reservations through mobile platforms such as mobile phones gradually enters the driver's field of vision.Interacting the parking lot information with the driver's information, the driver can make reservations for parking spaces in the parking lot before traveling, which will make the trip more planned.Therefore, scholars at home and abroad have conducted a lot of research on the related algorithms and reservation platforms of driver parking spaces.

Zhao Fei [1] integrated the factors that affect the user's choice of parking lot and parking lot, and constructed the optimal parking lot and parking space estimation model that can be used for reservation recommendation, which improves the reliability and timeliness of parking space reservations, and The appointment APP was designed. Ning Ruichang [2] analyzed and studied the reliability factors of parking lot reservations, and proposed an optimal parking lot selection model based on gray entropy to provide users with the best parking lot. Yang Yong [3] and others combined wireless communication technology and vehicle-mounted communication technology to design an

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intelligent parking lot reservation management platform. Yang Qingfang [4] et al. proposed a mobile phone-based parking reservation model based on the analysis of parking reservation algorithms at home and abroad, and introduced the system architecture and functions.

American scholar Karthi.M[5] and others proposed a smart parking reservation scheme based on cloud environment, an effective method of detecting and reserving parking spaces. Thanh Nam Pham [6] and others proposed a system based on automatic parking space search, which can help users automatically find a free parking space at the least cost, which can improve the probability of successful parking of vehicles and minimize the waiting time for users. Soh Chun Khang[7] et al. studied the problems in the Malaysian parking lot system and proposed a low-cost SMS reservation parking system based on wireless mobile phones. The SMS reservation service is implemented in the parking lot system, and the driver can receive Information about parking availability. Diaconu E[8] and others proposed an advanced parking service software, which finds the best parking lot for the driver and book a parking space in advance.

In summary, the existing research results of parking space reservations at home and abroad are based on the driver's perspective. When the driver makes a parking space reservation, it is provided to the driver through a series of parking space reservation algorithms according to the characteristics of the driver's own travel needs. The optimal parking lot and optimal parking space to meet the driver's requirements for punctual travel and vehicle parking convenience.When there are enough parking spaces in the parking lot, the parking space reservation mode is based on the principle of making reservations. However, when the number of parking spaces in the parking lot is seriously insufficient, that is, when multiple drivers reserve the same parking space at the same time, how to allocate the parking space Excellent reservation?In order to solve this problem, this paper proposes a parking space reservation model based on fuzzy analytic hierarchy process. When the driver makes a reservation for the last parking space at the same time, this model can select the best driver for the parking lot and maximize the overall benefits.At the end of this article, the WeChat reservation platform and web page are designed, and the driver can publish the information of free parking spaces and parking demand information in a timely manner on the platform to achieve real-time reservation of parking spaces.

The research results of this paper can make up for the shortcomings of the existing parking space reservation algorithm, and at the same time can provide effective parking reservation and parking guidance services for motor vehicle drivers in real time and accurately. The driver can reach the target parking space in time and accurately, avoiding the driver from looking for available parking spaces. The ineffective traffic flow caused by the continuous patrolling of parking spaces on the road not only saves a lot of parking time for drivers, improves the use efficiency of parking resources in parking lots, but also relieves the current situation of road traffic congestion and improves the urban traffic travel environment It has important meaning.

2. Fuzzy Analytic Hierarchy Process

Fuzzy Analytic Hierarchy Process (FAHP) and Computational Process Analytic Hierarchy Process (AHP) are a qualitative and quantitative system analysis method proposed by the American operations research professor T.L.Saaty in the 1970s. Fuzzy Analytic Hierarchy Process (FAHP) is an optimized development of Analytic Hierarchy Process (AHP). Fuzzy Analytic Hierarchy Process (FAHP) improves the existing problems of traditional Analytic Hierarchy Process and improves the reliability of decision-making [9].

The fuzzy analytic hierarchy process not only saves the consistency check, but also can use the power method to calculate the ranking vector, reduce the number of iterations, and improve the convergence speed to meet the requirements of calculation accuracy. The specific steps are as follows.

2.1 Construct the priority relation matrix F

The fuzzy judgment matrix is a multi-valued matrix on the finite universe $U=\{n_1,n_2...n_n\}$, $F=(f_{ij})_{m*n}$,

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f_{ij} represents the relative importance of element f_i to f_j; Where $0<<f_{ij}<1$ and $f_{ij}+f_{ji}=1$, When $f_{ij}=0.5$, it means that element i and element j are equally important; When $0<<f_{ij}<<0.5$, it means that element j is more important than element i; When $0.5<f_{ij}<<1$, it means that element i is more important than element j.

2.2 Transform the priority relation matrix B into a fuzzy consensus matrix R

$$R=(r_{ij})_{n\times n},\ r_{ij}=\frac{b_i-b_j}{2n}+0.5,\ b_{ij}=\sum_{j=1}^{n}f_{ij}, i=1,2...n$$

2.3 Calculate the sort vector W

Sort the importance of each element to obtain a sort vector W. The larger the number, the stronger the importance of a factor. Generally, there are three methods for calculating the sorting vector.

2.3.1. Normalization method

$$\mathrm{W}^{(0)}=\left[\frac{\sum_{j=1}^{n}f_{1j}}{\sum_{i=1}^{n}\sum_{j=1}^{n}f_{ij}},\frac{\sum_{j=1}^{n}f_{2j}}{\sum_{i=1}^{n}\sum_{j=1}^{n}f_{ij}},\ldots\frac{\sum_{j=1}^{n}f_{nj}}{\sum_{i=1}^{n}\sum_{j=1}^{n}f_{ij}}\right]^T$$

2.3.2. Square Root Method

$$W^{(0)}=\left[\frac{\sqrt[n]{\prod_{j=1}^{n}f_{1j}}}{\sum_{i=1}^{n}\sqrt[n]{\prod_{j=1}^{n}f_{ij}}},\frac{\sqrt[n]{\prod_{j=1}^{n}f_{2j}}}{\sum_{i=1}^{n}\sqrt[n]{\prod_{j=1}^{n}f_{ij}}},\ldots\frac{\sqrt[n]{\prod_{j=1}^{n}f_{nj}}}{\sum_{i=1}^{n}\sqrt[n]{\prod_{j=1}^{n}f_{ij}}}\right]^{\mathrm{T}}$$

2.3.3. Sorting method

$$w_i=\frac{1}{n}-\frac{1}{2\alpha}+\frac{\sum_{j=1}^{n}f_{ij}}{n\alpha}, i=1,2,...n;\ \alpha\geq\frac{n-1}{2}$$

2.4 Score each candidate for the final score

The importance of each factor is multiplied and summed with the element of each candidate to get the final score, and the best solution is selected with the highest score.

3. Parking Space Selection Reservation Model

Research on parking reservations by domestic and foreign scholars mainly starts from the driver's perspective and establishes a parking reservation algorithm to find the optimal parking lot and optimal parking space for the driver in many parking lots. However, for drivers with the same parking needs, they are making reservations. In the same parking space, the existing reservation algorithm cannot select the optimal driver for the parking space.Based on the above ideas, this article proposes a multi-objective linear parking space reverse selection reservation model from the perspective of parking spaces for parking lots with dynamic pricing, which can find the optimal reservation for the parking lot when the driver's reservation needs are the same.

3.1 Evaluation indicators

The selection of evaluation indicators must reflect the actual situation, be accurate, feasible, and representative. When making a parking space reservation, first, the two targets directly contacted by the parking space are the parking lot manager and the driver who reserved the parking space. The parking lot manager focuses on maximizing the economic benefits of the parking lot, and thus

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introduces economic indicators. The benefit is related to the length of time the driver makes a reservation and willingness to pay.

The time the driver stops at the end of the appointment and when the driver reaches the parking lot, and the time the parking space waits for the driver to use is a social indicator.

When the vehicle arrives at the reserved parking lot from the departure place, it will produce car exhaust, which introduces environmental indicators. When the impact of car brand and driver proficiency on exhaust emissions is not considered, the closer the driver is to the parking lot, The less exhaust emissions, the greater the environmental benefit.

To sum up, this article divides the evaluation indicators of the parking space reverse selection reservation model into four indicators: reservation time, willingness to pay, distance, and waiting time. As shown in Figure 1.

(1)Appointment duration (X): It is the time that travelers need to stop, the unit is hour (h);

(2) Willingness to pay (Z): the cost of parking per hour that travelers choose. This article sets the charging standard as 4 yuan/h, 5 yuan/h, and 6 yuan/h;

(3) Distance (Y): It is the shortest distance between the departure place of the traveler and the parking lot, in kilometer (km);

(4) Waiting time (W): It is the time that the driver waits for the use of the traveler when the driver reaches the parking lot from the end of the appointment to the time the driver stops. The unit is hour (h).

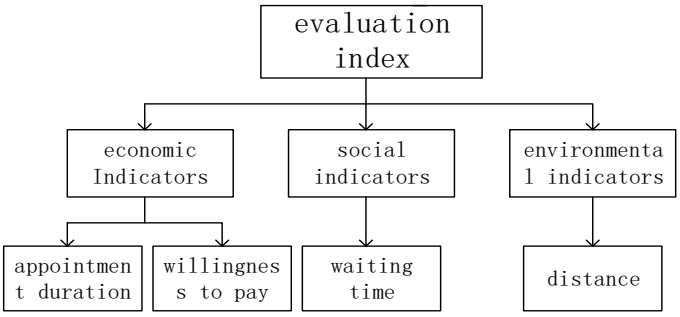

Figure 1. Indicator hierarchy diagram

3.2 Model establishment

Based on the principle of maximizing comprehensive benefits, a linear parking space inverse selection function H=aX-bY+cZ-dW is established according to the travel characteristics of travelers, where H is the comprehensive benefit, and a,b,c and d are the weights of the corresponding evaluation indicators., Quantify the travel characteristics of the reservations.

As shown in Table 1, takeS1,S2,S3,S4and S5 as the five reserved travellers.

Table 1. Travel requirements of reservations

	S1	S2	S3	S4	S5
X:Appointment time(h)	4	5	4	6	4
Y:distance(km)	2	4	2	1	5
Z:Willingness to pay (yuan/h)	6	4	4	4	5
W:waiting time(h)	2	4	1	2	3

3.3 Matlab calculation

3.3.1. Construct a priority relationship matrix

According to the influence of the four factors on the reverse selection of travelers, the priority relationship matrix is established as shown in Table 2, which shows the relative importance of each element. This process is the result of qualitative judgment.

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Table 2. Priority relationship matrix

	Appointment time	distance	Willingness to pay	waiting time
Appointment time	0.5	0.8	0.7	0.6
distance	0.2	0.5	0.4	0.3
Willingness to pay	0.3	0.6	0.5	0.7
waiting time	0.4	0.7	0.3	0.5

Enter in matlab:> F=input(' Input priority relationship matrix F:')

F:[0.5,0.8,0.7,0.6;0.2,0.5,0.4,0.3;0.3,0.6,0.5,0.7;0.4,0.7,0.3,0.5]

Run to get: F=

```
0.5000  0.8000  0.7000  0.6000
0.2000  0.5000  0.4000  0.3000
0.3000  0.6000  0.5000  0.7000
0.4000  0.7000  0.3000  0.5000
```

3.3.2. Fuzzy consensus matrix

Enter the conversion formula into the command line:

```
>> N=size(F)
r=sum(F')
for i=1:N(1)
for j=1:N(2)
R(i,j)=(r(i)-r(j))/(2*N(1))+0.5;
end
end
E=R./R'
```

Run to get:

```
0.5000  0.6500  0.5625  0.5875
0.3500  0.5000  0.4125  0.4375
0.4375  0.5875  0.5000  0.5250
0.4125  0.5625  0.4750  0.5000
```

3.3.3. Calculate the ranking vector w

The ranking vectors W1, W2, and W3 are respectively calculated according to the above formulas of sum line normalization method, square root method and sort method.

Enter at the command line:

```
>> W1=sum(R')./sum(sum(R))
for i=1:N(1)
S(i)=R(i,1);
for j=2:N(2)
S(i)=S(i)*R(i,j)
end
end
S=S^(1/N(1))
W2=S./sum(S)
W3=sum(R')/(N(1)*a)-1/(2*a)+1/N(1)
```

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After running, the result of the relation vector is shown in Table 3.

Table 3.Vector relationship result

	Appointment time	distance	Willingness to pay	waiting time
W1	0.2125	0.2875	0.2438	0.2563
W2	0.2592	0.2403	0.2518	0.2487
W3	0.3000	0.2000	0.2584	0.2417

3.3.4. Calculation results

According to the above calculation, the final scores of 5 travelers are shown in Table 4.

Table 4. Final score

method	Sc			Sch	Sc
Normalization	1.2250	-0.1375	0.9938	1.4500	-0.1375
Sorting	1.5696	0.3472	1.3147	1.8247	0.3482
Square Root	1.8670	0.7668	1.5919	2.1502	0.7669

Through comparison, finally the parking space selects user D.The parking space selection reservation model based on fuzzy analytic hierarchy process can select the optimal driver when the driver makes a reservation for the same parking space at the same time. This model can make up for the shortcomings of the existing parking space reservation algorithm research and provide specific implementation of future parking space reservations from an opposing perspective. Theoretical reference.

4. WeChat Platform and Web Design

When the driver has a parking demand, he can fill in the parking demand information on the platform, and the parking lot manager can publish the free parking space information on the platform. When the background management system finds the optimal parking lot and optimal parking space for the driver, The parking space information is pushed to the driver in real time, and the driver can reach the parking space under the platform's built-in navigation, obtain the right to use the parking space, and the parking process is over, and the rent can be paid on the platform.As shown in Figure 2.

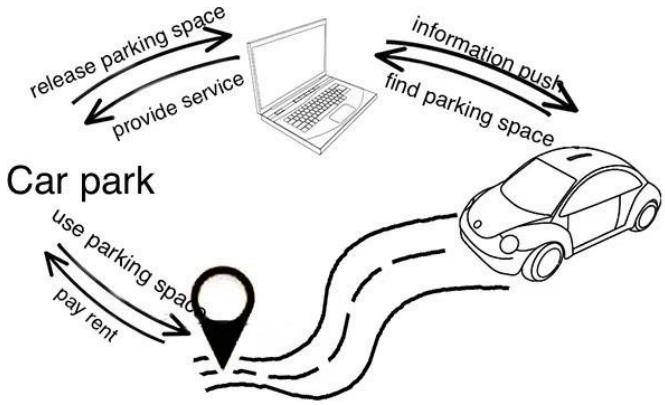

Figure 2. Parking space reservation concept map

Combining the parking needs of drivers and the needs of the intelligent development of Shanghai parking lots, we independently developed a WeChat reservation platform. The design of the WeChat

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reservation platform mainly includes five functional modules, namely, parking space search module, user information module, parking space reservation module, and news Dynamic module, contact us module. As shown in Figure 3.

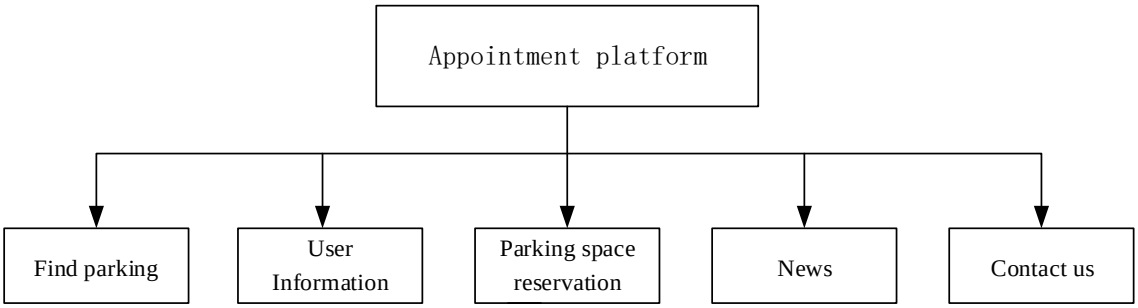

Figure 3. Block diagram of booking platform

4.1 Find parking module

In this module, the driver can search for all the parking lot information in Shanghai by area, including parking lot location, distance, remaining number of parking spaces, parking fee, etc. After the driver finds the target parking lot, he can use the platform's built-in navigation to timely and accurately Arrive at the parking lot for parking.

This module will improve the transparency and openness of parking information, and protect the driver's right to know.

4.2 User Information Module

In this module, the driver can fill in his own and vehicle information, including the driver's name, contact information, license plate number, and location. Under the condition of ensuring the safety of the driver's personal information, it will be classified and managed by region and parked by region to improve the convenience and safety of the driver's parking.

4.3 Parking space reservation module

In this module, the driver can publish travel demand information, including travel time period, departure place, destination, license plate number, willingness to pay, contact information, etc. After the driver submits parking demand information, the back-end system of the reservation platform will The clerk provides the number of free parking spaces and charging information in the parking lot. The driver can make a free reservation based on this information. After submitting the reservation information, the parking lot will promptly feedback to the driver based on the reservation information to ensure the success of the reservation.This module reduces the unnecessary trouble for the driver to randomly find the parking lot on the road and improves the accuracy and timeliness of parking reservations.

4.4 News module

This module can be used to publish the latest information on parking lots and on-street pricing changes in Shanghai, so that drivers can learn about Shanghai's parking dynamics in the first time, protect drivers' right to know, and improve the openness and transparency of parking information.

4.5 Contact us module

This module can be used by drivers to submit their opinions or suggestions on the platform to promote the accuracy and rationality of the platform’s reservations. At the same time, it can be used to submit suggestions for a certain parking lot management and parking fees, promote the improvement of parking lot management, and make reservations The platform is more humane and intelligent.

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Based on the design concept of the above reservation platform, the Shanghai parking reservation platform has been independently developed. At this stage, there are PC and mobile terminals. The mobile terminal uses WeChat as the carrier. After users scan the QR code with WeChat, they can enter the reservation platform interface. Later users can make parking reservations and demand information releases according to their own wishes.The PC terminal requires the user to enter the URL, and after logging in, you can view real-time information such as Shanghai parking information and weather.

Figure 4. QR code of WeChat appointment platform

Figure 5. WeChat appointment platform interface

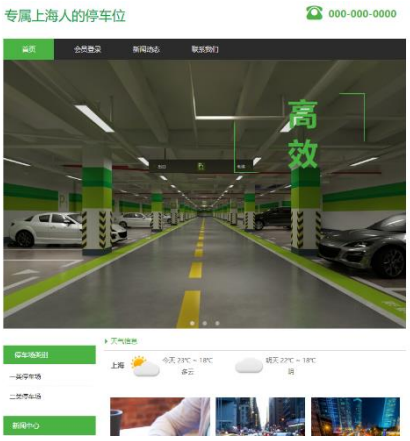

Figure 6. Web appointment platform interface (https://ee18054655.icoc.bz/)

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5. Conclusion

When the number of parking spaces in the parking lot is insufficient to meet the parking needs of the driver, this paper proposes a parking space reverse selection reservation model from the perspective of parking spaces. First, a representative evaluation index is selected and a parking space reverse selection model based on the fuzzy analytic hierarchy process is constructed. Then combined with an appointment case to verify the reliability and practicability of this mathematical model. According to the characteristics of parking demand and the characteristics of the driver, a parking reservation platform is designed, and each module in the platform is explained. The driver can make reservations for parking spaces through this platform.This platform interacts with the information of the driver and the parking lot, and the driver can query and reserve a parking space through a mobile phone, which improves the convenience and intelligence of parking, which is conducive to the improvement of the management level of the parking lot and the utilization of parking spaces.At the same time, in-depth research will be conducted in the following aspects.

(1) Regarding the reservation platform, only a simple design has been made in the system framework and reservation process. In the next step, the reservation platform based on parking spaces can be specially constructed and developed to develop a simple and practical intelligent reservation system.

(2) Only part of the factors are considered in this parking space reverse selection reservation model. There are still many practical factors that need to be considered for the driver and the parking lot, which also requires further research.

(3) In order to solve the problem of the prominent contradiction between the supply and demand of parking spaces, the concept of parking space sharing and parking at wrong time was proposed, and the parking lots of Shanghai office buildings and commercial circles were gradually opened to realize the sharing of parking spaces between office buildings and commercial circles.When the office building parking lot is fully loaded during daytime work, office vehicles can enter the commercial circle parking lot to park, and vehicles without parking spaces in the commercial circle parking lot at night can enter the office building parking lot to park at the wrong time.

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