

Research on Urban Parking Space Sharing Mode Based on Multi-Source Data Fusion

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Abstract:

The rapid increase of urban car ownership and the serious backwardness of urban parking facilities planning and management technology have led to the increasingly prominent problem of urban parking difficulties. Aiming at the problem of urban parking difficulty, this paper put forward a method of urban parking sharing based on multi-source data fusion. In the research, a platform system of urban parking sharing based on multi-source data fusion was constructed, and the adjustment method and dynamic adjustment mechanism of parking sharing conflict were proposed. In this method, parking space sharing period, sharing price and sharing distance are used as the basis of multi-source data. Then, according to the parking space sharing demand, the corresponding idle parking space sharing information is obtained through cloud computing and analysis to solve the personalized parking demand. The research in this paper provides theoretical support for the urban parking space sharing system, and plays a positive role in improving the utilization efficiency of parking spaces, alleviating the contradiction between supply and demand of urban parking, reducing urban traffic congestion, energy saving and emission reduction, and improving the efficiency of urban economic and social operation.

Keywords: Multi-source data fusion, Parking space sharing, Urban traffic, demand forecasting.

I. INTRODUCTION

With the development of global economy and the continuous advancement of urbanization, the number of urban cars is increasing, and the shortage of parking space planning and management technology makes the contradiction between parking demand and parking space supply increasingly prominent. Parking difficulty has become a key problem to be solved urgently in many cities. Due to the scarcity of parking space resources in cities, on the one hand, drivers need to cruise to search for parking spaces, which increases the time for searching for parking spaces. According to Shoup's research [1], to find a parking space, the vehicle driver will spend an average of 8.1 minutes more; on the other hand, it aggravates the degree of urban traffic congestion, resulting in fuel waste and environmental pollution. Ayala and others found that [2] in Chicago, the annual carbon dioxide emissions caused by finding parking spaces have exceeded 129,000 tons. Therefore, the difficulty of parking is not only a big problem for car owners to travel, but also one of the main reasons for the aggravation of urban environmental pollution. However, while the parking problem is increasingly serious, the utilization rate of urban parking spaces is generally low. A large number of parking spaces are owned by private owners, and private parking spaces are largely

idle when the owners go to work and go out. Parking spaces in parking lots of large shopping malls are tight during the day, but idle at night; government parking lots are generally in use during the day, but are basically idle at night and on holidays. Due to the limitation of land resources and construction cost, it is difficult to greatly increase the operability of parking lot land. Therefore, it is particularly important to optimize the management of existing parking facilities and improve the utilization efficiency of parking spaces. According to the research and analysis of Xie et al. [3], parking space sharing can optimize the allocation of parking space resources, improve the imbalance of parking space information and fully improve the utilization efficiency of parking spaces; the parking service can be completed by reservation allocation, so that the driver can define the parking destination and avoid the invalid detour caused by finding parking space, which not only reduces the travel cost, but also relieves the pressure of traffic congestion and reduces additional pollution emissions. By sharing parking spaces of different buildings in different regions, the construction investment of urban parking facilities and the waste of land resources are greatly reduced. sharing parking mode can not only bring benefits to operators and parking space providers, but also encourage users to accept sharing economy, which further integrates more parking space resources in cities and thus brings huge social and economic benefits.

II. RELATED RESEARCH

In 1980s, Mary Smith [4] put forward the concept of sharing parking for the first time, and realized the mode of shared use of parking spaces between adjacent buildings through the differences of parking time utilization characteristics of buildings with different land properties. Howard [5] et al. put forward the method of sharing parking spaces among regional buildings by signing agreements. Teodorovic. D [6] et al. put forward an intelligent parking allocation system considering parking revenue management. The system divides users into different service priority levels according to different charging levels, predicts the arrival rate and departure rate of various types of user groups based on machine learning algorithm, and realizes dynamic decision allocation of parking demand by maximizing the revenue of operation managers. Roca-Riu [7] et al. studied the problem of freight parking space reservation arrangement in cities considering time window constraints. By transforming the relationship between different parking requests into graph theory node connection processing, the objective functions were set with different evaluation criteria such as minimum time deviation, minimum total cost and minimum number of rejected requests, and a mixed integer programming model was established to realize the allocation of parking spaces. Zou [8] et al. put forward the parking space allocation mechanism based on the modern parking space sensing monitoring technology, in which the manager builds the parking space allocation model aiming at maximizing the operating income according to the information of the parking demander's arrival time, departure time, tolerable waiting time, and acceptable parking rate. In their research, Shao [9] et al. put forward a model. In this model, operators acquire and manage private parking spaces in idle time. Users send parking requests through mobile phone terminals, and operators regularly and uniformly complete allocation decisions. The model comprehensively considers the profit of operation managers and introduces penalty factors to reduce the negative impact of the late operation of the platform. Compared with the results of the first-come-first-served mode, it is found that the model can significantly improve the parking space utilization efficiency and increase operator profit. Guo [10] et al. studied the problem of

determining the reasonable scale of the acquisition of parking spaces in view of the sharing parking mode in which some parking operators acquire some private parking spaces and rent them out. In this method, Gaussian mixture model is introduced to describe different arrival and departure rules of vehicles, and random constraints related to the problem of maximizing benefits are set. Finally, the expected acquisition scale is obtained by simulation, which provides reliable basis for operators to make decisions. Xu [11] et al. took commuters with private parking spaces in cities as the main research object, and proposed a sharing allocation model based on parking spaces exchange in combination with market design theory. Alkheder. S [12] et al. put forward a technical framework of intelligent parking space reservation and allocation system based on the investigation and analysis of residents' parking travel choices in their research, which can improve the utilization efficiency of urban parking facilities and improve residents' parking convenience. Arellano-Verdejot [13] used the improved evolutionary algorithm, established a fitness function considering users' driving time and walking distance on the basis of analysis of users' parking preferences, and put forward a parking space allocation algorithm maximizing users' overall benefits. Tason. G [14] et al. took on-road parking spaces as the research object, and put forward a real-time parking space reservation system based on parking space detection by collecting on-road parking space status information. This method adopts the form of agent-based simulation. The results show that vehicles with the system and those without the system can get better parking space selection by comparing the walking distance, parking space searching time and other indicators. Lei[15] et al. set up a dynamic intelligent parking pricing and reservation management system, the core of which is to transform the game between decision makers and followers into a multi-period non-cooperative bilevel programming model, analyze the influence of the upper model changing the pricing scheme of parking lot on the parking choice of lower parking demand, and realize the balanced utilization of parking space resources by adjusting the time and space distribution of parking price according to the parking supply and demand status of different places. Kong [16] et al. incorporated the auction theory and market design theory into TTC algorithm matching, and provided parking spaces to parking spaces rental platform which rented the parking spaces to parking demanders through unilateral auction mechanism. Tan [17] et al. further divided the problem of sharing parking matching into two stages. First, the classic matching was carried out under the theory of market mechanism design, and then the static auction was extended to the dynamic continuous environment, which improved the matching efficiency. Jyun-Kailiang [18] used the partial least squares regression method of structural equation model to study the attitude and participation willingness of potential users towards sharing parking, and derived the feasibility and ways to promote sharing parking. Wang et al. [19] adopted the method of market design to share parking spaces, and enhanced privacy by decentralizing anonymous credentials and a special anonymous payment method in Monroe currency. F Bock and other researchers [20] first proposed a sharing parking resource management framework from two aspects, namely time dimension and space dimension, and developed an intelligent parking management system to simulate sharing parking operation, which finally proved that the utilization rate and turnover rate of parking spaces were improved. Ji et al. [21] established the prediction model of short-term idle car number by wavelet neural network method, and applied it to the parking sharing guidance system. C. G. Thigpen pointed out through research [22] that sharing parking space management is the integration of sharing mode and parking management, and the reservation control strategy of parking space sharing platform is the key.

There are many theoretical research achievements on urban parking space sharing, which mainly focus on parking space sharing period, sharing platform, sharing benefits, sharing reservation, sharing pricing, etc. However, no scholars have adopted multi-source data fusion method to carry out theoretical research on urban parking space sharing. The purpose of this paper is to study the urban parking space sharing system based on multi-source data fusion. On the one hand, sharing parking space information is dynamically collected to respond to sharing parking demand, thus solving the conflict of sharing parking time. On the other hand, the efficiency of urban parking space use is improved, reducing road congestion and automobile driving environment pollution, making up for the shortage of urban parking spaces, optimizing the allocation of urban sharing parking space resources and enhancing the vitality of sharing economy.

III. URBAN PARKING SPACE SHARING MODE BASED ON MULTI-SOURCE DATA FUSION

With the vigorous development of modern information technology, Internet, Internet of Things and cloud computing, cities, in a comprehensive manner, begin to enter the era of big data with data and information as the core resources. The sharing economy, as a new economic model, develop rapidly as a result. The mode of sharing economy is to efficiently integrate resources and match supply and demand through sharing platform, so as to solve the problem of information asymmetry between resource owners and demanders. In the economic model of urban parking space sharing, the idle parking resources can be allocated reasonably through the platform to solve the problem of urban parking difficulties. The core of sharing economy is the use rather than possession. When the parking space owner does not use the parking space, it is completely possible to supply the idle parking space to the parking demanders, so as to realize the efficient use of parking space resources, save social costs, improve social operation efficiency, and alleviate the adverse effects caused by parking difficulties to a great extent.

In the era of big data, there are increasing types of data, and the data are also increasingly dynamic. To obtain scientific, timely and valuable knowledge and information in urban parking space management, it is necessary to quickly and effectively collect and process all kinds of super-large-scale data. Therefore, a single data source can no longer meet the requirements of urban parking management. The application of multi-source data fusion is a prominent focus of urban parking management in the era of big data, and it is also a huge challenge for urban parking management. Multi-source data fusion technology refers to the use of relevant means to integrate all the information obtained from investigation and analysis to evaluate the information uniformly, and finally to obtain unified information. The starting point of this technology is to synthesize all kinds of different data information, absorb the characteristics of different data sources, and then extract unified information better and richer than single data. Multi-source data fusion can gather data with different structures from different channels by using a variety of acquisition methods, and it uses a unified format to enable data to face a variety of applications, so as to realize information sharing and information intercommunication. In the method of urban parking space sharing, the research on multi-source data fusion can not only quickly analyze the information of urban parking space sharing, respond to the parking demand of urban travelers, and alleviate the contradiction of urban parking, but also

play a significant role improving the efficiency of urban operation.

3.1 Overall Architecture of Parking Space Sharing System

Multi-source data fusion is to synthesize, calculate and analyze the sharing information of urban parking spaces, so as to realize fast, accurate and efficient processing of task information such as decision-making and evaluation. Compared with single data source decision-making, decision-making based on multi-source data can integrate more and better factors, optimize system decision-making information, reduce decision-making risks and obtain more reliable data processing results. The most important thing for the urban parking space sharing system based on multi-source data fusion is to change the imbalance of urban parking space supply and service. It intelligently allocates the demand of urban parking spaces through parking space sharing, thus alleviating the present situation of urban parking space resources shortage and realizing the optimal management of urban parking space resources. Parking space sharing system can be divided into three levels: customer, network and processing. The overall system architecture is shown in Figure 1.

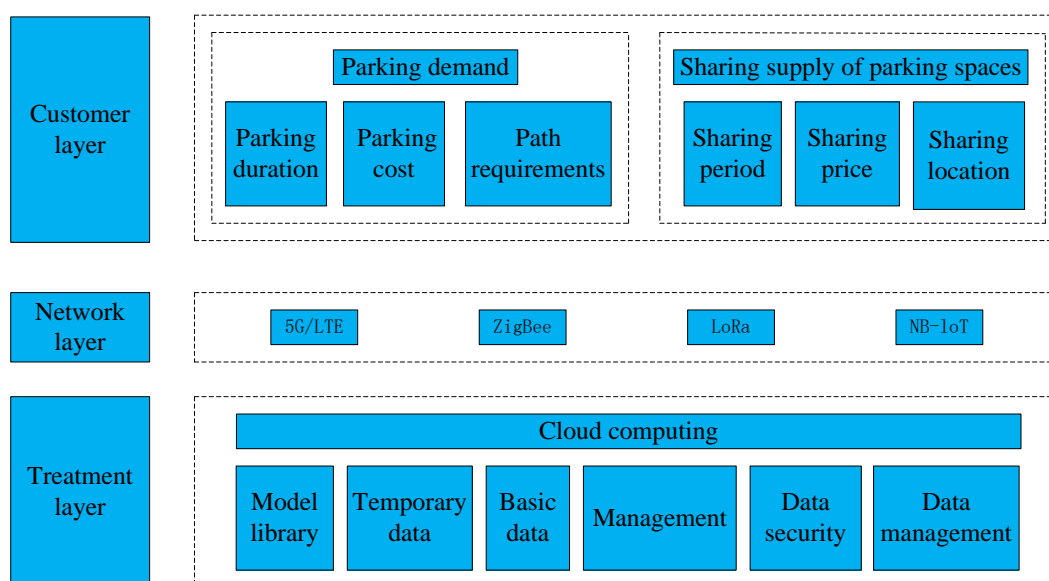


Fig 1: Overall architecture of parking space sharing system

The customer layer mainly collects and processes the related requirements from parking demand and sharing parking space supply customers, and transmits the related information downward through the transmission interface.

The main body of the network layer is the communication network and network management system, which is mainly responsible for the information transmission between different layers, ensuring the internal communication of the parking space sharing system and providing support for data transmission.

The processing layer mainly analyzes and processes customer demand information with the help of cloud computing platform, and uses virtualized resources to provide hardware support and security management for the system, so as to ensure the system's massive data processing capability with low delay and high reliability and realize real-time processing of customer demand and information.

3.2 Parking Space Sharing Processing Flow

When the parking space sharing system receives the parking space sharing request, its processing flow is as shown in the Figure 2.

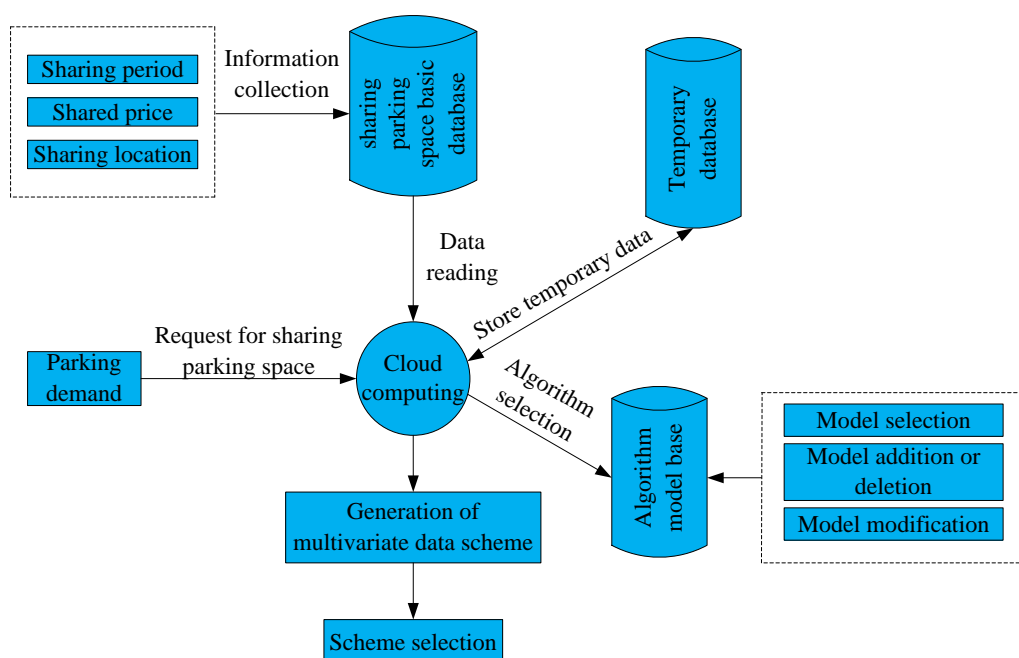


Fig 2: Processing flow of parking space sharing demand

Information collection is mainly responsible for collecting detailed information of sharing parking spaces, and storing the collected sharing parking space data into the parking space sharing basic database. The information in the sharing parking space basic database mainly includes basic information such as time period of sharing parking space, sharing parking space location and sharing parking space price, and the collected parking space information is initialized to a shareable state. This stage is mainly to complete the informatization of related sharing parking space data.

The request of sharing parking space is that the driver of the vehicle puts forward his own parking requirements according to his actual situation such as distance, location, price, etc. At this stage, it is mainly to accurately obtain the corresponding parking specific demand information and input it into the cloud computing processing module.

The algorithm model base is mainly used to store the solving algorithms of different types of target requirements. The algorithm model base can provide the cloud computing module with appropriate algorithm models to complete the calculation and analysis of requirements according to the needs of users. The algorithm model base can also modify, increase or decrease the algorithms to improve the requirements calculation algorithm.

According to the obtained parking demand information, the cloud computing processing module extracts data from the shared basic database of parking spaces, selects the corresponding algorithm model from the algorithm model library, completes the calculation and analysis of the extracted data, stores the intermediate data in the calculation and processing process into the temporary database, and finally generates the user parking demand scheme set.

Finally, when the parking rental user selects a certain target sharing parking space, the parking space sharing basic database will set the information of this sharing parking space as being shared. That is, when someone asks for sharing parking, the cloud computing module will not extract the occupied sharing parking space data to avoid conflicts; when the occupied sharing parking space is released, the sharing parking space is re-marked as being available for sharing.

3.3 Mediation Mechanism of Sharing Parking Space Conflict

The mediation mechanism of urban parking sharing conflict is to deal with the possible sudden conflicts quickly, accurately and efficiently when the use rights of sharing parking spaces conflict, otherwise, it will be difficult to promote and implement urban parking space sharing, and it will be difficult to achieve the purpose of releasing urban parking space resources and improving urban parking space resource sharing. There are several possible conflicts in the process of urban parking space sharing.

The first case is a conflict event when the provider of sharing parking spaces suddenly needs to use parking spaces within the provided sharing period given by the provider, and its handling mechanism is shown in Figure 3.

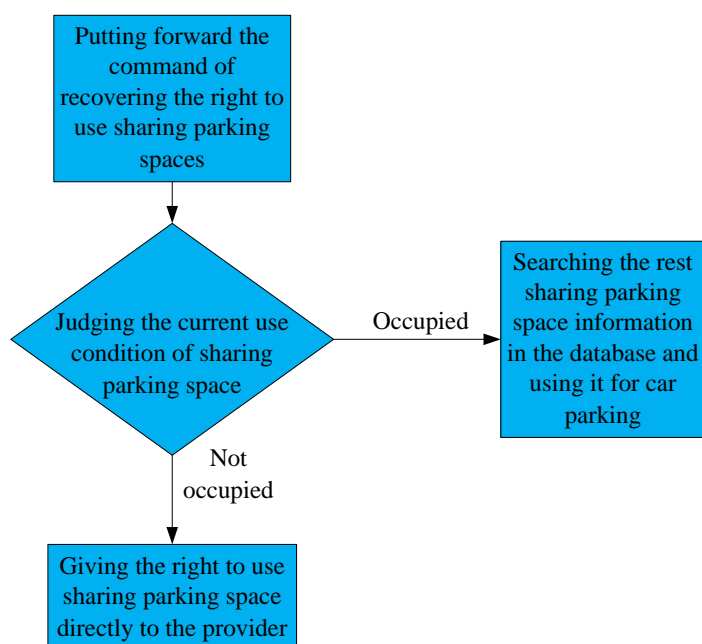


Fig 3: Conflict adjustment mechanism in sharing period

When the sharing parking space provider suddenly uses the parking space in the sharing time period provided, the sharing parking platform system, according to this situation, can allow the provider to directly use the parking space if the parking space is not shared. If it has been shared, the platform can provide the provider with the corresponding available sharing parking spaces for selection and parking. During this period. During the use, the sharing parking space will not be charged. When the use is over, the corresponding sharing parking space will be automatically released.

The second case is a conflict event when the sharing parking space rental user occupies the sharing parking space over time, and its processing flow is shown in Figure 4.

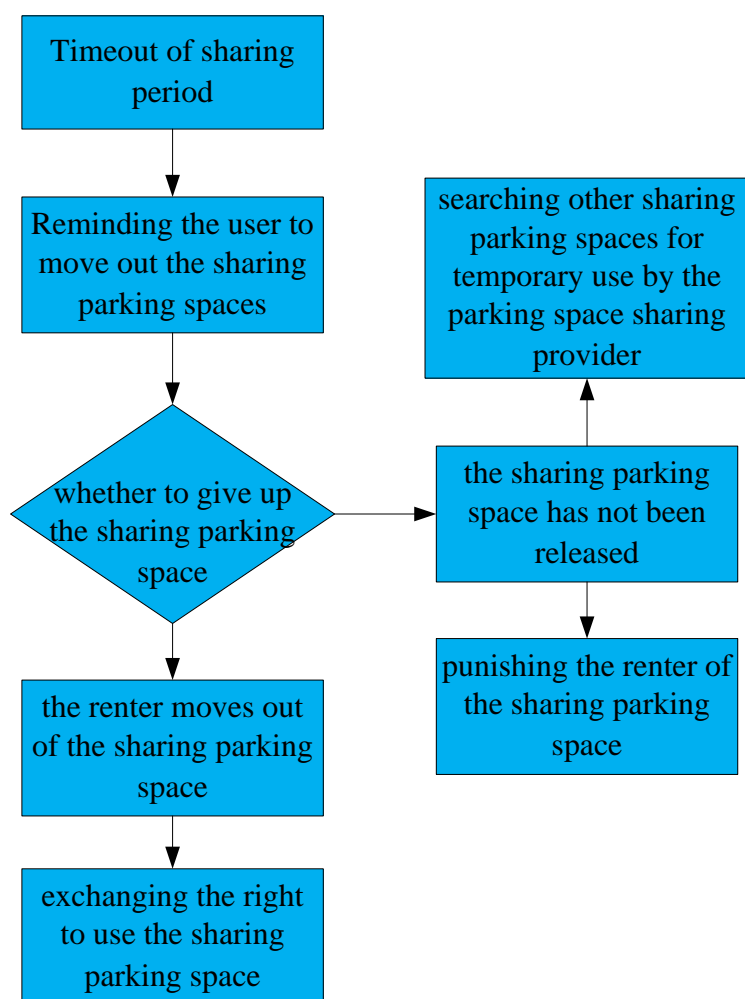


Fig 4: Adjustment mechanism of conflicts outside the sharing period

When renters of sharing parking spaces use the sharing parking spaces overtime, the platform system will remind them to move out of the sharing parking spaces and release the occupied parking spaces. The platform system of sharing parking spaces can provide other corresponding sharing parking spaces to the users whose parking is overtime, so that they can get sharing parking in other periods. If the sharing parking space renter does not operate according to the requirements of the platform system, the platform system will take corresponding punishment measures, such as increasing the parking fee or lowering the sharing parking credit score level of the sharing parking space renter.

3.4 Dynamic Adjustment Mechanism of Sharing Parking Spaces

The parking space sharing period information in the basic database can be dynamically adjusted according to the living habits, work changes and temporary changes of sharing parking space providers. The dynamic adjustment of the sharing parking space only needs the sharing parking space provider to enter the platform system with the account number and password and modify the corresponding

information of the sharing parking space to complete the operation. The platform system will feed back the update of this information synchronously, so as to provide an accurate and reliable data source for the sharing parking space system.

3.5 Policy Guarantee Mechanism of Sharing Parking Spaces

To improve the enthusiasm and initiative of the owners of urban parking spaces to participate in sharing parking spaces, in addition to certain economic benefits from sharing parking spaces, city managers should also support corresponding encouraging policies and measures, such as tax reduction and exemption for operators of urban parking spaces sharing platforms and certain legal and institutional guarantees for parking spaces sharing, thus continuously enhancing the participation of urban parking spaces sharing operation to promote the construction of an efficient sharing society operation mode.

IV. CONCLUSION

Private parking space sharing is a hot topic in current theoretical research and practice, and it is a part of sharing economy. Through private parking space sharing, private parking space owners or long-term renters can share the free time of parking spaces to meet public parking demand. On the one hand, the utilization of idle resources directly brings benefits to private parking space owners, and on the other hand brings great convenience to drivers who need parking. It is helpful to solve the problem of "parking difficulty" in the city center, and at the same time, it can reduce the vehicles cruising for parking spaces on public roads and improve road traffic conditions.

The wide application of big data technology and the fusion and sharing of multi-source data have brought positive influence to the efficient governance of urban parking problems, and provided theoretical and technical support for the governance of urban parking problems. In view of this phenomenon, this paper puts forward a multi-source data fusion urban parking sharing system, constructs a multi-source data fusion urban parking sharing platform system in the method, and proposes the mechanism of conflict adjustment and dynamic adjustment of sharing parking spaces. This method relies on the correlation of multi-source data to fully integrate the data. The integration of multi-source data maximizes the utilization efficiency of urban parking spaces, alleviates the contradiction of insufficient supply of urban parking spaces, optimizes the allocation of parking space resources, reduces urban traffic congestion, expands the influence of sharing economy, and improves the urban traffic governance model and social and economic operation efficiency, which is of great practical significance.

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