Design of multi-agent based decision system for building spatial planning

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Abstract: In view of the low efficiency of traditional system planning, a multi-agent based decision-making system for building space planning is proposed. The spatial characteristics of traditional villages in southeastern chongqing are analyzed and the overall structure is designed. B/S three-layer architecture is adopted, MapObject functional components are selected, and web browsers are set up to facilitate information retrieval. According to the actual situation, the Web server is divided into application hierarchy or scale scale, server structure and hardware type. Design the spatial decision-making information system by using various data and information, and process the business and basic information of the enterprise according to the information processing system of public participation. Two kinds of distributed database systems are designed to accommodate different databases for different purposes and improve the performance of the whole system. Under the natural environment, agricultural production and living conditions, design the spatial planning decision plan. According to the experimental results, the maximum planning efficiency of the system can reach 97%, providing a guarantee for building safety construction.

Keywords：Multi-agent; Architectural space planning; Decision making; Public participation in

1 Introduction

In practice, many business models have been formed by experts in the field of architectural spatial planning and decision-making, which urgently needs a platform for unified organization, management and sharing. At the same time, a large number of planning and implementation evaluation tools have been accumulated in the process of building spatial planning and decision-making information construction, which adopt different technology development systems and depend on different operational support environments. In order to enable relevant users of planning business to operate and use directly on the integrated and unified decision-making and management platform of architectural space planning, it is necessary to establish a unified environment supporting the operation of architectural space planning and business tools, build up a group of architectural space planning and decision-making tools, and make them play a greater application value[1].

Architectural spatial planning decision-making system is a complex system, whose

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spatial evolution is characterized by a large number of dynamic and adaptive micro-behavior subjects (enterprises, residents, farmers and various organizations, etc.) as well as the nonlinear interaction between the behavior subjects and the environment, producing discontinuous architectural spatial decision-making behaviors[2]. Because of its static characteristics, the traditional decision-making system of architectural spatial planning can not reflect the interaction process of many spatial time accumulation and spatial dimension in urban planning decision-making. The more difficult the spatial decision-making behavior of urban planning participants is to be effectively expressed, the more difficult it is to deal with the planning results, and there are certain restrictions on the acceptable level[3]. Oriented to the needs of urban planning, and relevant theories of multi-agent and intelligent science and technology, build can clearly express the city planning to participate in decision-making behavior subject space-time dominant feature space for urban planning decision system, and based on the build system, carried out the architectural space planning decision system and analysis of applied research, auxiliary to recognize and solve encountered in the process of architectural planning related unstructured problems, so as to enhance the scientific nature and rationality of architectural space planning decision-making, in order to promote the sustainable development of city decision-making to provide advanced technical method and reference.

2 The overall architecture

Chongqing southeastern area of chongqing is located in the basin edge mountains where the two mountains of dalou mountain and wuling mountain meet in the southeast of sichuan basin. The four provinces of Chongqing, Hubei, Hunan and Guizhou are merged, including Qianjiang Development Zone and four minority autonomous counties, including Shizhu, Pengshui, Youyang and Xiushan, covering an area of about 16900 square kilometers, accounting for 20.5% of the total area of the city. There are 28 ethnic minorities including miao, tujia, meng, hui, qiyegui, dong, zang, yi, hani, zhuang, man and yao. At the end of 2007, the registered population of southeast chongqing was 3,549,400, of which 86.96% were agricultural.

Architectural space planning decision system based on the planning space, database, the spatial planning oriented visual modeling, spatial planning tool group building, multi-dimensional comprehensive decision support model and on the basis of participatory planning decision support technology, computer technology, geographic information system technology, the remote sensing technology, communication technology, network technology, space planning and the theory of system science and comprehensive decision method is applied in the spatial planning and management of the integrated system, implements the effective integration of spatial planning tool and space planning decision-making model

library building, service and management for the decision of spatial planning provides a strong support, it also provides a set of reliable and efficient analysis tools and decision analysis means for spatial planning[4-6].

The overall system framework is divided into five layers from bottom to top: base layer, architecture layer, core data layer, operation support layer and application layer, as shown in Figure 1.

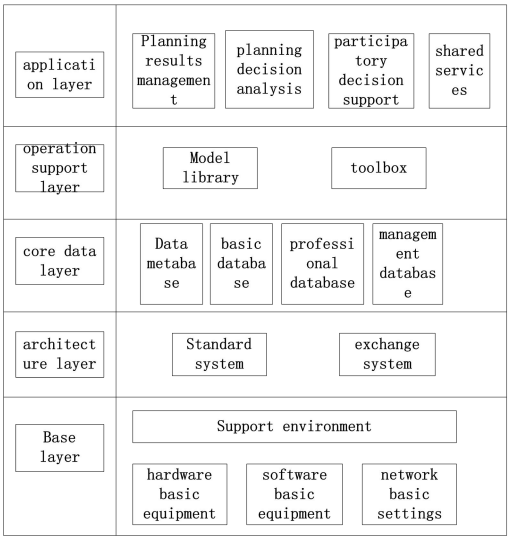

Figure 1 System overall structure diagram

（1）Basic layer: including basic supporting environment, hardware infrastructure, software infrastructure and network infrastructure. By establishing the building space maintenance database, the functions of storage, management, analysis and processing of various building maintenance information can be realized. It is used for the management and planning of building space planning and maintenance to provide basic data support[7].

（2）Architecture layer: including standard system and exchange system, using scientific methods to realize quantitative analysis and calculation of building space status, providing data support for land suitability evaluation and space utilization planning.

（3）Core data layer: including data metadata database, basic database, professional database and management database, which provides scientific basis for the suitability evaluation of small-space buildings. Through this system, the appropriate grade of land in each block of buildings can be determined objectively and accurately, providing technical support for further governance work.[8]。

（4）Operation support layer: including model library and toolbox, it can realize the

optimization of building utilization in small space, formulate the optimal utilization mode of building in small space, and provide spatial information support for decision-makers in order to obtain the best decision keeping scheme.

（5） Application layer: including planning results management, planning decision analysis, participatory decision support and Shared services. This layer mainly has a good user experience interface, which can realize system functions through simple operation.

3 System hardware architecture

Based on the regional characteristics of southeastern chongqing, this paper studies the rural settlement landscape and considers the following three feasibility points for the establishment of the research object.

First, the urbanization level in southeastern chongqing is very low, and the rural population accounts for about 90% of the total population, which lays a necessary material foundation for the study of rural settlement landscape.

Second, the southeast of chongqing is a typical mountainous region, which is a typical "karst" landform. It has special topographic and geomorphic characteristics, abundant natural and cultural resources, complex engineering construction, unique landscape and other characteristics, and high landscape sensitivity, which is an important condition for the study.

Thirdly, the minority population in the southeast of chongqing accounts for about 70% of the total population, among which tujia and miao are the main minority in the southeast of chongqing. The rural settlement landscape in the southeast of chongqing has obvious regional characteristics and ethnic characteristics. This provides necessary conditions for the study of rural settlement landscape based on the regional characteristics of Southeast Chongqing.

The hardware architecture of the system adopts a three-tier architecture based on B/S, as shown in Figure 2.

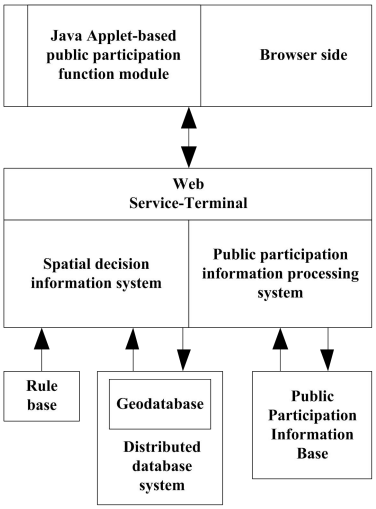

Figure 2 Three-tier system hardware structure based on B/S

The browser side is developed with multi-agent technology, and its main module is the public participation function module developed based on Java Applet -- PPGeoTool module, including the geography operation submodule and information feedback submodule.The submodule of geographic operations realizes the basic geographic operations of the client public, including attribute query, location query, spatial analysis, map browsing, map editing, display output, etc. The information feedback sub-module is used to realize the information interaction between the public and the system, including the inquiry of the information related to the planning project, the input and preservation of the information related to the public participation in decision-making and the public resume.

On the server side, MapObject functional components provided by ESRI are used to develop corresponding functional modules in VB language, including sub-modules of public participation information processing system and sub-modules of spatial decision-making information system. The sub-module of public participation information processing system is used to realize the functions of statistical analysis, spatial analysis, model analysis, information database building based on data model, and information display output. The sub-module of spatial decision information system is used to realize the spatial analysis function of traditional geographic information system and the auxiliary decision function of decision support system. On the basis of traditional geographic information database, public participation information database and rule database, the spatial analysis and decision-making of the system must introduce new analysis models and methods into the ten thousand square data of urban planning projects.

3.1 Browser

A web browser is an application that retrieves and displays information about the world wide web. These information resources can be web pages, pictures, videos or other content, they are marked by the uniform resource identifier, hyperlinks in the information resources to facilitate the user to browse relevant information.

The browser is accessed through a client program, known as a web browser, because it allows users to roam based on hypertext links without having to make purposeful queries. The browser is software that displays the contents of HTML files on a web server or file system and lets users interact with those files. Web browsers primarily interact with and retrieve web pages from web servers over the HTTP protocol, which are specified by urls, usually in HTML format, and specified by MIME in the HTTP protocol.

3.2 Web server

Network server is the core part of computer LAN, its efficiency directly affects the whole network operating system. Web servers have run the main function of the network operating system, control and coordination of all the work the computer in the network, the maximum to meet the requirements of customers and make a response and handling, storage, and management in the network sharing resources, to monitor and control network activity, to actual network management, resource allocation system, to understand and adjust the system running state and shut down/start some resources, etc. The Web server structure is shown in Figure 3.

Figure 3 Web server

The server type can be divided according to the actual situation:

(1) classification according to application level or scale

Entry-level server: the lowest level server, mainly used for office file and print services.

Workgroup server: suitable for smaller network, suitable for providing Web, mail and

other services for smes.

Departmental server: mid-range server, suitable for data center, Web site and other applications of medium-sized enterprises.

Enterprise server: high-end server, with super data processing capacity, suitable as a large network database server.

（2）Partition by server structure

Desktop server: also known as tower server, this is the most traditional structure, with good scalability.

Rack-mounted servers: rack-mounted servers are installed in a standard 19-inch cabinet and are available in 1U (1U= 1.75in), 2U, 4U, and 6U sizes, depending on height.

Blade server: a high-availability, high-density, low-cost server platform designed for specific application industries and high-density computing environments, where each "blade" is essentially a system motherboard.

Machine cabinet server: the machine cabinet is machine cabinet, in the server need to install many module components.

（3）Divide by hardware type

Dedicated server: specially designed advanced server, using special operating system (such as UNIX, MVS, VMS, etc.), mainly used for database services and Internet business, generally by professional companies to provide a full set of software and hardware systems and full service.

PC server: a server with Intel or Motorola dedicated processors as the core, compatible with a variety of network operating systems and network applications, performance can reach the level of mid-range RISC servers.

3.3 Spatial decision information system

Spatial decision information system is a comprehensive use of a variety of data, information, knowledge, artificial intelligence and model technology to assist high-level decision to solve semi-structured or unstructured decision problems. It is a human-computer interactive information system based on computer processing. In this system, the latest achievements in management, mathematics, database and computer science are fully applied. The structure of spatial decision information system is shown in Figure 4.

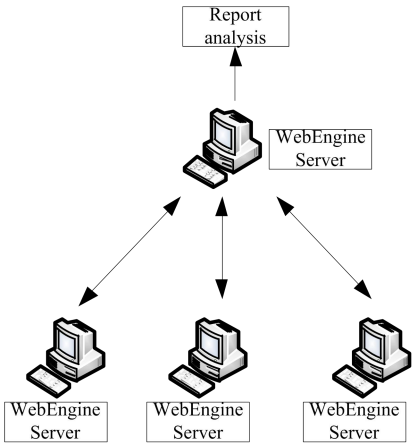

Figure 4 Spatial decision information system structure

Spatial decision support system is composed of spatial decision support, spatial database and other interdependent and interactive elements, and completes the processing, analysis and decision-making of spatial data as an organic whole. Its main behavior is a spatial decision support, and spatial decision support is the application of spatial analysis of all kinds of means to deal with spatial data transformation, in order to extract implicit in the certain facts and relationship of spatial data, and directly expressed in the form of graphics and text, and to provide a variety of applications in real world scientific and rational decision support. Because the method of spatial analysis directly integrates the spatial positioning ability of data and can make full use of the current characteristics of data. Therefore, the decision support provided by it will be more in line with the objective reality and therefore more reasonable.

3.4 Public participation in information processing systems

Public participation in information processing systems refers to computer-based processing systems. It is composed of input, output and processing, or hardware (including CPU, memory, input and output devices, etc.), system software (including operating system, utilities, database management system, etc.), applications and databases. An information processing system is an information conversion mechanism with a set of conversion rules. The structure of the public participation information processing system is shown in figure 5.

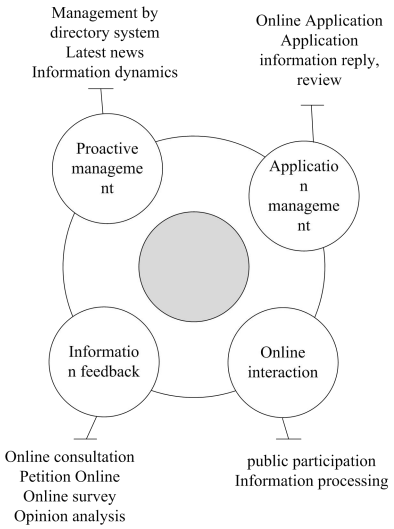

Figure 5 Public participation information processing system structure

Public participation information processing system is a very complex system, the design, construction, operation and maintenance of the system need a lot of costs, so it needs to be analyzed and studied from the point of view of systems engineering. System software is divided into two parts: program and database, which are equally important to information processing system. A good information processing system must have a good man-machine communication interface. The technology of developing information processing system is still developing, and the information processing system that has been applied also needs to be updated constantly. Public participation information processing system an information system that utilizes modern information processing technology to process business transactions and basic information of an enterprise in order to improve the efficiency and automation of business processing.

3.5 Distributed database system

There are two types of distributed database systems: one is physically distributed, but logically centralized. This kind of distributed database is only suitable for a single, small unit or department. Another kind of distributed database system is physically and logically distributed, which is called federated distributed database system. Because the seed database systems that make up the Federation are relatively "autonomous", such systems can accommodate various databases for different purposes, and are suitable for large-scale database integration. The structure of the distributed database system is shown in figure 6.

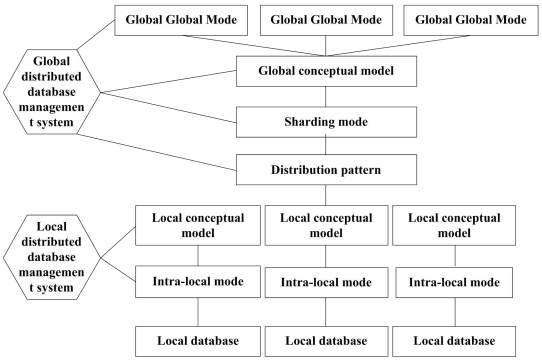

Figure 6 Distributed database system structure

Distributed database system includes distributed database management system and distributed database. In the distributed database system, an application can be transparent to the database operation, data in the database in different local stored in the database, managed by different database management systems, running on different machines, supported by different operating systems, are different communication network connection together. Compared with the centralized database system, the distributed database system is scalable, and the reliability of the system can be improved by adding appropriate data redundancy.In a centralized database, minimizing redundancy is one of the system goals because redundant data wastes storage space and tends to cause inconsistencies between copies. In order to ensure the consistency of data, the system has to pay a certain maintenance cost. The goal of reducing redundancy is achieved through data sharing. However, in the distributed database, redundant data is expected to be added, and multiple copies of the same data are stored in different locations. The reasons are as follows:(1) improve the reliability and availability of the system when a site has a failure, the system can operate on the same copy of another site, and the whole system will not be paralyzed due to a single failure. (2) improve system performance the system can select the nearest data copy to the user for operation according to the distance, reduce the communication cost and improve the performance of the whole system.

4 Software part design

There are two factors influencing the site selection of traditional villages in southeastern chongqing, namely, natural environment factors and agricultural production and living needs.

（1）Natural environmental factors

The settlement's location is largely influenced by the local natural environment, it is because the self-sufficient small-scale peasant economy has the economic capacity and technical conditions is limited, can only make full use of natural conditions, through the

reasonable conditions of site selection for good farming homes built environment and adapt to the local natural environment, satisfy the building ventilation, lighting, heat, cold basic living needs.

（2）Agricultural production and living needs

Agricultural production is the most basic economic activities of the villagers, but also the daily source of livelihood. Since ancient times, villagers have relied on agricultural production to provide for their daily needs. With the development of the society, the villagers depend on the output of agricultural production to meet the needs of food and clothing, and trade the surplus agricultural products to obtain economic sources.It can be said that agricultural production is the most important issue related to the development of settlements and the livelihood of villagers. Therefore, landform, soil conditions, climate characteristics and irrigation water resources and other factors related to agricultural production become the necessary conditions for settlement site selection.

According to the spatial characteristics of traditional villages in the southeast of chongqing, the design and planning decision plan is made. Using multi-agent decision technology, an abstract view of an agent is presented, as shown in Figure 7.

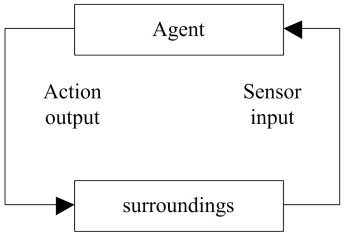

Figure 7 Multi-agent decision abstract view

In this block diagram, you can see that agents produce action output to affect their environment. In an environment of moderate complexity, an agent cannot fully control its own environment, but can only partially control it at best, that is, influence the environment. From the agent's point of view, this means that executing the same action twice in the same environment can have completely different effects.

System functions mainly include three parts: system maintenance management, spatial planning model/tools and decision support management. Among them, the system maintenance management module supports some maintenance management functions of system operation, including database maintenance, data source management, data source dictionary management, user rights management, system log management, etc. Model/tool integrated spatial scenario evolution analysis and dynamic simulation, spatial intelligent zoning, spatial planning implementation evaluation, spatial utilization constraint identification

and dynamic potential evaluation, and other model tools integrated management applications. Decision support management includes decision support system index setting, comprehensive decision making, decision support for participatory group planning, and outcome release. Main research contents of multi-agent system:

（1）Communication between multiple agents

The communication between agents is the basis of the interaction and cooperation between agents. The communication between agents involves the understanding and generation of physical mode and communication language. If agents are heterogeneous, how to translate different knowledge into a unified communication language of mutual understanding is also an important problem. At present, there are two common communication language design methods: process method and declaration method. The idea of process method is that communication can be simulated by the exchange of process instructions, the design process requires the information of the receiver, and the communication process is one-way, while many information exchanges of agents should be two-way, so the process method is not applicable to the communication between agents.

（2）Coordination and collaboration of multiple agents

Multi-agent coordination means that multiple agents with different goals make reasonable arrangements for their goals and resources to coordinate their behaviors and achieve their goals to the maximum extent. Multi-agent collaboration means that multiple agents work together to achieve a common goal by coordinating their behaviors. Multi-agent systems can be thought of as open, distributed environments in which one agent sometimes needs to work with other agents to construct complex programs, or to accomplish tasks that it cannot accomplish alone.

For multi-agent systems with common goals, the existing negotiation methods mainly include contract network protocol. Agents are dynamically assigned to the roles of manager and collaborator. An agent receives a new task and becomes a manager, responsible for the assignment of tasks. The other agents are collaborators, bidding on the current task, expressing capabilities and intentions for the task. The manager assigns tasks to the most suitable bidder based on the commitment of all bidders. Based on the work model, the formal definition of joint intention, social commitment and rational behavior is proposed to describe or constrain the cooperative behavior of intelligent bodies. In the collaborative process of multi-agent system, the thought of decision making and learning always permeates. Multi-agent interaction and cooperation based on game theory has a complete theoretical system and axioms of derivation. The countermeasures take the equilibrium point as the goal of the cooperation, so the convergence and stability of the cooperative process of intelligent bodies

are introduced into the cooperative research of intelligent bodies. Many of the theories in game theory can be used in the framework of multi-agent cooperation.

（3）Multi-agent conflict resolution

In the multi-agent system, each agent has autonomy and will act according to its own knowledge, ability and goal during the problem solving process. For some Shared resources, Shared conflicts often occur, and agents sometimes have different goals. Especially for multi-agent systems, it is not possible to design or implement an agent and then build it to match the goals of other potential agents. Due to the high degree of autonomy and flexibility of agents, their understanding of the environment is different, and their acquisition of global knowledge is often not comprehensive. Therefore, for multi-agent systems, dynamic conflict management is an inevitable requirement.

At present, the main method of conflict resolution in multi-agent systems is negotiation. Negotiation techniques include refactoring, limiting mediation, and arbitration. Negotiation technology is usually based on game theory, which assumes that agents have complete global knowledge and choose their own behaviors according to the principle of maximizing utility, and the utility matrix of agents is Shared knowledge. However, the knowledge of agents is often not complete, and their utility is not Shared but private. In order to simulate problems in the real world, the assumption of conflicts is usually avoided by establishing social rules. But social rules and standards impede the flexibility and adaptability of multi-agent systems. If individual agents simulate human intelligence, then many agent systems simulate human society. The conflicts in human society are solved by the social rules observed by the group, and the design of corresponding multi-agent system should also include the content of social rules.

The permission to use the system is controlled by the IP address through the hardware, and the specific process is shown in figure 8.

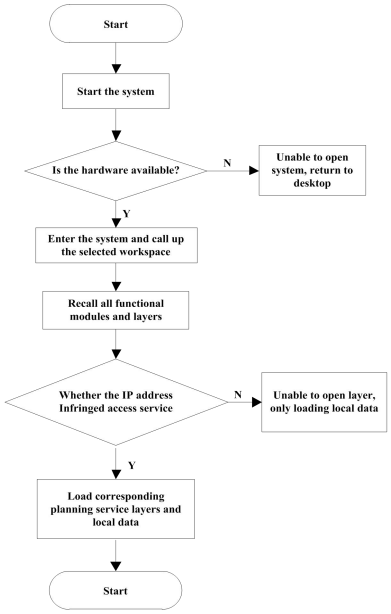

Figure 8 The decision-making process

5 The experiment

In order to verify the rationality of the design of building space planning decision system based on multi-agent, the experimental verification analysis is carried out under the environment of MATLAB simulation tool, Microsoft Windows XP operating system, Intel (R) Celeron (R) 2.6GHz processor and 24 GB memory. A 10-point scale was used for evaluation, so as to determine the planning rationality of the experimental target in the decision-making system of building space planning, as shown in table 1.

Table 1 Planning degree weight value

Serial number	The degree of planning	Weight value
1	unreasonable	5
2	Between very reasonable and moderately reasonable	4
3	Moderate and reasonable	3
4	Between average and moderate reasonable	2
5	general	1
6	Very reasonable	0

According to the weight values shown in table 1, the optimal planning effect of the traditional system and the multi-agent system on the building space was compared and analyzed respectively. In this process, two experimental conditions were set, namely natural

environmental factors and agricultural production and living needs. The comparison results are shown in Figure 9.

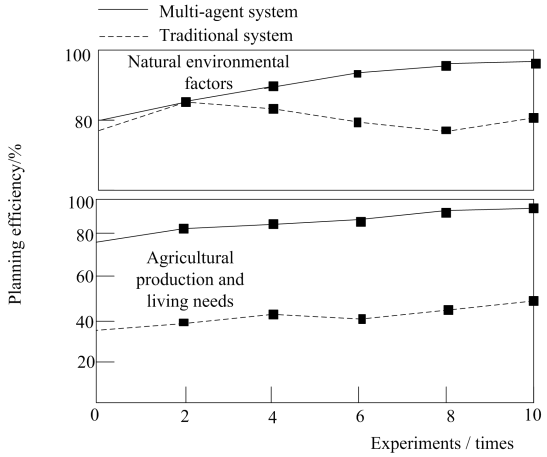

Figure 9 Comparative analysis on the efficiency of trajectory planning of the two systems

It can be seen from figure 9 that under the natural environment, the efficiency of the two systems is maintained at above 75%. Under the conditions of agricultural production and living needs, the efficiency of traditional system planning is lower than 60%. However, the planning efficiency of multi-agent based system is still high, which can be maintained at over 75%. It can be seen from this that the design rationality of the decision system of building space planning based on multiple agents is reasonable.

6 Conclusion

With the development of information technology, the planning assistance decision-making service will also change. In order to further meet the service needs of the public, the required elements will also increase, the data sources used will also gradually become multi-source, and the system function modules will also increase and improve. In terms of comprehensive research, the following aspects need to be further studied:

(1) the analysis quality of auxiliary data service products has been improved. With the existing data conditions and technical routes, a large part of the city details cannot be identified, and for the areas with close building spacing or lush trees, the information at the bottom of buildings cannot be accurately expressed. Therefore, the future development direction of the system will be to add the road street view collection information.

(2) the efficiency of relevant algorithms is improved. In some analyses involving a large number of models and terrain data, such as sunshine analysis, the execution efficiency is low and users need to wait for a long time. Therefore, relevant algorithms need to be optimized to

improve data processing capacity and provide a good user experience.

7 Fund projects

Chongqing Municipal Education Commission Science and Technology Research Project: Spatial Features and Planning of Traditional Villages in Southeast Chongqing
Research on design strategy (KJQN201904301).

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