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Research Article

Building a Smart City Planning System Integrating Multidimensional Spatiotemporal Features

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With the development of mobile communication technology and the popularization of mobile devices, the connection between people has become increasingly close, the data circulating between them have increased rapidly, and the multidimensional space-time characteristics have gradually entered the stage of the times. The proposal of the basic smart city system is a revolution in the concept of urban construction. A smart city is both an opportunity and a challenge for the urbanization process. By analyzing the multidimensional spatiotemporal feature engineering, this paper studies the development trend of smart cities and discusses how multidimensional spatiotemporal features play a fundamental role in the smart city system.

1. Introduction

The rapid development of today's science and technology, the popularization of the Internet, and the introduction of the Internet of Things have greatly increased people's demand for data transmission. At the same time, the construction of the mobile Internet has increased the number and scale of data transmission. With the development of information technology, the pace of urban informatization has been accelerated, and the level of urbanization has been further improved. Subsequently, urban problems such as environmental pollution, low urban management efficiency, unreasonable industrial structure, and traffic congestion have emerged. In order to solve the increasingly serious urban problems, the construction of smart cities has long been put on the agenda, and it is the application of multidimensional spatiotemporal features that provide the basic conditions [1]. This paper briefly introduces the smart city system and describes the application of multidimensional spatiotemporal features in smart cities with the help of examples. The purpose of multidimensional space-time feature engineering is to develop new or comprehensively utilize existing technologies to process multidimensional space-time features, so as to carry out planning, construction, and operation management of multidimensional space-time features. The research on multidimensional spatio-temporal characteristics is divided into processing analysis and secondary development. By analyzing this huge amount of data, a lot of hidden information can be discovered, and deep-level information can be mined, so as to propose a processing plan that adapts to the actual situation; dimensional spatiotemporal features carry out operations similar to businesses accepting consumer feedback, adjusting products, and engaging in operation management, so as to achieve their goals. The basis of smart city systems is multidimensional spatiotemporal feature engineering. The development of multidimensional spatiotemporal features affects the construction, development, and operation of smart city systems [2].

There is no doubt that man is wise. Let the city, an inanimate body, be as intelligent as a human being and be able to solve urban problems by itself. This is the construction of a smart city. The construction of a smart city includes many aspects such as government affairs, transportation, medical care, and security. It requires the support of various information technologies such as multidimensional space-time features, cloud computing, and artificial intelligence. It also requires the construction and improvement of infrastructure [3]. A smart city is a new form of urban development in contemporary society, which is of great significance for improving the government's service and management capabilities, promoting the upgrading of industrial structure and the gathering of knowledge-based talents. The new smart city is characterized by openness, co-construction, and sharing and is committed to achieving equalization of services, eliminating the information gap, and promoting the construction of urban characteristics. The construction and development of smart cities revolves around multidimensional spatiotemporal characteristics. A "smart" city is like a smart person. On the premise of having a complete infrastructure, it should extensively collect information and resources from all aspects of society and analyze and process them, so as to form various complete databases. On the basis of perfect data resources, through the use of advanced information technologies such as the Internet of Things, cloud computing, and multidimensional space-time features, various application platform systems are built to achieve effective prediction and monitoring of economic and social affairs and to assist leaders in making scientific decision-making and improve the management level of the city, so as to provide the public with more intelligent services [4]. During the whole operation process of the city, new data resources will be generated and perceived by the city, which will further promote the improvement of the database and the improvement of processing capacity, thus forming a closed virtuous circle. It can be seen that multidimensional spatiotemporal features play a fundamental role in the construction of smart cities. The building equipment monitoring system is an important part of the intelligent system of the smart community. As the name suggests, the building equipment monitoring system is built for the unified management and monitoring of different equipment in the building, including electrical equipment, HVAC equipment, water supply, drainage equipment, and special equipment [5].

The working principle of the system is as follows: data information is received from various sensors, so that the property can comprehensively and intuitively understand and grasp the operation status of different equipment in the building. For example, according to the pictures taken and transmitted by the camera, we can know whether anyone needs to use the public entertainment area and judge whether the lighting equipment in the area needs to be turned off or whether the temperature of the central air conditioner needs to be adjusted; with the information, judge the actual operation of the power transformation and distribution system and make adjustments in time; and according to the repair and maintenance dates of the equipment in the building, the property management can make appointments for professionals in time. After the system is completed, the information collection, centralized management, and control of all equipment in the building can be realized through the system. Such equipment management and control mode are conducive to the rational allocation of human, material, and other resources and can also save community public resources, thereby improving the energy conservation and environmental protection of smart communities. At the same time, the building equipment monitoring system can be used to realize the timely and accurate understanding and mastery of the energy consumption of different equipment in the building and provide effective reference information for the reasonable formulation of property energy use indicators and employee KPI indicators [6]. In the smart community, the video intercom system can provide voice and video transmission services for properties and residents, residents and visitors, and visitors and properties. At present, the video intercom system has been used more and more in the construction of smart communities. Many video intercom systems can not only transmit signals to the property owner but also connect with gas alarms, smoke alarms, etc., so that even when the resident is not at home, the property owner can timely discover the hidden safety hazards in the house and realize correctly. Effective control of the risk of household property loss is also conducive to simplifying the property management process and improving the quality of property services. When planning and designing the video intercom system, the property terminal should be installed at the property, the household terminal should be connected to each household, and the visitor terminal should be installed at the public entrance of each residential building [7].

2. Research Method Design

The design of this research method is divided into four parts: data analysis and acquisition, data cleaning and screening, multidimensional big data information fusion, and smart city flow spatiotemporal distribution design. The research technology roadmap is shown in Figure 1.

2.1. Data Acquisition. Frequently used software applications were found through offline questionnaire surveys, such as Weibo check-in, Douyin location sharing, and Mafengwo travel notes, and then the data were divided according to the software characteristics, such as the Weibo check-in data structure contains a user ID, check-in time, check-in location, and other information. Finally, use web crawlers to collect the information generated by tourists using popular software functions near POIID according to keywords, and form an initial data set according to the divided data structure standards for several months [8].

2.2. Data Cleaning. Since the initial data set consists of comprehensive and noncustomized data, which contains a lot of useless data, in order to ensure the scientificity and accuracy of the results, the initial data set needs to be fully cleaned before it can be applied to subsequent analysis [9]. In the data cleaning and screening stage, the deletion method, regression method, mean smoothing method, etc. can be used to preprocess the data first. On the one hand, it can solve the problem of missing data, and on the other hand, it can remove the noise in the initial data. First, data cleaning and screening standards were formulated, then many parameters were obtained through small-scale on-the-spot investigation, and a statistical model was established to perform data mining on the spatiotemporal information in the data and identify tourist groups. Then, according to the

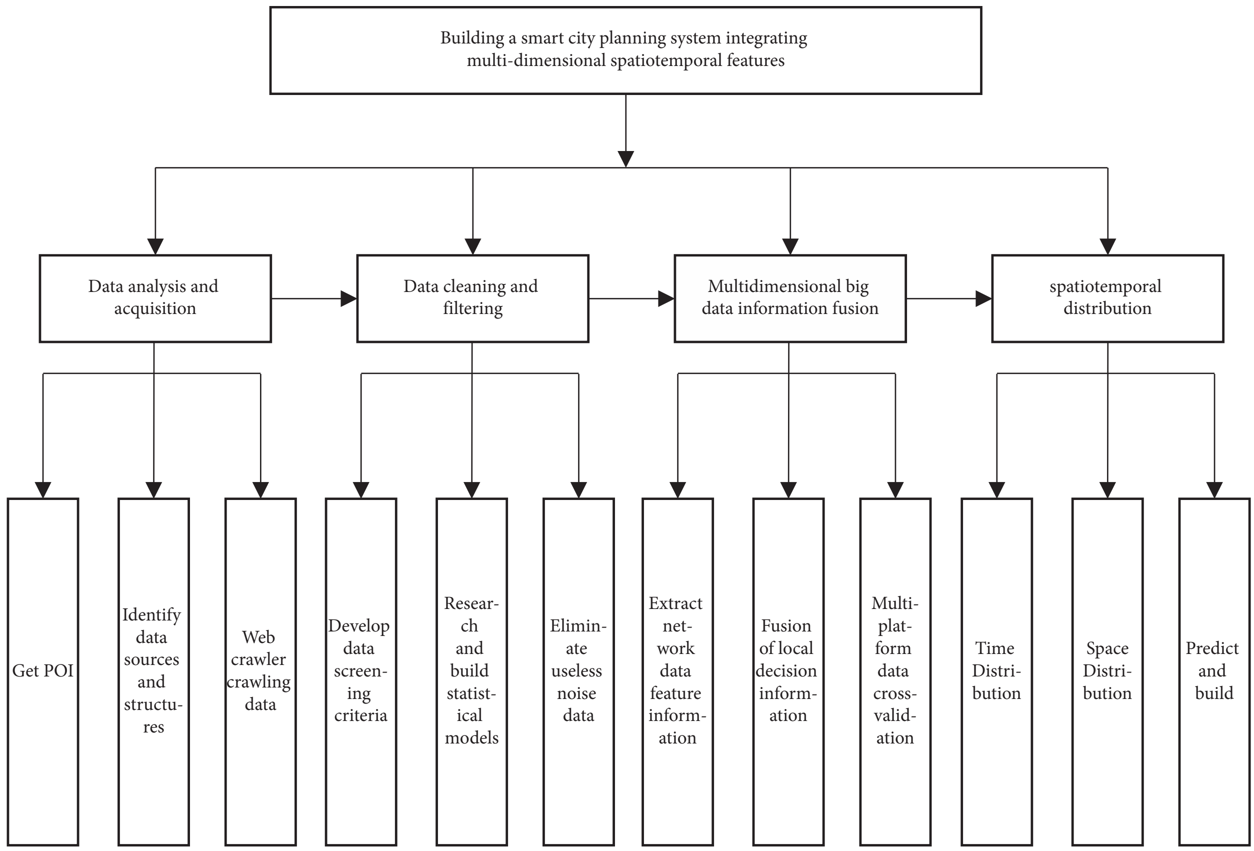

Figure 1: Technology roadmap.

user attribute characteristics, unclear geographical source, incomplete information, and the months with incomplete data or fewer data are excluded, and the final remaining data are used as the data basis of this study [10].

2.3. Multidimensional Big Data Information Fusion. Multidimensional big data information fusion has very important value and significance in the era of big data. In the study of smart city flow, there are often more than one factor that affects the spatiotemporal distribution characteristics of smart city flow, so using different data sources can provide important information from different sides and improve the accuracy of data and the reliability of results [11]. D–S or evidence theory, neural network, and other algorithms can be used to integrate and analyze the characteristic information extracted from the data of Weibo, Douyin, and other network platforms and further evaluate or infer the local decision information obtained by further mining the value of the data in order to enhance the role of information and, finally, conduct interactive verification of data on different platforms to exclude abnormal points, improve the confidence of data results, and prevent decision-making mistakes [12].

2.4. Space-Time Distribution Design. This method first integrates the information based on multidimensional big data and uses the time stratification method and software frequency index to analyze the seasonal, intra-month, intra-week, and intra-day time distribution characteristics of urban smart cities in the flow; then using GIS spatial analysis and kernel density methods, the spatial distribution characteristics of urban smart city flow, such as the "seasonal change" map of urban smart city flow core density and the smart city flow core density map of different attributes, were visualized. A statistical model was established for the analysis of spatial and temporal distribution characteristics of urban smart city flow and a general smart city flow research model to help researchers, city governments, or smart city enterprises re-understand the source market, develop smart city resources in a targeted manner, and design smart city products and smart city lines [13].

3. System Model Construction of Smart City

Models are the most important and most basic tools for studying systems. In order to express the characteristics, properties, or laws of motion of a certain aspect of the entity, the model abstracts the characteristics of the entity at a certain level and expresses them in a certain structural form, so as to help people better understand the characteristics of the object, predict changes, and control the operation or structural design. A system model is a description of the essential properties of a certain aspect of a system, which provides knowledge about the system in a certain form (such as words, symbols, diagrams, and mathematical formulas). A

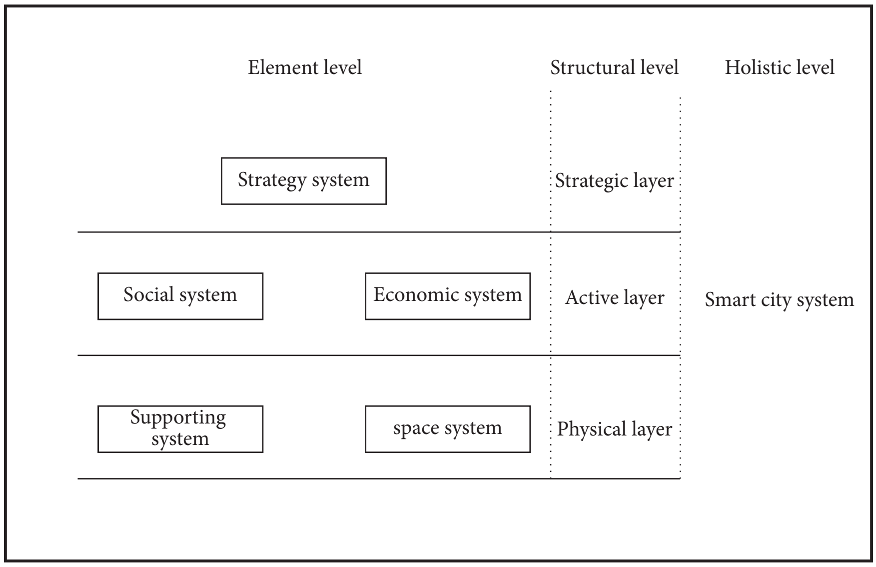

Figure 2: Schematic diagram of the elements and structures of the smart city system.

system model is a description, imitation, and abstraction of a real system. It consists of main factors that reflect the nature or characteristics of the system, and it embodies the relationship between these main factors [14]. This part will build a system model of a smart city based on the relevant theories of complex systems, combined with the previous analysis of the elements and structures of the smart city system.

3.1. Smart City System Based on Communication and Control Laws of Complex Open Systems. It can be seen from the above analysis that the smart city system is composed of five subsystems—strategic system, social system, economic system, support system, and space system—as well as three layers—strategic layer, activity layer, and physical layer. From the perspective of the hierarchy of the system, the five subsystems have different degrees of complexity, and the corresponding relationship between the five subsystems and the three levels is shown in Figure 2. As can be seen from the figure, from the structural level, the smart city system is composed of three complex levels: the physical layer, activity layer, and strategic layer; and from the element level, the support system and spatial system of the smart city system are located in the physical layer, the social system and the economic system are located in the activity layer, and the strategy system is located in the strategic layer.

This is how, in the smart city system, the three layers and the five subsystems are organized and connected.

The communication and control rules of the system are important mechanisms for maintaining complex open systems to withstand environmental shocks. In complex systems theory, another group of concepts equally important as the classification and hierarchy of the system is the communication and control of the system, i.e. the maintenance of the system level requires a series of information exchange processes for regulation or control. In other words, a hierarchy of open systems must require communication and control processes if the system is to survive the shocks dictated by the environment. In a complex system, control is an active action of the controlling subject on the controlled object. The controlling subject obtains, processes, or uses the information to make the controlled object act according to the predetermined purpose of the controlling subject and guide the object to the predetermined purpose [15]. In the control theory of complex systems, according to Ashby's Law of Necessary Diversity, the diversity of controllers must be equal to or greater than the diversity of controlled persons, that is, the diversity and complexity of the "organizational management" performed by the controlling subject must be equal to or greater than the "operational activities" carried out by the controlling subject to achieve the purpose, and the diversity and complexity of "operations" must be equal to or greater than the "objective environment" represented by the controlled object [16].

Corresponding to the smart city system, in order to achieve the purpose of building a smart city by smart city builders, the development strategy and the implementation measures formulated by the builders (control subjects) must be more complex and advanced than the activities of people in the smart city system. The material environment, likewise, the complexity, and the advanced level of human activities must be greater than the material environment faced by the smart city system, so as to effectively realize the transformation of the material environment. At the same time, in order to cope with the diverse changes in the environment, human activities at the active layer also need to play the greatest active role in a certain autonomous way. If the strategic layer restricts the diversity of people's activities in the active layer too much, it will make it difficult for the smart city system to adapt. If the changes in the environment are not well controlled, the development of the system will go with the flow, and the goal of smart city construction will not be achieved [17]. Based on the above analysis, the corresponding relationship between the three levels of the

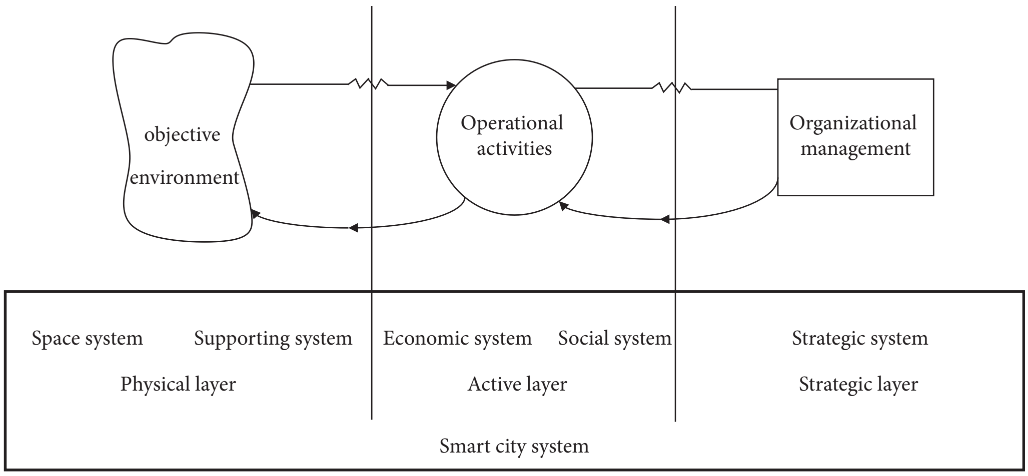

Figure 3: Relationship between the elements and structures of the smart city system and the communication and control of the complex system.

smart city system and the control and communication of the complex system is shown in Figure 3.

3.2. Smart City System Based on Viable System Model. The communication and control relationship between the three levels and five subsystems of the smart city system can be further analyzed using the viable system model (VSM).

In order to further understand the survival principle governing complex organizational behavior, Bill established a living system model formed by five subsystems connected according to certain communication and control laws, as shown in Figure 4. The model connects the five subsystems through a composite of information and control loops. The survival system model composed of the five subsystems through interconnection and interaction shows various control laws and conditions that are necessary to support the healthy operation of a complex system [18].

In the smart city system, the vital system model reveals the communication and control laws of different subsystems and different system levels of the smart city system.

There is a specific connection between the five subsystems and the three levels of the smart city system and the five subsystems of the living system model and the environment in which the five subsystems act:

(1) The external environment that is "System 1" in the living system model acts on correspondence to the physical layer of the smart city system. The "overall environment" in the physical layer is the space system of the smart city, which is the accommodation place for people to carry out various activities, has certain physical characteristics, and is reflected in the smart city as an intelligent flow space [19]. The "local environment" in the physical layer is the support system of the smart city. It builds corresponding to smart application systems in different functional areas of the city with emerging information and communication technologies and information infrastructure within a certain spatial range. In a smart city, these intelligent application systems have become the material and technical carriers that people rely on to carry out various smart forms of economic and social activities. At the same time, in the physical layer, it is precisely because of the extensive application of a large number of intelligent application systems established in the support system that the "overall environment" of the original material from in the space system begins to become intelligent and fluid. The flow space of urban space has brought the decentralized and network development of the physical form of urban space [20].

(2) "System 1" in the living system model, as well as the adjustment activities of "System 2" and the management and audit activities of "System 3," which are related to the implementation and operation activities of "System 1" themselves, all correspond to the smart city system's active layer. In a smart city, according to the different types of people's activities, the implementation and operation activities of "System 1" can be mainly divided into seven major activities: social and cultural activities, public administration activities, social interaction activities, production activities, circulation activities, consumption activities, and innovation activities. These different types of activities are guided, constrained, and controlled by the corresponding aspects of strategy execution and implementation from the strategy layer. The implementation of the strategy at the strategic level, on the one hand, in accordance with the planning and content of the strategic plan, combined with relevant resources such as funds and talents, organizes and manages the development of the above activities in seven aspects, provides necessary services, and conducts regular assessments to ensure verification of the degree of the intellectual development of different types of activities; on the other hand, it regulates and constrains people's

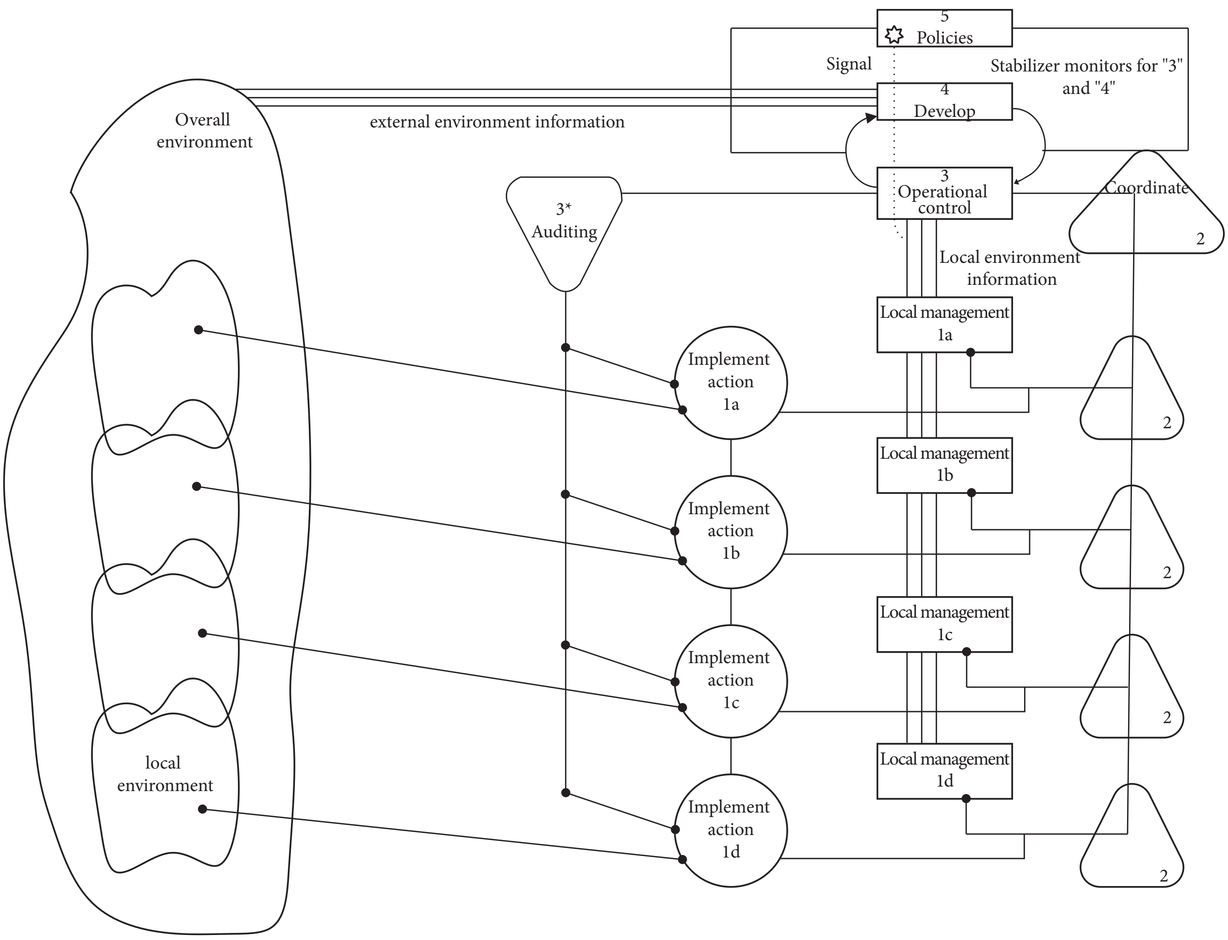

Figure 4: Living system model.

various economic and social activities through the supporting policies and regulations, technical standards and specifications, information security requirements and institutional innovation rules in the implementation of strategic planning, so as to ensure that each coordination of class activities. The above seven types of social and cultural activities are integrated with the guidance, restraint, and control from the implementation of the strategy to form a social and cultural system, public administration system, social relationship system, production system, circulation system, consumption system, innovation system. The corresponding economic and social subsystems such as the system, and the corresponding subsystems are further combined to form a social system and an economic system [21].

(3) "System 2," "System 3," "System 4," and "System 5" in the VSM together correspond to the strategic layer of the smart city system. Among them, "System 2" and "System 3" correspond to the "strategic implementation" of the smart city system strategic layer, "System 4" corresponds to the "strategic research" of the smart city system strategic layer, and "System 5" corresponds to the smart city system "strategic planning" at the strategic level. The strategy implementation that exerts the control function of "System 3" is connected with the strategic plan corresponding to "System 5." On the one hand, it is accepting and interpreting the basic plan for smart city development in the strategic plan, and on the other hand, it is related to the economic and social situation of the people in the activities. Activities are connected to guide, control, and constrain people's economic and social activities in accordance with the requirements of strategic planning. "System 2" is also an integral part of strategic implementation. As mentioned above, it regulates people's economic and social activities in accordance with policies and regulations, technical standards and specifications, information security requirements, and institutional innovation rules that support and guarantee the implementation of strategic planning. "System 3" jointly ensures the implementation of the strategic plan. The strategic research that exerts the development function of "System 4" fully analyzes the internal and external environment faced by the development of the smart city system through relevant basic research, special research, and case studies and provides necessary information support for the strategic planning and implementation of the

smart city. The strategic planning that exerts the policy function of "System 5" indicates the direction and path for the development of the smart city system by describing the strategic vision of smart city development, formulating strategic goals and strategic tasks for smart city construction, and clarifying the strategic focus of smart city construction, so as to ensure that the smart city system can develop into a city system with "smart" characteristics [22]. It can be seen that the strategic layer and the strategic system are the core of the smart city system, which establish the communication and control mechanism of the entire smart city system and promote the city system to continuously move towards a "smart" city system.

It can be seen that the living system model realizes that different parts of the organization and the entire organization operate according to their own goals through appropriate information flow and communication chain. The operation and development of smart city systems also follow these communication and control laws.

3.3. System Model Description of Smart City

3.3.1. Corresponding Relationship between the Elements and Structures of the Smart City System and the Conceptual Connotation of the Smart City System. The smart city system is an urban system with the characteristics of "smart" formed by the coupling and effect of the intelligence of information technology and the intelligence of people and the urban system. From the analysis of the conceptual connotation of the smart city system above, it can be seen that in the formation and operation of the smart city system, the first is the combination of emerging information technology and the city subsystem to build an intelligent city subsystem, and then the human wisdom and intelligence. The intelligent urban subsystem is combined to form a smart urban subsystem. Finally, human wisdom is combined with various intelligent urban subsystems and smart urban subsystems to build a smart urban system. At the same time, it can be seen from the previous analysis that the smart city system is composed of five subsystems: strategic system, social system, economic system, support system, and space system and also how they reflect the wisdom of people in the smart city system and the intelligent city subsystem and the connection and combination of smart city subsystems.

From the relevant analysis of the elements and structures of the smart city system, it can be seen that the smart city system is composed of three layers: the strategic layer, the activity layer, and the physical layer, and five subsystems: strategic system, social system, economic system, support system, and space system, which are interconnected, interact, and jointly build a smart city system with "smart" characteristics. In the smart city system, the support system and the space system are located at the physical layer, which is the result of the intelligent transformation of the original urban material elements and material forms by emerging information and communication technologies. They are all intelligent cities with intelligent application systems as the core subsystem. Therefore, the support system and the space system correspond to the intelligent urban subsystems in the smart city system. The social system and the economic system are located in the activity layer, which mainly reflects the intelligent form of people's economic and social activities. They are constructed by people with the ability to "cognition, judgment, analysis, and action" using information technology under the support of the support system and the space system. Various forms of activities carried out by the intelligent application system and related activities are integrated into the intelligent city subsystem. Therefore, the social system and the economic system correspond to the smart city subsystems in the smart city system. The strategic system is located at the strategic layer. It formulates smart strategic planning with human "insight, foresight, and wise response," and plans, organizes, guides, and coordinates the construction of smart city subsystems and the development of smart city subsystems. In turn, a more scientific and reasonable development model emerges in the entire smart city system to realize the "smart" development of the entire city [23]. Therefore, the strategic system corresponds to a good combination of human intelligence, intelligent city subsystem, and smart city subsystem in the smart city system.

3.3.2. System Model Design of Smart City. The system model of the smart city is the description, imitation, and abstraction of the smart city system, and it describes the relationship between the elements of the smart city system in a certain structural form. According to the three levels of the smart city system structure and the relationship between the five subsystems, this paper constructs the smart city system model shown in Figure 5. It can be seen from the figure that the system model of a smart city is composed of three layers: strategic layer, activity layer, and physical layer, and five subsystems: strategic system, social system, economic system, support system, and space system. The strategic system is located at the strategic layer, which is at the highest level of the smart city system; the social system and economic system are at the activity layer that is at the middle of the smart city system, and the support system and space system are at the physical layer that is at the bottom of the smart city system. At the same time, the strategic system, social system, economic system, support system, and space system are all interrelated, interactive, and interdependent [24].

The formation, operation, and development of the smart city system are revealed through the interconnection and interaction between the five subsystems in the three layers. Specifically, the formation, operation, and development of the smart city system are realized by the relationship and function of the five subsystems from high to low complexity [25]. Among them, the strategic system is the soul and core of promoting the entire smart city system to present "wisdom": the construction of information network infrastructure, intelligent application system, and public information platform in the system; the formation of highly intelligent flow space and scientific and rational spatial development pattern in the

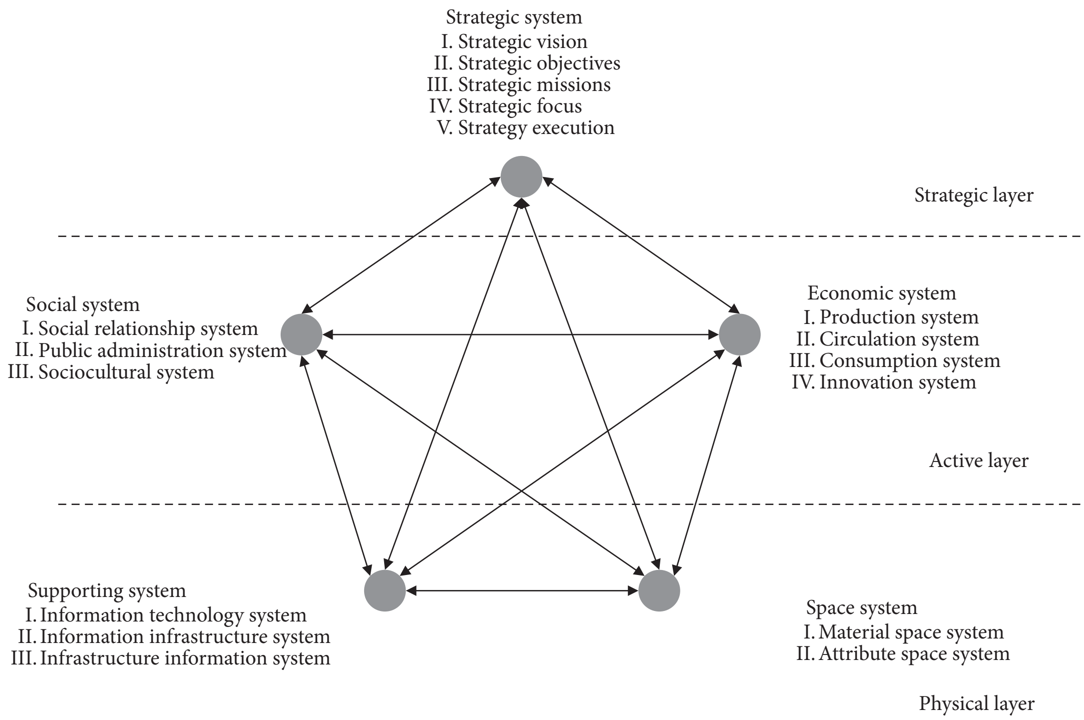

Figure 5: Schematic diagram of the system model of a smart city.

space system; and the social environment in the social system that is more in line with the needs of modern people's survival and development. On the other hand, the strategic system realizes the social system, economic system, support system, and spatial system through its restraint, control, and adjustment functions; coordinates and balances development; and then promotes the continuous optimization of the entire urban system. The social system and the economic system are closely related to human activities, and they are the most dynamic and creative system components in the smart city system. Under the guidance and regulation of the strategic system, as well as the support of the support system and the space system, the social system creates a good social environment and conditions to promote the all-round development of human beings. The economic system lays a solid material foundation for the all-round development of human beings by creating more diverse and rich material living conditions and environments, thus creating a social and economic environment in the city that is more in line with the development needs of modern people. The support system and the space system are closely related to the material elements in the city. They are formed in the deployment and implementation of the strategic system and provide the material basis and support place for people's economic and social activities in the smart city. Social activities provide technical and material support, and the space system provides resources, environment, and support sites for people's economic and social activities. It can be seen that the support system and the space system jointly build the basic conditions that are more in line with the needs of modern urban operation and development.

4. Conclusion

In this rapidly developing information age, opportunities and challenges coexist. The combination of informatization and urbanization is inevitable, and so is the construction of a smart city system. Firmly grasp the technical foundation of "multidimensional space-time characteristics" and reasonably solve the problems of security and privacy are of great importance to the construction of smart city systems. In terms of building a smart city, my country has lagged behind for a period of time, with insufficient infrastructure construction, and is competing with many developed countries. It must vigorously develop multidimensional space-time characteristics to solve difficulties and come first. My country's smart city construction should be designed and planned according to local conditions, combined with its own original characteristics, based on multidimensional space-time characteristics, comprehensive use of various science and technology, and strong strategic support to bring urban construction to a new height.

Data Availability

The data set can be accessed upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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