ISSN 2663-1563 Vol. 6, Issue 4: 96-101, DOI: 10.25236/AJAGE.2024.060415

Integration and Innovation of Urban AI and Intelligent Planning and Design

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Abstract: *On the basis of combing the basic concepts and theoretical technologies of urban AI and intelligent planning and design, this paper points out that urban AI focuses on optimising urban governance, while intelligent planning and design focuses on improving the scientificity of planning. Both of them have solved a lot of problems in urban development in their respective real-life scenarios, but they are facing the problems of lack of top-level design, data non-sharing, non-collaboration of business, and insufficient human-centred response, etc. In the future, it's need to deepen their Integration. It is suggested to promote the high-quality development of smart cities through the promotion of in-depth urban integration, the establishment of data sharing mechanisms, the promotion of ecological synergy, and the enhancement of human-centred response and participation.*

Keywords: *Urban AI, Intelligent Planning and Design, Integration, Innovation*

1. Introduction

As China's urbanisation process accelerates, a series of problems on social development and urban management have been gradually exposed, putting forward new requirements for the carrying capacity and management level of cities. At the same time, 5G network, Internet of Things, artificial intelligence and other smart technologies continue to develop. China has actively responded to this. Since 2011, China has launched different batches of national pilot cities for smart city construction. In 2014, the National New Urbanisation Plan (2014-2020) proposed to "promote the construction of smart cities". In 2017, "smart society" was written into the report of the 19th National Congress of the Communist Party of China (CPC). In the same year, the State Council issued the "New Generation of Artificial Intelligence Development Plan", which strategically deployed China's development of AI [1].

The two technologies of "urban AI" and "intelligent planning and design" represent the wind direction of smart cities' development in the new era. And their basic concepts, related technologies (including big data, cloud computing, the Internet of Things, etc.), as well as their application practices in various industries within the city, especially in the areas of transport, energy, environment, security and integrated governance, etc, have been the subject of a lot of research, environment, security, and integrated governance, etc. In this paper, we will focus on exploring the development direction of complementing the advantages of the two, integrating them, developing them innovatively and applying them to urban reality on the basis of analysing their basic concepts, theoretical and technological foundations, as well as the current status of their application and existing problems.

2. Basic concepts and theoretical and technical foundations

2.1 Basic concepts

2.1.1 Urban AI

Urban AI is essentially an AI (artificial intelligence), which is a new technological science based on computer science and the integrated use of philosophy, mathematics, logic, psychology, linguistics and other disciplinary methods to study theories, methods, techniques and applications used to simulate human intelligence. AI represents a wide variety of technologies, including understanding and analysing natural language, image data, quantitative data, detecting system patterns and abnormal behaviours, etc., and having the ability to continuously learn[2]. With the rapid development of information technology, artificial intelligence has become an important force for social progress.

Urban AI is a product of the deep integration of artificial intelligence technology with urban

ISSN 2663-1563 Vol. 6, Issue 4: 96-101, DOI: 10.25236/AJAGE.2024.060415

governance, urban management, urban services, etc. It mainly focuses on AI technologies applied to various fields such as urban management and services. And it is aimed at building a more efficient, safer and smarter city, with urban research, urban planning, urban construction and management driven by intelligent technologies with AI at the core[3].

2.1.2 Intelligent planning and design

Intelligent planning and design refers in particular to the planning and design of "Smart City". Since 2006, Tongji University and IBM jointly proposed "Smart City", and the latter released it as a business concept to the world [4], and it has been practiced a lot in the world. "Smart City" is the enhancement of "digital city", and its core features are "perceivable, judge-able, react-able, and learnable"[5]. The development of smart cities has reshaped the understanding of cities by governments, planners, and citizens, which is considered an inevitable choice for modernizing urban governance capabilities[6].

Intelligent Planning and Design mainly refers to the use of intelligent technology to develop and plan the work of smart cities more precisely and efficiently. In the planning and design process, advanced technologies such as the Internet of Things, cloud computing, big data and artificial intelligence are fully introduced, and attention is paid to making them effectively utilised in specific urban scenarios.

In terms of basic concepts, urban AI improves the quality of urban life and changes the habits of residents, focusing on improving the present level of development of the city, while intelligent planning and design rely on the integration of existing urban life data to help us better lead the future of the city.

2.2 Theoretical and technical basis

2.2.1 Internet of Things (IoT) technology, cloud computing technology, big data technology

The three technologies are the most basic and common technologies in intelligent planning and design. IoT realises real-time perception and collection of multi-dimensional information such as urban environment, traffic conditions, usage of public facilities, energy consumption, etc. through sensors, RFID tags, cameras and other smart devices deployed in every corner of the city. Cloud computing provides fast aggregation, efficient storage and flexible access to massive amounts of data, as well as parallel processing of large-scale data analysis tasks . Big Data technology is used for deep data mining and value discovery through the use of data analysis algorithms and models .

They are applied to intelligent planning and design, complement each other and closely connected. With the ability of conducting timely and accurate perception and access to urban planning information, fast and efficient analysis of the acquired data, analysis of development patterns and prediction of development trends, IoT improves the ability to control the urban situation, which makes planning and design more precise and efficient. In addition, the comprehensive interconnectivity and interoperability of the technologies makes them highly interactive, which not only serves the collaboration among planners, but also provides a platform for the public to participate in planning.

2.2.2 Machine learning and generative AI techniques

The basic theory of Artificial Intelligence is based on "Machine Learning", which enables computers to learn and improve automatically without explicit programming. It can be used to analyse a large amount of geospatial data, demographic data, economic data, etc., in order to discover the patterns and trends of urban development, and to provide a scientific basis for planning decisions. At the beginning of 2024, generative AI technologies such as Sora, ChatGPT, etc. have attracted a lot of attention across the industry for their unique disruptive nature. Compared to traditional reasoning or discriminative AI technologies, it is able to create entirely new content based on its intrinsic logic and knowledge base, and thus is more relevant to the needs of intelligent city planning and design, as well as urban regeneration[7].

2.2.3 Urban systems theory

Theories in the field of urban planning should also not be ignored. Take "urban system theory" as an example, which views the city as a complex system composed of multiple interrelated and interacting subsystems, including natural systems, economic systems, social systems and human systems. The core view is that the urban system is an organic whole, and its overall function is much more than the simple sum of the functions of various subsystems, showing a unique comprehensive effect; it has a hierarchical structure which are interconnected and interacted with each other to maintain the stability and development of the urban system; it is also an open system and constantly in the dynamic change, with the ability of self-organization, self-regulation and self-repair.

ISSN 2663-1563 Vol. 6, Issue 4: 96-101, DOI: 10.25236/AJAGE.2024.060415

2.2.4 Spatial syntax theory

As urban AI and intelligent planning and design converge, a new theoretical foundation is gradually being constructed. "Spatial syntax" was firstly proposed by Bill Hillier of the Bartlett School of Architecture, University of London in the 1970s, which is a mathematical method for describing and analyzing spatial relationships. Its basic idea is to divide the space into scale and space segmentation, and to analyse its complex relationships, so as to explore the connection between human activities and spatial patterns. So far, it has developed into a set of complete theoretical system and mature methodology , reflecting and defining each element of space with variables such as "connection value", "control value" and "depth value", and exploring the analysis methods such as convex space analysis method, visual field analysis method and axial map analysis method, etc. Now it has been equipped with special spatial analysis software technology, which is not only applicable to the analysis of the internal space of the building, but also widely used in the fields of urban planning, landscape design, etc., spanning across a wide range of scales from a single building to a large city.

3. Development status and issues

Urban AI has a wide range of applications, playing a significant role in transport, security, government, healthcare and more. Intelligent planning and design has also been applied to a variety of scenarios, ranging from intelligent territorial spatial planning to the analysis and evaluation of public service facilities in urban localities based on community living circles, or specific aspects such as simulation of climatic environments and water logging prevention planning, and assessment of comprehensive carrying capacity of transportation and municipalities, etc. It nowadays has been able to face the current five levels and three types of territorial spatial planning of the whole element, cycle, process, space intelligent management needs, and to significantly improve the planning of the scientific and practical. Comprehensively diversified applied in the field of "intelligent planning and design", urban AI not only provides an accurate basis for current planning, but also simulates and predicts the development of the city, optimizes resource allocation and reduces negative impacts.

Although the both are playing their respective roles efficiently, they are also revealing their limitations and shortcomings. First of all, smart city is a giant system of cross-system interaction, involving many elements, if there is no integrated planning and design, the construction process will inevitably appear in their own way, information silos, duplication of construction and so on. In 2014, the National Development and Reform Commission and other eight ministries and commissions set forth the "Guiding Opinions on the Promotion of the Healthy Development of Smart Cities," which explicitly put forward the need to strengthen the top-level design of the smart city. Secondly, although AI and digital information systems have been used in cities for a long time, but the problems such as the lack of data access and business synergy among various departments still exist. It’s difficult to consider information from different fields and aspects in an integrated manner, thus not effectively enabling decision makers to make accurate judgement[8] .At the same time, although "intelligent planning and design" has significant advantages in terms of dynamic sensing and control, influenced by the concept of "static blueprint planning", which does not adequately take into account the practical and specific needs of the general public, it’s difficult to follow up on the effectiveness of implementation in real time during the planning and implementation phases. Therefore, in the face of the new background of land space and the new demands of modernized governance, the technology is not detailed enough, and the human-centred response needs to be improved.[9]

As a result, only under the framework of the overall design of smart city construction, the creative integration of both urban AI and intelligent planning and design, can make the development of smart city qualitatively improved.

4. Analysis of the direction of development

As technology continues to advance and application scenarios continue to expand, the development of urban AI and intelligent planning and design will show trends such as deep integration, data sharing, ecological synergy, and, most importantly, will continue to enhance the "human-centred" response and participation.

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4.1 Deep integration

Urban AI will be more deeply integrated into all aspects to achieve comprehensive intelligence of urban governance and services, which means from urban planning, traffic management, environmental protection to public services and other aspects, there will be a deep involvement of AI to improve the overall efficiency and comprehensive intelligence. At the same time, with the continuous progress of technology, AI technology and intelligent planning and design will be seamlessly connected with other advanced technologies such as the Internet of Things, big data, cloud computing and other advanced technologies, forming a closer technological ecology, and jointly promoting the construction and development.

Focusing on the field of urban planning, using urban AI, on the one hand, is able to help formulate schemes, generate design drawings and conduct scheme comparison more efficiently in traditional methods, and on the other hand, can contribute to deep learning to generate large models directly from massive data, synthesize non-quantitative elements, culture, institutions, history, etc., which have been neglected in urban models in traditional methods, to correct the bias of urban simulation, redefine the design process, and innovate the planning methods[9].

4.2 Data sharing

The data sharing mechanism will be gradually established and improved with the expansion of intelligent planning and design to achieve data interoperability and sharing among functional departments (see Figure 1), and to create a big data platform for data integration, management and interoperability and sharing to provide a real-time and dynamic basic database, which will provide more comprehensive and accurate data for decision-making and management for the city AI. This will help improve the science and accuracy of decision-making and provide strong support for the sustainable development of smart cities. Big data technology will continue to play a key role in data analysis, revealing the intrinsic laws and trends of urban development through in-depth excavation of data value, and providing a more accurate basis for intelligent planning and design.

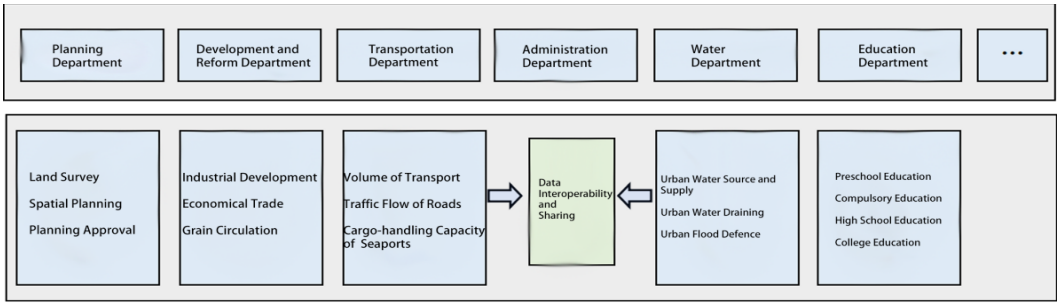

Figure 1: Schematic diagram of data interoperability and sharing among functional departments

4.3 Ecological synergy

The innovation ecosystem of the smart city aims to improve the collaborative innovation performance of the system, takes enhancing the collaborative innovation potential of the innovation ecosystem as the core, and completes the whole process of innovation ecosystem technology or product from innovation generation to technology diffusion through the close cooperation between system members and the synergy between many innovation elements[10]. The development of urban AI and intelligent planning and design will promote ecological synergy and resource sharing between different fields and industries. This will help break down information silos, achieve data inter-connectivity and promote the overall optimization of urban governance and services. On this basis, a perfect industrial ecology will also be gradually built up around urban AI and intelligent planning and design, including algorithm vendors, data providers, technical service providers and other links, which will form an ecological synergy to collaboratively promote the construction and development of smart cities.

4.4 Human-centred response and participation

Our current attention to the development of AI in cities often focuses on the technology itself and how it can be applied to cities. But whether urban AI or intelligent urban planning and design, although there is a clear distinction between the two in terms of core technology, essential characteristics, and scope of

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application, they are fundamentally about the interaction between "technology" and "people" - collecting "human" data, grasping "human" needs, and building a more beautiful "human" living environment. Human needs, emotions and values should always be at the centre. "Human-centred Response and Participation" emphasizes the core principle of human-oriented in the construction of future smart cities. In which "participation" requires that people's opinions and suggestions be fully listened to and respected during the process of urban planning and management, and that a digital participation platform be set up for residents to enhance their understanding of science and technology and planning, so as to achieve benign interaction between the government and the public and joint decision-making. While "response" requires that the urban science and technology, with a high degree of sensitivity and adaptability, can accurately identify the needs of the public through the AI's sensing, judging, reacting, learning, deducing, and iteration, and can dynamically adjust the planning strategies, and even be able to provide personalized services to residents, to make every effort to improve everyone's quality of life, and to promote the precision of urban governance (see Figure 2).

Figure 2: Scenario of multi-AI interaction in a city square[5]

5. Conclusion

City AI and Intelligent planning and design are two technologies that represent the direction of smart city development in the new era of intelligence, and both have been widely applied in various fields of the city. But their limitations and shortcomings, including the lack of integrated planning and integrated design, the lack of data, the lack of synergy in business, the difficulty of responding quickly to changes, and the lack of human-centred response, have also been apparently revealed.

Accordingly, this paper proposes to fully integrate the advantages of the current analysis and future conception of the both, so that the development of smart city can be qualitatively improved by creative integration and innovative development. By pulling various smart city technologies together and deeply integrating them into all aspects of urban governance and services, making efficient, shared and comprehensive use of data, promoting ecological synergy and resource sharing between different fields and industries, we will realise intelligent and efficient urban management, and leading the city to make planning decisions for the future globally, holistically and comprehensively. It also pays more attention to the feedback of human-centred participation and response and truly implements the modern smart city value of "People's city built by the people, people's city built for the people", enabling itself to become the leading force for the sustainable development of the city in the future.

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