Spatial Analysis Method of Urban Design Based on Big Data

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Abstract

With the development of information, digitization and network, the connotation and form of urban space are undergoing new changes. The limitations of traditional urban design methods to integrate and plan urban space are becoming more and more obvious. Based on big data and new technology, the analysis methods of vector space, 3D GIS and data flow simulation can effectively break through the limitation of space design on a series of static and relative plane design frameworks and platforms, such as 2D layout, 3D elevation design and meeting the targets; the problem of urban design is to stop on the design division and superposition of two-dimensional layers, and constantly divide and cut, without fusion and dynamic systematic distribution.

Keywords: *Big data, urban design, analysis method*

I. Introduction

Under the background of the information age, the development of informatization, digitization and networking promotes the continuous reform and innovation of the framework design of urban space development. Relying on big data, the new urban design effectively meets the needs of urban residents and promotes the planning and construction of the city. Driven by technologies such as digital earth, smart city, mobile Internet and artificial intelligence, the concept, method and technology of urban design have achieved new development [1]. At present, the spatial analysis of urban design in China is still limited to the traditional way, and with the connotation and form of urban space constantly changing, the limitations of traditional urban design methods for urban space integration and planning are more and more obvious. With the help of big data and new technology, it is particularly important to promote the overall reconstruction of urban design form, expand from a single space level to a complex and diverse level, and expand from static urban space to dynamic urban space.

II. The Evolution of the Concept of Modern Urban Space Design

2.1 Idealism

In the late nineteenth Century, the industrial revolution opened up a new world for human economic and social development, but it also brought about many negative problems such as the deterioration of the city environment. In this context, the material and technical means of constructing beautiful urban space came into being, and the ideal urban space such as garden city theory was put forward. Based on this theory, the unique urban space at that time was constructed.

2.2 Functionalism

After the Second World War, western countries entered the period of post-war reconstruction. In order to restore the appearance of cities, the country carried out a comprehensive transformation of cities, laying the foundation for the rapid recovery of urban economy and population. During this period, the theory of functional zoning became the basis of urban design, which was used to analyze urban space, so as to ensure the effective use of urban land

and the scale of urban space.

2.3 Humanism

In the post industrial era, with the development of the city, all kinds of contradictions become increasingly prominent. The traditional urban design can not meet the needs of further development. Therefore, modern urban design abandons the past design method which only pays attention to aesthetic factors, and begins to emphasize the internal interaction between people and space, emphasizes the importance of landscape design for people's activities and psychological perception, and reflects the respect for people's physical and psychological needs through various specific design techniques. The concept of humanistic care advocated by modern urban design has greatly enriched the core connotation of the development of urban planning and architectural design in the second half of the 20th century.

2.4 Concept of sustainable development

Since the 1980s, the concept of sustainable development has swept the world, and derived many design concepts such as ecological city, smart city, digital city and so on. With the continuous development of the Internet and the progress of science and technology, in the interactive environment of big data and new technology, the spatial analysis method of urban design has been really changed. The rationality and scientificity of spatial analysis have laid the foundation for the feasibility of urban design. Especially in the current information age, with the full integration of online and offline information, a more complex social operation mechanism needs to realize the collection, analysis and transformation of big data by understanding the impact of specific parameters on urban spatial form, so as to serve the design of urban spatial form.

III. Spatial Analysis Elements of Contemporary Urban Design

Eight elements of urban design proposed by American urban designer Hamid Schwann in the urban design process are: land use, building form and volume, flow and parking, pedestrian walkway, open space, sign, preservation and maintenance, activity support [2]. After many years of urban design practice, Mr. lujiwei, an expert in urban design of China, further discusses it, and suggests that the content (elements) of urban design be summarized into five aspects [3]:

3.1 Space use system

Three dimensional function layout and use intensity.

3.2 Traffic space system

Vehicle transportation, rail transportation, pedestrian transportation, parking, transfer, etc.

3.3 Public space system

Square, public green space, waterfront space, pedestrian street, second floor pedestrian system, underground public space, indoor public space, etc.

3.4 Space landscape system

Spatial structure, urban contour, height control, terrain shaping, architectural form, landmark, landscape, urban (or regional) entrance processing, etc.

3.5 Space system of natural and historical resources

Natural resources include: natural mountains, natural waters and natural trees. Historical and cultural resources include: historical buildings, historical sites and historical blocks.

IV. The Influence of Urban Industrial Structure on Urban Spatial Structure

In fact, the above elements are focused on the "hardware" scope of urban design, ignoring the extremely important "urban industrial structure" as a soft index. The urban industrial structure directly determines the economic function of the city, and then has an impact on the urban spatial structure.

Urban industrial structure is the internal factor that determines the economic function and nature of a city. The adjustment of industrial structure and the transformation of population from agricultural type to industrial and post industrial type are the main characteristics of urbanization process, the main reason for the evolution of urban material form and the real power to promote urban development. Northam, an American geographer, once divided urban development into three stages, corresponding to different industrial structure characteristics (Table 1).

Table 1: Industrial structure and urban development

features / stage		Pre industrial stage	industrialization stage			post industrial stage
			early stage	mature period	later stage	
proportion of employees (%)	primary industry	>80%	from 80% to 50%	from 50% to 20%	from 20% to 10%	<10%
	the secondary industry	<20%	from 20% to 40%	about 50%	from 50% to 25%	<25%
	the tertiary industry	<10%	from 10% to 20%	from 20% to 40%	from 40% to 70%	>70%
non agricultural population / total population (%)		<20%	from 20% to 30%	from 30% to 50%	from 50% to 70%	>70%

Obviously, the continuous progress of industrialization liberates more and more people from agriculture and industrial production, which provides the possibility for the development of the tertiary industry. The rapid development of the tertiary industry in the late stage of industrialization creates conditions for further absorbing the surplus population of traditional industries, thus promoting the evolution of urbanization and the development of cities. In this process, on the one hand, the adjustment of industrial structure makes new types and new demands of urban land appear; More importantly, it promotes the further improvement of urban functions, which fundamentally has a significant impact on the broad urban spatial structure including urban land structure, urban system and regional urban groups [4].

V. Spatial Analysis Method of Urban Design Based on Big Data

In the environment of big data and new technology, urban construction is gradually developing towards intelligence. At this time, in urban design, the traditional spatial analysis method has been unable to guarantee the comprehensiveness and intelligence of urban construction, and the change of spatial analysis method becomes inevitable.

5.1 Vector space analysis

In urban design, the application of vector spatial analysis is mainly through the joint analysis of spatial data and spatial model, mining the potential information needed by urban design, such as spatial location, specific shape, spatial distribution, distance, location, topological relationship, etc. As the spatial feature of a city, it can be directly used as the foundation of data query, reasoning and analysis in urban design. The application of vector space analysis method is mainly to divide the space object to be analyzed through the points, lines and surfaces to get different morphological structures, and combine the spatial data and attribute data to provide the basis for the spatial calculation of spatial design. Vector space analysis method mainly includes the following points:

5.1.1 Element merging

As the distance of vector space, it is mainly according to the spatial adjacency, classification attributes of data consolidation or data conversion, in order to synthesize the data. After the merging of elements, the more complex categories will be transformed into simple ones. In the space design, the mapping can be directly carried out in the order of location, area and large area.

5.1.2 Spatial query

It mainly uses the Internet, through the input layer and query coating for spatial topology discrimination, the input layer extracts the primitive to ensure that it meets the conditions of topology discrimination.

5.1.3 Stack analysis

In urban design, two layers with the same coordinate system should be selected for the superposition analysis of space. The application of this kind of spatial analysis method is mainly to superimpose multiple data layers in spatial elements to produce new element layers. The main goal of this spatial analysis method is to understand the relationship between the spatial characteristics and thematic attributes of the objects in the same spatial location. Superposition analysis mainly includes the superposition of point and polygon, which is convenient for designers to understand the relationship between point and polygon and add attribute elements better; The superposition of lines and polygons is mainly to judge the relationship of separation, inclusion or intersection between lines and polygons; The superposition between polygons is mainly used to understand the vector data layer of two or more polygons, so as to generate a new polygon data layer.

5.1.4 Buffer analysis

The spatial analysis method mainly uses GIS to analyze urban space, which is widely used in urban planning and design. In fact, the buffer analysis is mainly aimed at the point, line, surface and other entities, in order to establish the buffer type. Generally, the generation of buffer includes the following three types: point, line and face.

5.1.5 Network analysis

In the process of urban design, we should actively use big data and new technology to analyze and model the geographical network and urban network infrastructure, so as to provide basis for subsequent network design. Network analysis includes path analysis, address matching and resource allocation, which provides details for the reasonable design of urban network.

5.2 Spatial analysis method of urban design based on 3D GIS

Urban design is an important direction of 3D GIS application. With the concept of Bim and CIM, the development of 3D GIS gives new meaning to urban design. Taking the urban physical environment as the research object, the paper implements the urban planning idea and guides the further design of urban environmental elements through the spatial design of three-dimensional urban environment. The 3D GIS for urban design includes many new technologies, including three-dimensional entity data model which can express urban reality and abstract space, multi-source 3D data fusion for different scales, real 3D spatial analysis and calculation, and new technology of 3D interaction and output.

5.2.1 3D GIS is the key technology for digital urban design

For the large-scale urban space form, digital urban design is a kind of urban design which can be implemented. It not only includes the functions of relatively complete, systematic and reliable multi-source data acquisition, analysis, synthesis and integration, but also includes the material space form construction facing design implementation, operation and maintenance management, urban sustainable development and necessary elasticity. This is in line with the function of GIS. Digital city is based on digital engineering, involving the whole life cycle process of urban design, including design, achievement review, implementation evaluation and public participation. The digital technology adopted includes data acquisition, data analysis and data visualization technology [5]. The research has proved the practicability of 3D GIS in urban design to some extent. For example, Gong Jing and others have created the urban planning database by using the technology of 3D model construction and GIS, and established the approval system of 3D urban auxiliary planning [6]. Hongcheng has established the basic framework and steps of urban design based on GIS [7]. Zhuqing and Zhangxia discuss the digital city GIS technology and its application in different levels of urban design [8-9].

In the environment of big data and new technology, digital city has become an important goal of urban construction. At this time, the traditional spatial planning and analysis method has not met the needs. The appearance of 3D GIS spatial planning analysis method has been widely used in urban design. The spatial analysis method of 3D GIS mainly uses GIS system to describe spatial geographic phenomena. Compared with the traditional two-dimensional description, it has more spatial information and provides more sufficient data support for urban design. However, the reform of spatial analysis, the transformation of 2D to 3D, the rapid increase of data volume, more complex spatial relations, bring more complex problems for urban design. In this regard, we should actively use big data and use big data mining technology to provide scientific and representative data for urban design.

5.2.2 Establishment of DEM

DEM is the foundation of three-dimensional model. In urban design, DEM should be taken as the benchmark strictly to ensure the authenticity of data obtained from urban design. Usually, in spatial analysis, the urban mapping department will provide DEM directly, and it does not need to be rebuilt. In terms of planning requirements, staff can directly select representative grid DEM data in different interval units in mass data. In the analysis of urban ground space, if DEM data is not available, it is very complicated to extract contour lines and elevation points directly on a certain proportion of topographic map. It is very complicated, while increasing the workload, there are big errors, which will bring some influence on urban design. In the process of spatial analysis, it is very important to master the establishment of DEM. DEM is generally established by following steps: firstly, the data format is set to (ID, x, y, z) for elevation points collected on the ground that meet the requirements of spatial density. The more precise the format is, the more realistic the model is built. Secondly, the collected elevation data is imported into BEM software to form GIS data. The tin function is used to form a triangle network. Then check whether there are any outliers in the 3D environment, and put forward data errors effectively. Third, the 3D model is established by using triangle network and DEM software, which provides 3D ground model for the rational design of urban space. The application of 3DGIS spatial analysis method provides a clear three-dimensional model for the urban design, such as open space elements, road elements, building elements, natural environment elements, etc., which is convenient for its planning and design.

5.2.3 3D GIS and its key technologies are important support for digital urban design

Digital urban design is a three-dimensional design including human, natural and social factors, and plays a key role in improving the quality of the city. 3D GIS and its key technologies are the important support of digital urban design, and its function is mainly reflected in the aspects of multi-source heterogeneous data fusion, 3D object processing, real-time spatial analysis and spatial operation, data output and real-time or near real-time 3D visualization. The greater advantage of 3D GIS is that it can integrate various technologies, software platforms and even multiple working stages related to urban design, and gradually develop into a city design information management platform for the whole life cycle. It is not only convenient for data sharing and interoperability, but also supports multi-scale design from macro to fine, and then gradually changes the working mode of urban design.

With the application of artificial intelligence and deep learning, it will promote the development of 3D GIS and improve the intelligent and automatic level of GIS in urban design, planning and decision-making.

5.3 Data stream simulation driver

The dimension of space design has been built on a series of static and relative plane design frameworks and platforms, such as two-dimensional plane layout, three-dimensional elevation design, and meeting indicators. Urban design is more stay in the design of two-dimensional layer division, superposition, continuous division, cutting, neither fusion, nor dynamic systematic distribution. In the context of full integration of information technology and daily life, online services and offline services, real world and virtual world, static assets and dynamic assets sharing distribution, physical world has been constantly affected and reconstructed by the new platform mode assisted by information technology. All these changes are due to the faster and faster information flow and the reconstruction of the function and boundary of the real world space brought by technology. Space is no longer a dimension that can be recognized by static thinking. Three dimensional space is full of information flow beyond dimensions. The function of four-dimensional space needs to be continuously reconstructed and challenges the dynamic design transformation of three-dimensional functional space. Our cognition and use of complex data should not only pursue the accumulation of a large amount of data, but also fully understand the pattern behind multidimensional data. Only in this way can we gradually establish a deep understanding of complex data and phenomena, and generate the logic (code) about the analysis model, that is, by observing the abstract model of phenomena and substituting parameters, the algorithm is used to demonstrate and test the possibility of design optimization mechanism space. The programming research of swarm intelligence is based on the swarm algorithm (Boids) developed by Craig Reynolds in 1986. It is a behavior simulation algorithm based on bird Swarm (in order to protect each other from predators and minimize the loss of colony in large-scale migration of birds, fish and other groups of organisms), The form of the group constantly adapts to the external changeable site conditions, It was first widely used in the simulation of cluster behavior in movies and games. The complexity of the algorithm is relatively low. At the same time, it can adjust the parameter variables according to the needs and add new customized functions. Because of the development of game industry and film industry, more algorithms based on biological behavior have been developed, such as "ants behavior", a biological optimization behavior based on adaptive selection strategy, and more complex adaptive decision-making strategy has been introduced. Ant colony has a complete system of social division of labor. Each individual participates in the operation of the whole system, and has the ability of independent individual behavior decision-making. Individual decision-making is fed back to the nearest neighboring individual through the way of pheromone. In this way, the information spreads among individuals and becomes the whole local dynamic information. Through mutual influence and decision-making, the ant colony has the ability to make decisions, to achieve top-down system and bottom-up group decision-making optimization. This kind of continuous research on natural algorithm enables us to call different algorithm programs through the programming software platform, establish our own behavior logic world in the computer algorithm world, and test the decisions we need to verify and make. The observation of the crowd in a specific area of the real world enables us to bring the observed behavior logic into the programming software, select the program library of the relevant algorithm, and modify the algorithm according to the specific situation. Then, with the help of big data, different parameters are introduced to test and demonstrate the site design decision based on the interaction between urban crowd and space site [10].

VI. Conclusion

In a word, in the environment of big data and new technology, the city is gradually changing to digital and intelligent. However, with the increasing number of urban construction projects, only using CAD technology to analyze urban space, the obtained two-dimensional drawings are difficult to meet the needs of urban design, increasing the workload of designers at the same time, the feasibility of design is difficult to guarantee. In this regard, we should actively use big data and new technologies to promote the transformation of urban design spatial analysis methods, from 2D to 3D and 4D, to truly reflect the actual situation of the city and provide a strong basis

for urban design.

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