Research on Key Technologies of City Information Modeling

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Abstract. In order to solve urban development problems and achieve sustainable urban development, building smart cities has become an essential core concept for urban development in the world today. From the perspective of current smart city needs, this article introduces the concept and basic characteristics of CIM, an information technology closely related to smart cities, and analyzes its key technologies BIM (Building Information Modeling), GIS (Geographic Information System), IOT (The Internet of Things), and a brief overview of the relationship between the three, laid a preliminary foundation for further related research.

1. Introduction
According to statistics, as of the end of 2019, the urbanization rate of the permanent population in our country has reached 60.60%, an increase of 1.02 percentage points from the end of the previous year. With the increase in the urbanization rate, solving many problems in the process of urban development has gradually become the focus of attention of the whole society. The emergence of smart cities is to provide a practical solution to urban development problems. Although my country has achieved certain results in the construction of smart cities in recent years, serious problems such as "data islands", "repetitive construction", and "information chimneys" will still occur in the specific process of practice. Therefore, with the development of smart cities, CIM (City Information Modeling), as a tool to realize the intelligence of man-made environments, is the information technology closely related to smart cities, which has received extensive attention.

2. The Concept and Characteristics of City Information Modeling
The City Information Modeling is based on city information data to establish an organic synthesis of a three-dimensional urban spatial model and urban information. It has four main characteristics: multi-dimensionality, visualization, openness, and perceptibility[1].

2.1 Multi-dimensionality
CIM uses a unified data platform to structure and standardize information on various spatial and temporal dimensions of the city. While presenting the information of urban space and geographic level, it also carries the attribute information of urban elements. And the information collected in the database also changes in real time, which can realize the dynamic perception of the analysis object.

2.2 Visualization
Using CIM technology, traditional drawings can be upgraded to multi-dimensional models. The virtual realization of the physical state and spatial geographic information of the building allows people to observe the data directly. And while realizing the visualization of building and geographic information, it also realizes the visualization of the Internet of Things data through digital technology, so that the data collected by the IOT can be connected with the entity.
2.3 Openness

CIM is an information collection that can be shared and requires multi-party cooperation. It can provide data interfaces to other fields and departments, and realize information transfer and open applications between departments and fields within the city.

2.4 Perceptibility

CIM is capable of refined real-time perception of the operating conditions and production and living activities of geospatial physical entities. All Internet of Things data is associated with the urban space to ensure accurate the perception of all analysis objects to facilitate later operation and maintenance.

Compared with traditional digital cities, CIM integrates information in all dimensions of time and space, and can effectively present the status of various facilities such as above ground, underground, indoor and outdoor in the form of digitalization, and fine-tune the granularity of data and information. Every component inside the city's single building has improved the lack of dynamic update and the existence of data islands in traditional digital cities, forming a holographic scene of the city's past, present, and future. Upgrade to a digital twin city that can be dynamically perceived, interconnected, and play a role in the entire process of urban construction management and refined governance through information sharing.

3. The Key Technologies of City Information Modeling

The operation status of each entity in the city and its production and living activities are a complex complex. A smart city needs to be aware of its operating status in time, respond in time when emergencies occur, and predict what may happen in the future. It is far from enough to rely on a single technology to meet the development needs of smart cities. Judging from the current development status, CIM is an organic synthesis integrating IOT (The Internet of Things), GIS (Geographic Information System), BIM (Building Information Modeling) and other technologies.

3.1 The Internet of Things

In the process of data collection, the IOT technology has played an indispensable role. The IOT is an extended application and network extension that is based on the communication network and the Internet technology that recognizes, locates, collects, processes, and transmits item information through sensing devices and communication modules. Based on the information interaction, things are connected and interconnected between things and people. The IOT extracts the underlying data based on the overall network architecture of "perception layer, network layer, platform layer, and application layer", and finally realizes its wide application in multiple fields of urban construction. Among them, the perception layer is to monitor objects through sensors, and return collected information through the communication module; the network layer is mainly responsible for data transmission; the platform layer can integrate the collected data for use; the application layer passes Combine Internet technology with various fields to achieve the ultimate goal of the Internet of Everything. From the collection of information at the perception layer to the application of various fields at the application layer, each layer is a combination of multiple technologies. It can be said that the IOT is a comprehensive application of many high-tech.

3.2 Geographic Information System

GIS is a comprehensive technology integrating computer science, geography, cartography and other disciplines. Collect geospatial data through GPS, drone aerial photography, digital remote sensing and other means, and use a database management system to manage it. And using geographic models and other analysis methods to present real geographic information in three dimensions, which further improves the efficiency of information analysis and provides help for subsequent geographic research and geographic analysis. Simply put, it is a simulation system of realistic geographic spatial relationships.

In the GIS system, users can automatically obtain and store various location-based data, perform spatial information analysis, edit the data on the map, and display it in the form of a three-dimensional scene. GIS plays a leading role in many fields such as urban planning, environmental management,
and resource protection with its mature spatial data management capabilities, intuitive spatial display methods, and powerful spatial analysis functions. It is used to support information management and analysis functions of various applications, helps people observe and analyze data intuitively, can provide auxiliary decision-making for urban construction projects, and provide technical support for the entire process of urban governance and construction.

3.3 Building Information Modeling

BIM is a brand-new work mode and information management technology in construction project management, which can present the engineering information, process and resources in the entire life cycle of a single building from design to demolition. Form an intuitive and shared digital model, and conduct multi-directional and multi-angle interactive collaborative management of the project based on this model. Simply put, it can also be understood as a database containing all the details of the building.

BIM implements virtual realization of the physical state and functional characteristics of buildings through three-dimensional digital technology, so that workers in different stages of engineering design, construction, operation and maintenance, and different types of work can interact and work together. Entering, extracting, updating and modifying information in BIM can effectively improve the efficiency of the entire process of construction projects. It is a basic technology to realize the transformation and upgrading of the construction industry, promote the development of green buildings, improve the information level of the construction industry, and promote the construction of smart cities[2].

4. The Relationship between GIS and BIM

Although both BIM and GIS have information storage functions, the relationship between the two is not a substitute for each other, but a partial and overall relationship. It can also be understood that GIS is an extension of BIM technology within a city.

Before BIM technology was developed by people, urban infrastructures such as buildings were usually represented by a two-dimensional or three-dimensional block [3], which could not show every detail inside the building. All this until the emergence of BIM it was able to replace the rough expressions in the past. Nevertheless, BIM technology still has obvious limitations in the analysis of regional geographic information and the overall display of the surrounding environment of structures [4]. The limitation of BIM in the expansion of buildings to the periphery has prompted its integration with GIS technology. GIS is mainly responsible for describing the information of larger-scale objects outside the facility. It is used for other physical entities except single buildings at the scale of the city or street. The analysis mainly relies on GIS technology. For example, when designing buildings in a crowded urban environment, noise may become a concern for designers. The use of GISs to analyze surrounding buildings and infrastructure can enable designers to have a deeper understanding of building noise sources and take necessary measures in the BIM design process. This design process uses both BIM and GIS data to achieve seamless data integration between BIM and GIS [5].
Similarly, BIM and GIS have mutual information requirements. Before the integration of BIM, the GIS description of the single building itself was not accurate enough to manage the internal structure and engineering volume of the single building. After docking with BIM technology, GIS has also achieved a further improvement from outdoor to indoor and from macro to micro, which has promoted the maturity of GIS.

Generally speaking, BIM is the detailed presentation of the entire life cycle information of the buildings inside the city, while GIS is the storage and analysis of the environmental information outside the building and even the entire community and city. BIM and GIS can complement each other in the spatial field, and the data structure is also related to each other. Every single building in BIM can be regarded as a part of GIS. Every pipe, street lamp and other urban infrastructure in GIS can also be regarded as a component of BIM. The integration of GIS and BIM provides a strong data foundation and technical support when managing areas of different scales such as the interior of buildings, communities, streets, and entire cities. It will bring inestimable value to multiple areas of urban construction. The exchange and combination of BIM information in the micro field and GIS information in the macro field can effectively realize dynamic visual management, which is the general trend of future technology development.

5. The Relationship between BIM and IOT
The relationship between BIM and IOT tends to be upper and lower. BIM technology is responsible for the integration and sharing of underlying data and forms a central model database. The IOT technology extracts building operation data through sensors at the upper level, and reflects the collected information to the local operation center and remote users in real time through the Internet.

The IOT can give full play to its role based on BIM. Without BIM, the application of the IOT will be restricted and cannot penetrate into the interior of the building. For example, after the completion of the project, many components and equipment are in a state of being shielded, and people cannot observe the actual building. Only through the BIM model can the information of the building site facilities be visually displayed. BIM allows people to observe the properties and status of each component and equipment, so as to make maintenance plans later. BIM is the basic data model for IOT applications and the core and soul of the IOT. IOT applications cannot be separated from BIM.

Also in the implementation of construction projects, inconsistencies between the actual situation and the data model expression occur from time to time. Equipment, components, facilities, etc. may change at any time, and BIM cannot capture the status information of these objects in real time.
Therefore, in order to realize the dynamic link between physical entities and virtual data, the IOT technology must be combined to build a communication bridge between the real environment and the virtual model. Realize the timely perception and dynamic monitoring of the changed object status, and improve the comprehensiveness of the BIM model.

Only BIM without the IOT, information collection is not timely enough; only the IOT without BIM, information processing is inconvenient and the information is relatively scattered, unable to form a whole. The integration of BIM and IOT technology can link the virtual in the design phase with the actual conditions in the construction and operation and maintenance phases, so that the integration between the virtual information and the physical environment in the whole construction process can be guaranteed. The combination of BIM and the IOT has promoted smart cities to a new level and is an important link in the development of informatization of the construction industry in the future.

6. The Relationship between IOT and GIS

Before the integration of GIS technology, although the IOT sensors can collect a large amount of data information, it is still unable to make full use of it. The reason is the lack of a city-level spatial information analysis platform. The data collected by IOT sensors needs to be combined with corresponding spatial background information to become more intuitive and valuable. For example, the precise geographic location of the data collection object, the specific time, the prescription requirements, the mutual influence and the law of change and development. And GIS provides such a visual geographic information management platform that can perform spatial positioning and spatial analysis. The combination of the two makes it easier for the IOT to analyze geographic space and attribute information, and further strengthen the information management capabilities of IOT applications. And it can effectively improve the ability of data analysis, and use digitization for systematic and holistic analysis and decision-making to replace the previous experience.

The data sources collected by the IOT are diversified, the scale and structure are extremely complex, and the norms and standards are not uniform. There are also fuzzy data in non-metric spaces, and various multimedia spatial and non-spatial data such as text, image, audio and video[9], but what people can observe more intuitively and are more willing to accept is graphic information. Therefore, the IOT needs to combine the technology of GIS spatial data visualization technology to be able to present the collected digital information to people more intuitively. The combination of the two allows the data processing and analysis results to be visualized, which is convenient for people to observe the simulation and calculation process.

GIS makes the application of the IOT more extensive, more accurate, more intuitive and easy to use. Conversely, the emergence of the IOT has also brought great development opportunities to GIS. The IOT provides a new data collection method for GIS, broadens the channels and scope of information acquisition, and makes the scope of GIS application wider and more thorough research. In this sense, the IOT and GIS are a complementary relationship, and the comprehensive application of the two is an inevitable choice.

7. Summary

The realization of the smart construction and management of the city requires the coordination and integration of multiple technologies, a more comprehensive, more flexible, and more efficient organic combination of all levels of city construction to achieve the development of smart cities. From the above analysis of the key technologies of the city information model, it can be seen that the city information model is based on the integration of data at various spatial scales, while paying attention to the access and calculation of massive real-time big data from the IOT. Its key technologies BIM, IOT and GIS all play a role in the construction of smart cities with their unique advantages, and the three are closely related and interdependent. As an emerging information technology, CIM's integration of key technologies organically integrates the micro and macro, static and dynamic information of the city, laying a good foundation for the construction of smart cities, and it will bring to city management in the future Incalculable value. In the future construction of smart cities, the use of CIM technology to achieve accurate analysis and efficient management of city information is an inevitable trend of development.
8. References

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