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Research on Digitalization of Non-Exposed Space

Luzhou Lin[1], Cai Jia[2*]

[1]Academy of Regional and Global Governance, Beijing Foreign Studies University, Beijing 100089, China,linluzhou@bfsu.edu.cn

[2]School of Geography and Tourism, Anhui Normal University, Huajin Campus, South 189 Jiuhua Rd, Wuhu 241002, China,515769131@qq.com

[*]Corresponding author,E-mail:515769131@qq.com

Abstract

Non-exposed space is defined relative to exposed space, and mostly refers to indoor or semi-indoor scenes, such as urban rail transit, tunnels, coal mines, factories, shopping malls, hospitals, etc. Navigation and location information are closely related to human production and life. No matter in exposed or non-exposed spaces, it is increasingly urgent to obtain location information of mobile terminals quickly and accurately and to provide navigation and location services. Therefore, it is necessary to use the spatial digital technology to complete the three-dimensional visualization modeling of the spatial structure, buildings and facilities of the non-exposed space using a unified spatial coordinate system and BIM technology, so as to realize the spatio-temporal integration of the non-exposed space and the exposed space. Data twinning and structural perspective, complete the smooth transition of business applications in the two spaces, and enhance people's sense of comfort and security in non-exposed spaces. This paper will build the structure of the digitalization of non-exposed spaces, discuss the key technologies, and analyze people's needs for non-exposed spaces..

Keywords: Non-Exposed Space, Space Digitalization, Digital twinning

1.Introduction

People switch between exposed and non-exposed spaces in their daily lives. Therefore, open space and non-exposed space are all about people's living space. With the rapid development of urban construction, underground spaces or non-exposed spaces on the ground, buildings or facilities are becoming more and more complex. In the non-exposed space, accurate positioning signals are difficult to obtain, and the road topology information of the electronic map is very imperfect, which makes the navigation guidance of the navigation electronic map difficult, and the space asset management is not easy to carry out, which makes the work and life in the non-exposed space very inconvenient. The difficulty of the dynamic service of the spatial location of the non-exposed space is like a wall, blocking the rapid expansion of people's extensive production and living activities. Therefore, it is of great significance to study how to "transparent" non-exposed space, break the BIM independent system of building units, form a continuous location service in time and space, and improve the utilization efficiency and effectiveness of non-exposed space.

2.Digitalization of Unexposed Space

The non-exposed space is defined relative to the exposed space. The exposed space is what we often call the open space outside the room, while the exposed space refers to indoor or semi-indoor scenes. To be more precise, the area that can communicate with navigation satellites is regarded as exposed space, and the others are regarded as non-exposed space. The digitalization of non-exposed spaces refers to the use of spatial digital technology to transform the spatial structure, buildings and facilities information of non-exposed spaces into a unified time system, a unified spatial coordinate system, a unified BIM technology, and a unified Internet of Things data. Transmission protocol and unified broadband transmission technology, complete 3D visualization modeling, realize spatiotemporal integration, data twinning, display visualization, and structural perspective of non- exposed space and exposed space, and complete the smooth transition of business applications in the two spaces, to enhance people's sense of comfort and security in non- exposed spaces. Quickly and easily guide people to a safe area in case of special circumstances.

In actual business application scenarios, the three- dimensional space display capability of virtual reality is used, the BIM model is used as the carrier, the real-time operation data of the Internet of Things is integrated, and all kinds of fragmented, scattered and fragmented information data, including non-exposed space The basic structure of the building itself is integrated. Information, fire protection, strong and weak electricity, HVAC, water supply, drainage, sewage, security, energy, facilities and equipment, assets, hidden works, roads, elevators, gathering areas, etc., are further introduced into the daily operation and maintenance management functions of non-exposed spaces , created a virtual reality non-exposed space and equipment operation and maintenance management based on BIM model. At the same time, it also provides the three-dimensional spatial location of traffic, facilities, equipment, and pipelines, quickly locates faults, and shortens the maintenance cycle; intuitive and comprehensive information records are used for the whole process management of building operation and maintenance, creating functions such as statistics, analysis, and data mining. condition.

In people's life scenes, people can know their precise location anytime and anywhere through indoor positioning technology and auxiliary display devices, rely on 3D BIM maps for road navigation and discover surrounding points of interest information, which provides people with comfort in non- exposed spaces. Life, shopping, transportation provide a good foundation.

Specifically, the digitalization of non-exposed spaces means that people can achieve precise positioning and virtual reality environment display through smart terminals at any time and anywhere, and achieve smooth display with exposed spaces. Through the digitalization platform, "Where am I?", "What am I interested in?", "How do I go to my destination?", "How do I escape?", "The space for my assets What is the location and status?", "I want customer service communication" and other functions related to time and space related to the life and work of people and companies, allowing people to experience the same comfort in non- exposed spaces as in exposed spaces.

3.Digitalization for Non-Exposed Spaces

The digitalization system for non-exposed space is shown in Figure 1, it consists of the following seven layers:

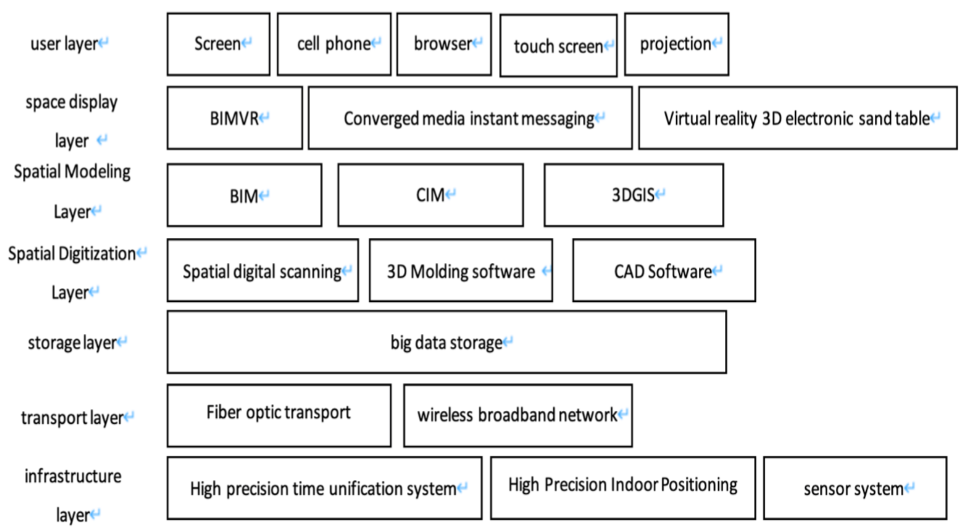

Figure 1. The digitalization system of non-exposed space

● infrastructure layer. The infrastructure layer mainly provides a unified space-time reference platform for the non- exposed space, and at the same time completes the access of various sensors.

● transport layer. The transport layer completes the transmission of data information, including internal data transmission and external data sharing.

● storage layer. The storage layer completes the storage and operation of massive big data.

● Spatial digitization layer. The spatial digitization layer completes the digital processing of non-exposed spaces, and realizes the digitization of spatial entities, environments and resources mainly through spatial digital scanning, CAD architectural software and 3D modeling software.

● Spatial modeling layer. The spatial modeling layer realizes the integration of BIM, CIM and 3DGIS, constructs a twin space that is realistic with the real environment, and quantitatively visualizes the attributes and relationships of various entities in the space.

● Space display layer. The space display layer uses the instant communication of fusion media as a link, and displays the non-exposed space realistically through BIMVR and virtual reality 3D electronic sand table, and completes the human-computer interaction at the same time.

● user layer. The user layer realizes the positioning and environmental display of non-exposed spaces on various smart devices, and at the same time realizes information interaction and special information in the form of acousto- optical prompts.

4.The Significance of Digitalization for Non-Exposed Spaces

With the continuous development of the social economy, people's life and work are carried out in non-exposed spaces for more than 60% of the time every day. The open space has many familiar reference objects to judge its own position and environmental characteristics, which can make people feel a sense of authenticity and security. In the non- exposed space, due to the relatively closed space, there is a lack of surrounding environment that can be referenced and positioned, which often makes people feel nervous and insecure, which can easily lead to loss of direction and cause certain problems for people's work, life and travel. difficulty. In the event of a special situation, how to escape in an emergency is a major problem that needs to be solved in non-exposed spaces. These situations are especially evident in non-exposed spaces such as urban rail transit, tunnels, coal mines, factories, shopping malls, and hospitals.

The establishment of a digitalization platform for non- exposed spaces has the following meanings:

● Show the real physical space harmoniously and con- tinuously with CIM, and solve the "jumping" problem when the space is switched between different systems.

● Realize the seamless connection between outdoor navigation and indoor navigation, and realize the smooth connection of indoor and outdoor path guidance.

● Realize fast and rapid escape guidance in emergency situations, which greatly enhances people's sense of security and improves the success rate of rescue.

● Provide undifferentiated space and time base for the life and work of ordinary users.

● Rapid positioning and traceability of asset management to achieve visual and maintainable asset management.

5.Digitalization Requirements for Non-Exposed Spaces

5.1. Unification of Time

The time of the exposed space and the non-exposed space must be unified and the precision is high enough to ensure the continuity of people's sense of time when switching between the two spaces. For example, the time of the subway system and the time of the public bus system can be unified to ensure people's efficient transfer and travel, so as to achieve the goal of saving time and improving the quality of life.

5.2. Unification of Space Coordinates

At present, due to the difficulty of introducing standard positioning information in non-exposed spaces, independent relative positioning methods are mostly used to build BIM systems, which leads to inconsistencies with the coordinates of exposed spaces, making the built BIM system and the exposed space GIS system unable to fit well. The spatial structure and the road cannot be connected continuously, which brings great inconvenience to people's use of electronic map for orientation identification. Therefore, the spatial coordinate system of the non-exposed space and the spatial coordinate system of the exposed space use the same standard.

5.3. Unification of Positioning Standards

With the development of smart cities and new infrastructure, the need for accurate positioning technology is more urgent. It can be said that non-exposed spatial positioning is the bottleneck that restricts the development of the entire smart city.

From the perspective of the national market application, the non-exposed spatial positioning technology is still in a very early incubation stage, and there are many difficulties:

● Accuracy requirements. The non-exposed space environment is complex and changeable, there are more devices involved in positioning, and people's requirements for positioning accuracy are much higher than those in outdoor areas, especially in some industries involving high- speed mobile device positioning, which have more stringent requirements for accuracy and positioning delay. .

● Construction and deployment are difficult. The non- exposed spatial positioning network needs to be deployed separately at a relatively close distance, and requires a lot of communication and post-construction work. In addition, the privacy structure of the indoor space also greatly increases the workload of the mesh.

● The positioning platform is not unified. Since the non- exposed spatial positioning has just started, the standards are not mature and unified, and the fragmented application scenarios increase the cost of updating dimensions. From a technical point of view, it is not that the current technology cannot solve it, but the cost is too high. In terms of technology, there are many mature non-exposed spatial positioning technologies: 5G, 4G, Bluetooth 4.2, Bluetooth 5.1, Wi-Fi, UWB and vSLAM, as well as RFID, Li-Fi and millimeter-wave base stations that are under discussion. These different positioning methods have different requirements for positioning environment, positioning algorithm, positioning accuracy and positioning communication protocol. Different positioning systems are difficult to interconnect and interoperate, resulting in fragmentation of the positioning system in the exposed space, which cannot be well and complete. It provides common positioning specifications for business scenarios.

5.4. Unification of BIM Data Exchange Standards

Non-exposed spaces rely more on BIM systems for spatial modeling, and form basic electronic maps on the basis of these spatial models. The producers of BIM systems and the publishers of basic electronic maps are often different spatial data producers, resulting in A large number of BIM cannot be used by electronic map manufacturers, nor can it fit well with the building map projection obtained through remote sensing information, resulting in a lot of waste of resources. Therefore, it is necessary to improve the effective use of BIM data by formulating BIM map data exchange standards.

5.5 Unification of Digital Scanning Processing Technology in Non-exposed Space

The spatial digitization of non-exposed spaces is mainly carried out in two ways, one is through the CAD drawing of architectural design, and the other is through the camera +laser point cloud to carry out the spatial dataization. However, different companies use different software systems and different resolutions of spatial data scanning, resulting in inconvenient, unsightly, and uneven accuracy of spatial data- based results in non-exposed spaces, which cannot provide users with a good experience.

6.Digitalization Technology for Non-Exposed Spaces

6.1. Time Synchronization

Countries around the world establish and maintain their own time systems with atomic clocks with excellent performance. GPS time is a time base in the United States, GLONASS is a time base in Russia, and Beijing time is the main time base in my country. The time bases of countries can be compared with each other through Coordinated Universal Time (UTC). The time unification system is composed of a time system center and a number of time distribution centers, and its equipment is composed of radio receivers, atomic frequency standards, standard signal generators and amplification and distribution equipment. The receiver receives the standard time and standard frequency signals broadcast by the National Astronomical

Observatory, so that each time system is synchronized with the standard time and standard frequency. The frequency standard source generates an accurate and stable reference signal, which is sent to the signal and time generator. After frequency division and synthesis, various frequency standard signals, sampling signals, control signals and time codes are formed. Wired cables to user equipment in non-exposed spaces. The distance between the user equipment and the time system center is different, and the time delay of the time system signal reaching each device is also different. When precise synchronization is required, the transmission delay of these signals must be measured and corrected in the data processing process.

Ethernet technology has been widely used in telecom-level networks due to its openness, low price, and ease of use. Ethernet technology is "plug and play", that is, connecting Ethernet terminals to IP networks. You can use the services it provides at any time. However, only a "synchronized" IP network is a true carrier-class network, which can provide guarantee for the multiple-play services that the IP network transmits various real-time services and data services. At present, carrier-class networks have very strict requirements for time synchronization. For a city-wide IP network, the backbone network delay is generally required to be controlled within 1ms. The current Internet time protocol NTP (Network Time Protocol), simple network time Protocols such as Simple Network Time Protocol (SNTP) cannot achieve the required synchronization accuracy or convergence speed. The IEEE 1588 standard is particularly suitable for Ethernet, and can achieve microsecond-level high-precision clock synchronization in a geographically dispersed IP network. The full name of the IEEE1588 standard is "IEEE 1588 Precision Clock Synchronization Protocol for Network Measurement and Control Systems", referred to as PTP (Precision Timing Protocol). The clocks of all nodes are calibrated and synchronized, so that the Ethernet-based distributed system can achieve precise synchronization. The accuracy of synchronization is closely related to timestamp and time information. The pure software solution can achieve the precision of milliseconds, and the combination of software and hardware can achieve the precision of microseconds.

The current version of IEEE 1588 is v2.2, which is mainly used in relatively localized and networked systems. The internal components are relatively stable. The advantage is that the standard is very representative and open. Because of its openness, it is especially suitable for the Ethernet network environment. Compared with other synchronization protocols commonly used in Ethernet TCP/IP networks such as SNTP or NTP, the main difference is that PTP is designed for a more stable and secure network environment, so it is simpler and occupies less network and computing resources. . The NTP protocol is a time synchronization protocol for various independent systems widely dispersed on the Internet. GPS (Satellite-based Global Positioning System) is also aimed at widely dispersed and independent systems. The network structure defined by PTP can achieve high precision, and PTP can achieve precision within microseconds. In addition, the modular design of PTP also makes it easy to adapt to low-end devices.

The precise network synchronization protocol defined by the IEEE1588 standard realizes a high degree of synchronization in the network, so that no special synchronization communication is required when assigning control work, thus achieving the effect of separating the communication time mode from the application program execution time mode. Judging from the current technical level, the best choice for the time system system of non-exposed space is to choose the PTP technology system.

6.2. Positioning Technology

Commonly used positioning methods in non-exposed spaces are: WI-FI positioning, Bluetooth positioning, RFID positioning, ZigBee positioning and ultra-wideband (UWB) technology. The characteristics of these technologies are compared as follows:

As can be seen from the Table 1, UWB technology has obvious advantages:

Table 1. Comparison of Unexposed Spatial Positioning Techniques

Positioning Technology	UWB	Bluetooth	Wi-Fi	ZigBee
IEEE specification	802.15.3a	802.15.1	802.11a/b/g	802.15.4
Maximum signal speed	110Mb/s	1Mb/s	54Mb/s	250Kb/s
Transmission distance range	10m	10m	100m	10-100m
Coding efficiency in ideal environment	97.84	94.41	97.18	76.52
Positioning accuracy	0.1-0.25m	3-5m	3-10m	5-10m
Security	Excellent	Good	Good	/
Penetration	Strong	Weak	Strong	/
Anti-interference	Strong	Weak	Medium Strong	/
Power consumption	Low	Medium low	High	/
Radiation	Low	Medium low	Medium high	/
Locate the farthest distance	200m	10m	30-50m	100/m
construction cost	Medium	High	High	/

● High positioning accuracy

The positioning accuracy of WB is higher and can reach centimeter level. Bandwidth determines the resolution (proportional relationship) of signal distance. The bandwidth of UWB is very wide, which brings an advantage to UWB systems, that is, it can be higher than other traditional systems in distance resolution, and the resolution accuracy is more than 100 times that of traditional systems under certain conditions. The broadband of the UWB pulse signal is in the nanosecond range, and the positioning accuracy is usually less than a few centimeters.

● High security

The transmission power of UWB is low, and the signal can be well concealed in other types of signals and environmental noise. The traditional receiver cannot recognize and receive, and must use the spread spectrum code pulse sequence consistent with the transmitter to perform demodulation. The system has Strong system security.

● Strong system stability and anti-interference ability

From the perspective of radio frequency mechanism, the anti-interference ability of the pulse wave emitted by UWB is stronger than that of continuous electromagnetic waves, and the frequency band of UWB operation is 3GHz-10GHz. Compared with the wireless positioning technology in the 2.4G frequency band, the external interference signal is also much less.

● High transmission rate

Channel capacity is proportional to bandwidth. UWB has wider bandwidth and higher transmission rate, up to 1000Mbps or more.

● Low power consumption

Ultra-wideband radios have RF bandwidths above 1 GHz and require very low average power to transmit. Especially in short-distance communication applications, the transmit power of UWB transmitters is generally lower than 1mW; the lower transmit power can prolong the working time of the system, and the transmit power is low, and the electromagnetic wave radiation to the human body is also small.

● Very wide bandwidth

Have more than 500MHz bandwidth.

● Low cost

The project is simple and cheap.

Therefore, UWB is the first choice for positioning technology in non-exposed spaces.In the future, doing a good job of navigation and positioning into more non-exposed space scenes can effectively promote the all-round construction of the Beidou space-time system and realize the construction of smart cities.

6.3 Spatial Digital Scanning

3D Laser Scanning Technology (3D Laser Scanning Technology) is a high-tech emerging in the mid-1990s and a new breakthrough in surveying and mapping technology after GPS. It uses the principle of laser ranging, by recording the three-dimensional coordinates, reflectivity, texture and other information of a large number of dense points on the surface of the measured object, and quickly reproduces the three-dimensional model of the measured object and various graphic data such as line and surface. Therefore, Also known as “Reality Reproduction Technology”.

3D laser scanning technology is a direct, fast and accurate way to obtain spatial data of objects, which has many advantages. 3D laser scanning technology can provide object point cloud data and structural information, and realize efficient and accurate monitoring of non-exposed spaces from different spatial scales. Terrestrial Laser Scanning (TLS) provides a new efficient and accurate 3D data source. Large- scale acquisition of 3D points. Use TLS to obtain point cloud data, and use corresponding software to extract the basic parameters of the measured object.

At present, the most advanced technology is: using lidar + 3D vision algorithm, combined with Internet 3D rendering technology, to quickly and cost-effectively complete 3D digitization of space, and apply the digitized space model to multiple ports such as PC and mobile. The device is designed with an integrated body, capable of shooting high-definition graphics, accurately collecting point cloud data, with a spatial accuracy of centimeters, fully adapting to a variety of complex indoor environments, and capable of high-precision scanning of indoor and outdoor large space scenes Through the supporting software, digital results of non-exposed spaces can be quickly generated. Its characteristics are as follows:

● With excellent color details, the as-built data can be obtained safely and quickly;

● Provides reliable and realistic visualization, even in extreme light conditions;

● Simplify various measurement tasks by integrating scanning and imaging workflows, even in challenging environments;

● It can be operated by one person, improving on-site efficiency.

Generally, the indicators of large space 3D scanners should not be lower than the following parameters:

● Scanning distance: 0.6-350 meters

● Measurement speed (pts/sec): 2,000/244,000/488,000/976,000

● Ranging error: ±1mm

● Resolution: no less than 165 million pixels, color

● High Dynamic Range (HDR): Exposure 2x, 3x, 5x;

● Parallax: coaxial design, no parallax.

6.4 BIM

BIM is a process of analyzing, simulating, visualizing, constructing drawings, and engineering quantity statistics of buildings in various stages of design, construction, operation and maintenance using the information in the digital model of the building. Therefore, BIM is a process of creating, collecting, managing, and applying information.

The so-called BIM model (or virtual model, digital model), its core is not the model itself (geometric information, visualization information), but the professional information stored in it (architecture, structure, electromechanical, thermal, acoustic, material, price , procurement, specifications, standards, etc.).

The current role of BIM in non-exposed spaces is:

● BIM model maintenance

Refers to the establishment and maintenance of BIM models according to the project construction progress, the use of the BIM platform to summarize all the construction engineering information of each project team, to eliminate the information islands in the project, and to organize and store the obtained information in combination with the 3D model for the whole process of the project. All stakeholders of the project can share it at any time.

● Visual management

The emergence of BIM enables users not only to have 3D visual design tools, what you see is what you get, but more importantly, through the improvement of tools, users can use 3D thinking to complete various changes in the life cycle of buildings. , and also enables owners and end users to truly get rid of the restrictions of technical barriers and know what their investment can get at any time.

● Pipeline synthesis

With the increase in the scale of buildings and the complexity of the functions used, the requirements for the integration of electromechanical pipelines by design companies, construction companies and even owners are becoming more and more intense. Using BIM technology, by building various professional BIM models, users can easily find the collision and conflict in the design in a virtual three- dimensional environment, thereby greatly improving the comprehensive design ability and work efficiency of pipelines. This can not only eliminate collisions and conflicts that may be encountered in the construction process of the project in a timely manner, but also significantly reduce the resulting change application forms, greatly improve the production efficiency of the construction site, and reduce the cost increase and construction delay caused by construction coordination.

● Construction progress simulation

Building construction is a highly dynamic process, and as construction projects continue to expand in scale and complexity, construction project management becomes extremely complex.

By linking BIM with the construction schedule, integrating spatial information and time information into a visual 4D (3D+Time) model, the entire construction process of the building can be reflected intuitively and accurately. 4D construction simulation technology can reasonably formulate construction plans, accurately grasp the construction progress, optimize the use of construction resources and scientifically arrange the site during the project construction process. , reduce costs and improve quality.

● As-built model delivery

A building as a system, when the construction process is completed and ready to be put into use, first needs to be tested and adjusted as necessary to ensure that it can operate as originally designed. In the handover link after the completion of the project, the property management department needs to obtain not only the conventional design drawings and as- built drawings, but also the documents and materials related to operation and maintenance such as the actual equipment status, material installation and usage, etc. that can be correctly reflected.

BIM can organically integrate building spatial information and equipment parameter information, thereby providing a way for owners to obtain complete building global information. Through the association between BIM and the recorded information of the construction process, it is even possible to realize the integration of completion information including hidden engineering data, which not only brings convenience to the subsequent property management, but also can be used for the owner and the owner in the process of future renovation, reconstruction and expansion. The project team provides valid historical information.

● Maintenance plan

During the service life of the building, the building structure facilities (such as walls, floors, roofs, etc.) and equipment facilities (such as equipment, pipes, etc.) need to be continuously maintained. A successful maintenance program will improve building performance, reduce energy consumption and repair costs, and in turn reduce overall maintenance costs.

The BIM model combined with the operation and maintenance management system can give full play to the advantages of spatial positioning and data recording, reasonably formulate maintenance plans, and assign special personnel to special maintenance work, so as to reduce the probability of emergencies during the use of buildings. For some important equipment, the history of maintenance work can also be tracked, so that the applicable status of the equipment can be judged in advance.

● Asset management

An orderly asset management system will effectively improve the management level of building assets or facilities. However, due to the separation of information between building construction and operation, these asset information needs to be entered by a large number of manual operations in the early stage of operation, and data is prone to appear. Entry error.

A large amount of building information contained in BIM can be smoothly imported into the asset management system, which greatly reduces the time and manpower investment in data preparation for system initialization. In addition, since the traditional asset management system itself cannot accurately locate the asset location, the asset tag chip of BIM combined with RFID can also make the location of the asset in the building and related parameter information clear at a glance.

● Space management

Space management is the management of building space in order to save space cost, effectively use space, and provide a good working and living environment for end users. BIM can not only be used to effectively manage resources such as building facilities and assets, but also help management teams to record space usage, handle end-user requests for space changes, analyze existing space usage, allocate building space reasonably, and ensure that space is properly managed. maximum utilization of resources.

● Disaster emergency simulation

Using BIM and corresponding disaster analysis and simulation software, it is possible to simulate the process of disasters before the occurrence of disasters, analyze the causes of disasters, formulate measures to avoid disasters, and emergency plans for evacuation and rescue support after disasters occur.

When a disaster occurs, the BIM model can provide rescuers with complete information about the emergency situation. Combined with the timely acquisition of building and equipment status information through the building automation system, the BIM model can clearly show the location of the emergency situation inside the building and even find the most suitable route to the point of emergency to improve the effectiveness of emergency operations.

The use of BIM determines the accuracy of the details of the BIM model. According to the current BIM standard, the model accuracy should not be lower than LOD300.

The most widely used BIM software today is Revit. Revit can export data models to various intermediate exchange formats. The data in these intermediate formats can be directly imported into 3D GIS software to realize the data integration of non-exposed space and exposed space.

6.5 CIM

City Information Modeling (CIM) is based on technologies such as Building Information Modeling (BIM), Geographic Information System (GIS), Internet of Things (IoT), and integrates urban above-ground and underground, indoor and outdoor, historical status and future multi-dimensional and multi-scale information model data and data. City perception data, to build a three-dimensional digital space urban information organic complex.

In the non-exposed space digitalization technology system, CIM plays the role of smooth data connection and seamless visual operation and display between non-exposed space and exposed space.

The CIM basic platform is a basic platform for establishing three-dimensional digital models of buildings and infrastructures on the basis of urban basic geographic information, expressing and managing three-dimensional urban space, and a basic operating platform for urban planning, construction, management, and operation. It is the basic, critical and physical information infrastructure of smart cities.

In terms of scope, it is an organic combination of GIS data of large scenes + BIM data of small scenes + Internet of Things. Compared with the traditional GIS-based digital city, CIM refines the data granularity to an electromechanical component and a door inside a single city building, and upgrades the traditional static digital city to a perceptible, dynamic online, virtual-real interactive one. A digital twin city provides a data foundation for agile city management and refined governance.

CIM requirements:

- Hasanopenarchitecture
- Strong multi-source data storage and management capabilities
- Excellentmassdatacarryingandschedulingcapabilities
- Excellent 3D rendering engine
- Multidimensional information fusion and visualization
- Good scalability and rich application functions
- Excellent cross-platform and network portability
- Sufficientstabilityandgoodcompatibility

Commonly used CIM software in China are: Tsinghua CityMaker, SuperMap, Terry Skyline, and some platforms that can provide special capabilities.

6.6 BIMVR

BIMVR (Building Information Modeling in Virtual Reality) is a technical means that combines BIM (Building Information Modeling) and VR (Virtual Reality).

VR virtual reality technology is an important direction of simulation technology. It is a collection of simulation technology and computer graphics human-machine interface technology, multimedia technology, sensing technology, network technology and other technologies. It is a challenging cross-technology frontier. disciplines and fields of study. It can bring users the most realistic visual and even tactile experience. Immersion, interactivity and conception are the three major characteristics of virtual reality technology. Users experience various scenes in virtual space through hardware devices, and through Visual, auditory, tactile and other 8 sensory systems for realistic experience.

For BIM technology, it is an inevitable trend to combine various new technical means, whether it is BIM and VR, BIM and big data, BIM and artificial intelligence, and even BIM and block chain may bring extreme benefits to the engineering industry. big development.

Now design and modeling software can make very real BIM building information models before construction, but the current visual 3D model has great limitations, and most of what it brings to users is look and feel. Combining BIM and VR technology allows users not only to see the model, but also to go deep into it and be immersed in it. Through a 1:1 virtual reality environment, they can truly feel in the model. With the development of VR technology, BIMVR can also allow the experiencer to touch this model. The VR immersive experience strengthens the figurative and interactive functions, and greatly improves the BIM application effect, which can make the digitalization of non-exposed spaces reach a higher and better realm.

At present, the commonly used BIMVR software includes Yida VRBIM, Fuzor, Storyboard VR, Smart-Reality and so on.

6.7 Sensors

Collect and transmit the relevant operation and maintenance data of buildings/facility/equipment through the Internet of Things and sensor technology, and display the data collected by the sensor through the BIM visualization feature, so that the collected data is more intuitively reflected in the model, and the data generation can be viewed in real time. position and relative spatial relationship. It is also possible to reprocess the data collected by the sensor through other settings. For example, if a certain threshold is exceeded, the point will flash an alarm to prompt the management to cause an alarm or perform related processing. Combining sensor technology with BIM can realize the linkage between building operation and maintenance data and BIM model, and provide a 3D visualization platform for building operation and maintenance.

Sensors are an indispensable technical means to realize the digitalization of non-exposed spaces.

6.8 Fiber Optic Transport Network

Optical fiber transmission, that is, data and signal transmission using optical fiber as a medium. Optical fibers can not only be used to transmit analog and digital signals, but also meet the needs of video transmission. Optical fiber transmission is generally carried out using optical cables. The data transmission rate of a single optical fiber can reach several Gbps, and the transmission distance can reach tens of kilometers without using repeaters.

There are several advantages to fiber optic transmission. Compared with the rate of 1.54MHZ per second of copper wire, the operating rate of optical fiber network reaches 2.5GB per second. From the bandwidth point of view, the big advantage is that the optical fiber has a large information capacity, which means that a small size cable can be used, and there is no need to update or enhance the signal in the transmission cable in the future. Fiber optic cables have a high resistance to electromagnetic noise such as radios, motors, or other adjacent cables, making them immune to electrical noise. From the perspective of long-term maintenance, the final maintenance cost of the optical cable will be very low. Optical fibers use light pulses to transmit information along optical lines instead of using electrical pulses to transmit information along cables. Optical fiber transmission has the advantages of low attenuation, wide frequency bandwidth, strong anti-interference, high safety performance, small size and light weight, so it has incomparable advantages in long- distance transmission and special environments. Optical fiber as the transmission medium of optical signal has the characteristics of low loss, the frequency band of optical fiber can reach more than 1.0GHz, the bandwidth of general image is only 8MHz, the image of one channel is more than enough to transmit with one core optical fiber, and it is more than enough to transmit voice, control signal or contact signal. more advantageous. The carrier wave in optical fiber transmission is light wave, and light wave is electromagnetic wave with extremely high frequency, which is far higher than the frequency used in radio wave communication, so it is not disturbed. In addition, the glass material used in the optical fiber is non-conductive and will not generate sparks due to circuit breakage, lightning strikes, etc., so it is highly safe and is especially suitable for flammable, explosive and other occasions.

In the non-exposed space, optical fiber transmission will be the core network of the entire information transmission system.

6.9 Big Data Storage

To build a city information model (CIM) and non-exposed space BIM, it is necessary to efficiently load, browse and apply massive CIM/BIM data, aggregate 2D data, BIM models, oblique photography, white model data, and video and other IoT data to achieve historical The visual display of the integration of status quo planning, integration of ground and underground, integration of indoor and outdoor, integration of 2D and 3D, and 3D video integration provides basic functions such as evacuation simulation, progress simulation, virtual roaming, model management and service API, and builds the data brain of smart cities.

Manage all kinds of data, models, drawings and complete digital projects involved in the CIM platform. The database replaces the model as the information carrier, and realizes the aggregation, processing, storage, management, governance and exchange of engineering data in the whole life cycle. Through the application of system software, the tight integration of information, data and business is realized.

The technology used for big data storage is relatively mature at present, and there are many options, which will not be repeated here.

6.10 Converged Media Instant Messaging

A converged media instant communication system that supports text, voice and video, provides early warning, alarm, notification, announcement and other services for applications and people in non-exposed spaces, and terminals can be accessed through UWB or wifi or 5G/4G communication links , to provide quick communication channels for various customer service in non-exposed spaces.

In the non-exposed space, various types of customer service systems are the basic means to ensure the digitalization of the non-exposed space. It creates a virtual open space and enhances the comfort of people in the non-exposed space. The open instant messaging system of convergent media realizes the rapid and extensive transmission of early warning, alarm and real-time video information, and provides various service interfaces to third-party service systems to realize the interaction between systems and ensure the timeliness of customers or maintenance services.

6.11 Virtual Reality 3D Electronic Sand Table

The virtual reality 3D electronic sand table system is based on basic geographic information data, model data, attribute data, and graphic data, and is a system established by various 3D simulation methods. Data is the basis of the entire system. The basic geospatial information database includes the main scale topographic map (DLG), orthophoto map (DOM), raster map data (DRG), digital elevation model (DEM) data, BIM data and other basic geospatial data.

The virtual reality 3D electronic sand table is widely used in urban planning, military exercises, engineering design, agricultural planning, environmental management and other fields, providing convenient and fast measurement functions. Distance measurement, area measurement, height measurement, model distance measurement, etc.

The electronic sand table established by integrating remote sensing, geographic information system and 3D simulation technology has the following functions:

● The terrain information is accurate

Using the national standard topographic map to establish a digital ground model, it can accurately restore the landform form in proportion, and can also accurately restore the building/facility form of the unshielded space.

● Feature representation in detail

Realistically reflect the same surface morphology as the field, and information such as rivers, vegetation, roads, and residential areas is clear at a glance.

● Intuitive performance of ground objects

The color of satellite remote sensing images, through reasonable band combination and time phase selection, can simulate the scene on the spot, as if you were there.

● Easy to browse

In the three-dimensional electronic sand table, you can zoom and roam arbitrarily, simulate flight, and conduct all-round observation and analysis of the target;

● Terrain information retrieval

You can query the geographic coordinates and altitude of any place.

● Terrain analysis and calculation

The calculation of distance, area and volume can be carried out on it, as well as analysis of visibility, section and submergence.

● Simulation

Fire field, explosion, etc. can be simulated at any position above, and route selection and planning can be performed.

● Three-dimensional ground facilities

The building and other infrastructure are displayed in three dimensions.

● Attribute query

Various information can be directly inquired on the three- dimensional electronic sand table.

● Integrated GPS system

Realize tracking and scheduling directly on the three- dimensional electronic sand table.

In short, through the use of virtual reality three-dimensional electronic sand table, the non-exposed space will be completely transparent.

7.Conclusions

By discussing the use of various technologies in non-exposed space to realize its visualization, perceptibility, tactility and immersive experience, this paper makes the transition between non-exposed space and exposed space smooth in time, space and psychology. This paper builds a complete set of digitalization technology system for non-exposed space, and discusses the key technologies.

Non-exposed space is an emerging new field, and it is also the only way for the construction and development of new cities. Make good use of non-exposed space to provide better convenience and services for people's lives, comprehensive use of various technologies, and greater Explore space.

Conflicts of Interest

The author declares that there is no conflict of interest regarding the publication of this article.

Author Contributions

Conceptualization: Cai JIA; Writing: Luzhou LIN; Supervision: Cai JIA; Funding acquisition: Luzhou LIN.

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