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Research Article

Three-Dimensional Visualization Algorithm Simulation of Construction Management Based on GIS and VR Technology

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With the development and application of information technology, the digitization of information management and the virtualization of physical models have become very important technical application fields in the world. The establishment of the 3D landscape model and the realization of the 3D geographic information system (GIS) are based on this, and there is not only a wide range of development prospects in many aspects such as urban planning and management, planning and design, local government construction, housing industry development, land monitoring and management, and environmental monitoring and evaluation. There are not only research studies and formulations but also a practical significance in other analysis, evaluation, decision making, and other departments. In recent years, the research of 3D city modeling has been developed rapidly, and most of the existing 2D-GIS can be transformed into 3D visual landscape. Based on the three-dimensional geographic information system and desktop drawing software AutoCAD, this paper takes the two-dimensional line drawing (DLG) of a residential district as the base map, expounds the design process of the three-dimensional simulation model of the urban community from the aspects of map preprocessing, building simulation model construction, texture mapping, and virtual visualization, and discusses the problems encountered in it. The main contributions of this paper are that this technology puts forward a new solution for the integrated corridor operation and maintenance management, greatly improves the intelligent management level of the integrated corridor operation and maintenance work, and simplifies the complex integrated corridor operation and maintenance management. It is helpful to improve the work efficiency of operation and maintenance, reduce the dependence of personnel, and respond to the long-term construction needs of the smart city at the same time.

1. Introduction

The building information model (BIM), mainly presents the specific information of the building through the model structure, the characteristics of 3D visualization, coordination, simulation, optimization, drawability, parameterization, integration, information completeness, etc., to share and transmit all kinds of building information in the whole life cycle of project planning, construction, operation, and maintenance [1–4]. It can provide the decision-making basis and intelligent management platform for all kinds of work in the whole life cycle. Virtual reality (VR) belongs to an interactive simulation system that simulates and experiences the virtual world, which forms a virtual world by merging multiple resource information through a computer and then perceiving the actual behavior through a three-dimensional dynamic scene [5]. Complex public construction projects have various architectural forms, complex functions, and high construction requirements, such as the hospitalization building hall, waiting hall, nurse station, and multi-specification ward; each special part of the functional room needs to make several sets of on-site templates and ask the leader for guidance, modification, and repeated determination [6]. It consumes a lot of manpower and material and financial resources and seriously delays the progress of construction, as shown in Figure 1. Moreover, because the roof of the complex public construction project is the important, difficult, and bright spot in the construction of the project and it is more complex than other types of projects, for example, the roof shape of this project is irregular

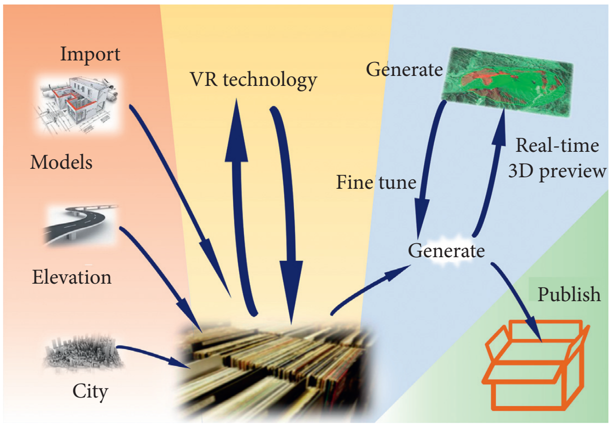

Figure 1: Architecture of the management of the city models.

herringbone, on which hundreds of fan equipment are designed, we need to consider the arc lines, equipment foundation, roof brick color, the overall typesetting effect, and other factors, in terms of the current situation [7]. The main method used is to effectively separate the building elevation and, at the same time, with color to facilitate observation so that the scheme can be determined. There are also shortcomings in using this method, mainly that the more the elevation, the more correct the scheme, so a lot of drawings will be drawn, which greatly increases the workload [8–10].

Here, the specific models and the information of the city can be inputted in the VR technology, and the output real-time preview can be generated for tuning the management. In consideration of this, the project validates in various ways based on BIM technology, engineering modeling, deepening design between templates, changing room layout and tuning, and outputting design layouts and models through Fuzor software to generate interactive programs. Finally, use the VR device to display it in front of you. Visual management of 3BIM and VR technology: BIM and VR are an effective combination of data models and virtual images and can further improve the effect of virtual performance. The main decision of the fine decoration scheme is to enter the decoration room model into the computer and then connect to the virtual reality device. The purpose of this is to improve the user's sense of reality and experience. Decorating schemes can be directly viewed and compared. You can save time to choose the best ones as well as eliminate the waste of resources. Not only create multiple templates but also greatly improve the flexibility and versatility of the template scheme and make the final scheme more reliable.

After the 1990s, due to the rapid development of three-dimensional visualization and virtual reality technology, it is possible to establish the three-dimensional GIS, and the "Digital Earth" has put forward more urgent requirements for the establishment of the three-dimensional GIS [11]. Relying on the XYZ geo-spatial framework, the 3D GIS maps the real world to the virtual space in a visual and intuitive way, organizes and manages the target entities in the virtual space in a structured and object-oriented form, and supports 3D spatial analysis and operation, which has gradually become the key technology in the construction of Digital Earth, digital city, intelligent city, and so on [12]. Thanks to the wide recognition of Google Earth, especially the free opening of the Google Earth version to the public, three-dimensional GIS technology has accelerated into public view [13]. At the same time, three-dimensional spatial-data acquisition technologies such as three-dimensional laser scanning and tilt photogrammetry tend to be mature, which greatly ensures the basis of application data. In recent years, with the development, the Internet of three-dimensional model data has become a major development trend; the desktop software of the traditional three-dimensional GIS has turned to WebGIS and a more lightweight mobile app, to the direction of specialization and lightweight [14]. On the contrary, supermaps have successively carried out research on the fusion of 3D GIS and VR, but the VR-GIS is still in its infancy, and its application potential needs to be further tapped [15]. VR technology uses computer to generate a real environment to build a multisource fusion, interactive three-dimensional dynamic scene, and entity behavior simulation system, with multiperception; users have vision, hearing, touch, taste, smell, and other perception in the virtual environment to provide an immersive experience [16–19]. In order to do a good job in civil air defense, with the help of advanced information technology, there is an urgent need to improve the efficiency of civil airdefense project management and improve the emergency response speed of civil air defense [20]. Civil air-defense project management, the business covers the monitoring and management of the main body of engineering structures, supporting equipment and facilities, and their operating status [21]. In terms of the management of the main body and supporting equipment and facilities of the civil air defense structure, in view of the fact that the civil air defense project belongs to the underground structure, and the facilities and equipment are related to power supply, ventilation, water supply and drainage, fire-fighting, communication, and other special facilities and equipment, the structure is complicated, all kinds of pipelines crisscross, and the management and maintenance work is often demanding and difficult [22]. The building information model, namely, "Building Information Modeling" (hereinafter referred to as BIM), is based on the relevant information data of the construction project, establishes the building model, and simulates the real information of the building through digital information simulation [23–26]. BIM technology is a kind of data tool, which integrates all kinds of relevant information of the project through the building model, shares and transmits the information in the whole life cycle of project planning, design, construction, operation and maintenance, and plays an important role in improving production efficiency, saving cost and shortening the construction period [27]. Comprehensively and scientifically promoting the application of BIM technology in the field of civil air defense not only effectively saves project costs, shortens the construction period, reduces project risks such as rework, conflicts, and errors in civil air-defense engineering construction but also assists in civil air-defense project management to be familiar with all kinds of components and facilities and equipment of the structure and reduces the difficulty of operation and maintenance, thus greatly reducing management costs and improving management efficiency. In the aspect of monitoring the operation status of the civil air defense project, the operating status of the equipment and facilities include the ventilation state of the civil air defense project, the working status of the ventilation valve, the water storage capacity and water quality of the water tank, the water quality of the well, the access information of the power supply, the status of the power generation equipment, and the voltage, current, and power of the power input and output [28]. The internal environmental quality includes temperature, humidity, pressure difference, and the concentration of oxygen, carbon dioxide, carbon monoxide, and methane in the civil air defense project, and these indexes can be input into the computers, as shown in Figure 2. The security protection refers to the video surveillance of the civil air defense interior and entrances and exits, the intrusion of entrances and exits, the number and density of insiders entering, the water seepage within the project, and so on. The monitoring content involves many categories, and the situation is complex, which requires timely and accurate control of the data situation, and there is an urgent need to use the Internet of Things technology [29, 30]. In the aspect of improving the response of civil air defense emergency and disaster prevention, emergency drills are usually used to improve the ability of organization and coordination and find the weak links of emergency work. As a conventional emergency exercise mode, although the actual combat exercise can achieve the goal of well-trained and improve efficiency, it often has some shortcomings, such as single situation, limited areas involved, and time-consuming and labor-consuming evaluation [31]. In this model, privacy and security are very important for designers, so we need to set up a firewall just in case. On the contrary, the traditional desktop exercise is too stylized and step-by-step, often around one or more virtual scenes designed in advance to carry out simulation exercises in accordance with the established steps, resulting in poor perception, and it is difficult for all kinds of exercise roles to enter the state [32]. VR technology has the characteristics of interaction, immersion, and imagination and can quickly set or change the exercise scene according to the user's imagination, and at the same time, it can give all kinds of exercise roles a sense of immersion and interactive real experience in the virtual scene, so as to meet the requirements of "intensive exercise, real scene participation, dynamic deduction, and accurate evaluation" [33–35].

The emergence of virtual reality technology (VR) is an important sign of digitization and modeling of information management and is gradually applied in various fields of the society. Computer simulation technology, electronic integration technology, sensor technology, and other computer virtual technologies form a complete VR technology. In this work, this technology uses a hardware operation panel as an intermediary to realize the interaction between a user and a computer, where users can experience virtual real senses. With VR technology, the user can actively manipulate and control the virtual scene interface to obtain a variety of feedback experiences. 3D dynamic modeling, virtual graphics generation, and 3D dynamic display are key technologies for virtual reality representation. In this paper, we propose a three-dimensional simulation of urban planning by applying VR technology in urban planning and design The design of the MultiON system and the database as the basis of urban 3D planning and design can achieve safe storage of data in the data collection and design process in the urban area and complete the three-dimensional modeling of the urban elements with a three-dimensional module system. The virtual scene of city planning is presented in the VR simulation design module, and the interactive roaming of dynamic landscape of city planning is realized, so users can get immersive virtual experiences.

2. Application of VR Technology in 3D Simulation Design of Urban Planning

2.1. Overall Architecture. The design of the urban planning 3D simulation design system based on VR technology includes two parts: 3D design and VR simulation design. Based on the open GL module, the urban-planning 3D simulation design system is designed. The function of the VR simulation design module is the model traversal rendering and the interactive roaming of the urban planning scene. The VR simulation module and the 3D design model rely on the same data interface for communication. At the same time, the VR system has the functions of visual inspection of the corridor building structure through the wall, three-dimensional demolition and display of the equipment, control of the on-site equipment to start the switchgear, and other functions, which can display the facilities and equipment which cannot be inspected by the naked eye, and there is no monitoring dead corner. This technology enables the operation and maintenance of underground pipeline corridors to achieve information-based, visual, and intelligent management. It can display the optimized virtual map, the sections of the pipe corridor marked in the map, personnel positioning, robot inspection, and so on. We can click on the porch pop-up window to display the corridor environment, personnel, and other information. Important special facilities, such as fire brigades, schools, hospitals, and gas stations can be marked in the GIS map. The operation and maintenance data will mainly display the current equipment status in the integrated management corridor by big data as well as the operation and maintenance work data (such as the number and time of inspection, the number and frequency of maintenance equipment, and maintenance equipment statistics). Visual graphics are used to display information such as corridor operation status, entrance pipeline and toll, comprehensive energy consumption, and operation quality. In the VR virtual inspection, the equipment in the VR field of vision can click and pop up to display specific information such as the model, status, installation time, use time, maintenance, repair log, and memo of the selected equipment, as well as the disassembly chart of the equipment, in order to provide operation and maintenance personnel on when and what kind of maintenance, how to maintain, whether to replace new equipment, and other operation guidance. The VR perspective can be used to see

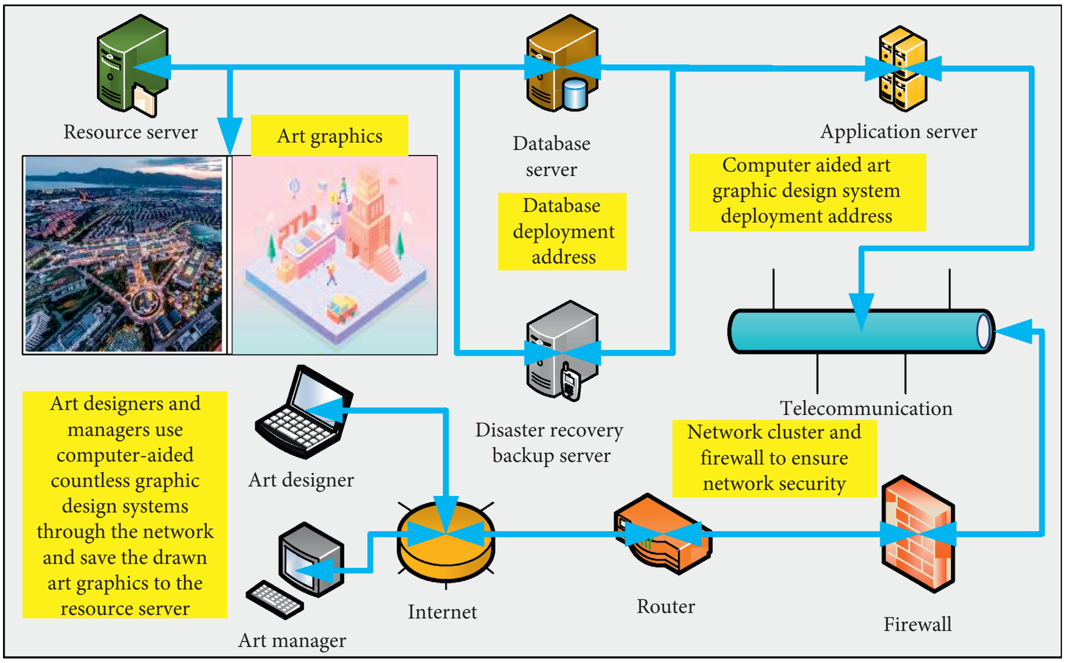

Figure 2: The computer design for the city buildings.

through the wall and view the internal pipelines, concealed facilities, and equipment of the wall. Road map and simulation design drawing can be referred in Figure 3. We can carry on the remote control to the equipment in the VR patrol inspection and collect the original independent operation and operation of each equipment to the VR inspection experience system for management and control. On the one hand, understand the operation status of the equipment; on the other hand, carry out remote control.

2.2. Database Construction. The MongoDB database is constructed by using the measured urban field planning data to ensure the data security. The data generated during the design process such as the construction of 3D model, graphic mapping, and rendering are stored in the Mongodb database. The advantage of the Mongodb database is that it has a large storage space and meets the needs of large-scale data storage; at the same time, it has the function of resource data sharing, and data resource sharing plays a key role when two-dimensional software transmits data to three-dimensional software. The nonrelational database is a high-performance product of the development of modern electronic technology, which is used frequently. The Mongodb database belongs to the nonrelational database. The advantage of nonrelational Mongodb database is that it is easy to expand, flexible to deal with data, and has strong data processing performance. The Mongodb database stores data in a format, which is the main form of data transmission and storage. Format is a binary data storage format; data objects and embedded document objects can run well in the format. The operating principle model of the virtual-reality technology display mode based on the computer screen display construction industry is a high-risk industry. The simulation map is used for long-distance communication and construction management, as shown in Figure 4. Although the mortality rate has decreased year by year in recent years, the overall mortality rate is still high. For enterprises, safety is the greatest benefit, and accidents are the biggest waste. The safety management of the construction team adheres to the principle of "safety first, prevention first, and comprehensive management." The government and industry have issued many laws, rules and regulations, methods, etc., and carried out the activity of "production safety month" every year. As the main body of production safety responsibility, enterprises are constantly improving the safety management system, innovating safety management methods, and effectively implementing the production safety responsibility system. To ensure the safety of engineering production is the need of harmonious development.

Virtual reality technology (VR) is composed of programming software, electric machinery, information technology, and so on. It is a multidisciplinary comprehensive technology developed on the basis of computer, digital model, sensing technology, display technology, artificial intelligence, simulation technology, ergonomics, and psychology. Use the computer technology to create a real-time interactive 3D image world for users in a simulated manner. People interact with the virtual world formed by images using specific devices and generate immersion. Due to the rapid development of the present intelligence, the Internet of Things technology has created a technology platform for boldly using virtual reality technology in the library, and innovation of the technological innovation and the service concept for various changes of the library service are also provided. Virtual reality technology is to reflect virtual information into the real world with the help of computer processing technology, to realize the integration of virtual

FIGURE 3: Road map and simulation design drawing.

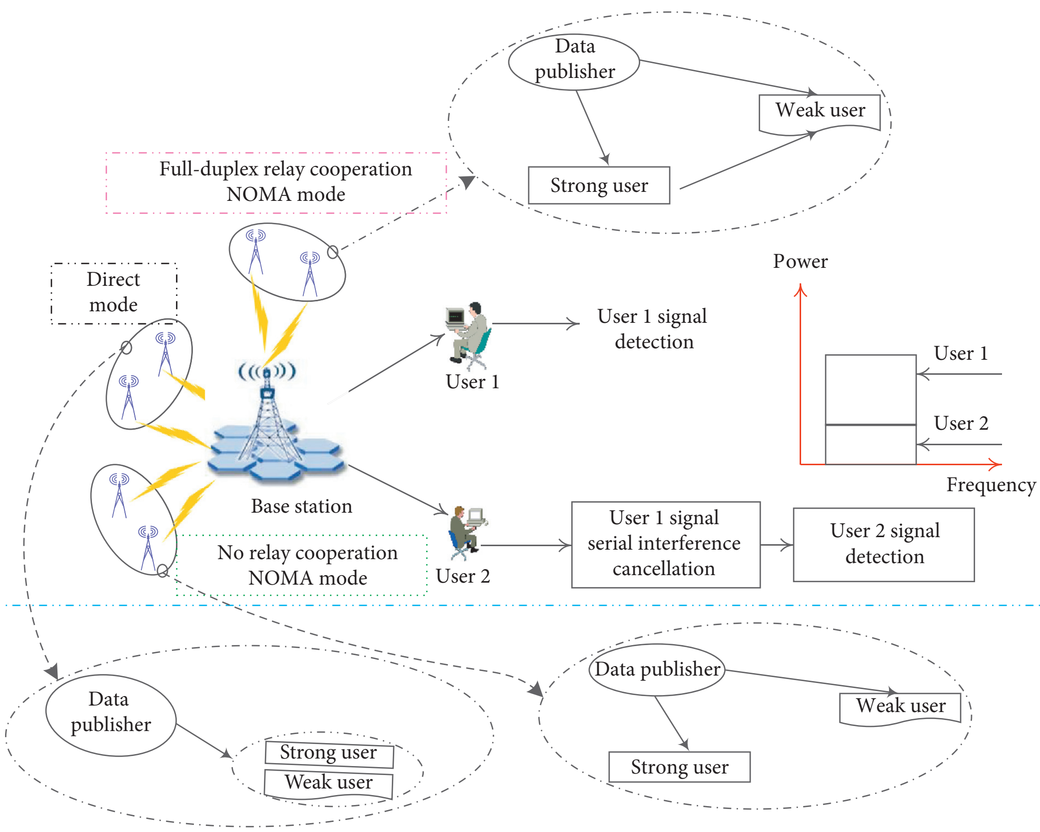

FIGURE 4: The simulation map used for long-distance communication and construction management.

objects, scenes, actions, and other objects and apply them to real scenes. The introduction of virtual reality technology in the smart library creates a comfortable smart virtual space for readers, allowing readers to enhance their desire to enjoy library services in the context of services. Virtual reality technology is a special form of virtual reality technology. It has the characteristics of strong interaction, integration of virtual and reality, and three-dimensional positioning. It introduces three-dimensional registration and virtual compatibility. At present, if libraries want to efficiently broaden the scope of public cultural services, they should introduce AR virtual reality technology as soon as possible, show the service model to readers in a brand-new form, and use high-quality resource construction to burst out the library's own advantages.

2.3. Virtual Reality Technology Improves the Effectiveness of Information. At present, most of the safety technologies at the construction site are paper materials, and a few projects use multimedia information toolboxes (participants need to swipe their ID cards to register and file) or use mobile phone QR code scanning as carriers. Most of the operators are not highly educated and lack the ability to predict the environmental characteristics and possible safety risks in the process of structural construction. The degree of mastery of conventional safety technology is uneven and cannot get very good results. According to research, the information that people see through their eyes and can actually feel can be remembered for a long time in their minds. Therefore, the "BIM + VR" technology can dynamically show the risks, matters needing attention, and the use of first aid equipment and on-site first aid in the process of construction operations, such as types of work and operation sites, and can greatly improve the actual effect of training.

The safety training and education for employees and collaborators in the project department are generally carried out by PPT, Word, or animation personnel, and the trainees are unable to experience the necessary safety knowledge and emergency response knowledge because of their work experience. Sometimes, although the employees are familiar with the safety knowledge, they are unable to deal with the emergency effectively or forget it when they encounter an emergency in the actual production. The establishment of a virtual experience hall through "BIM + VR" technology has the characteristics of authenticity, interaction, and detail so that the employees can personally experience the dangers that may occur during the construction process including hole fall, seat-belt experience, collapse (scaffolding, slope, deep-foundation pit, wall, high formwork, operation frame, decoration stage bridge, and large system air duct), electric shock, fire escape and fire extinguisher use, balance-beam walking, rail area safety (rail-car avoidance and transportation of materials and equipment), cardiopulmonary resuscitation, illegal search and other modules, increase the visualization, interest, and interaction of the learning content. Conducting emergency drills and commanding rescue emergency drills can be divided into desktop drills, functional drills, and comprehensive drills. The purpose of the emergency exercise is to test and evaluate the emergency operation capability of emergency organizations and departments at all levels. The "BIM + VR" technology simulates the scene reproduction and sets off the atmosphere under the emergency situation, which is closest to the reality of the scene, and can better test the ability of emergency management than the written explanation, the dangerous situation on the spot, or the accident scene. In view of the complex location, structure, and surrounding environment of the accident, when the rescue force is unable to carry out the rescue effectively or the internal situation is not clear and is not conducive to the formulation of the rescue plan, the rescue command organization or external experts can grasp the internal structure by means of "BIM + VR" technology and Internet, so as to facilitate the decision-making and rescue.

3. The Combination of VR Technology and GIS Technology

With the continuous improvement of the current power infrastructure, the investment in power infrastructure is also increasing. With the continuous expansion of development, power infrastructure began to gradually develop from the ground to the underground, and large number of power pipelines began to be laid underground. With the laying of large number of basic power facilities, it is more and more necessary to strengthen the monitoring of the underground pipe network. However, with the continuous expansion of the current scale, the management problems of the pipe network begin to be gradually exposed and become increasingly prominent. For example, in some urban construction, due to the random laying of the pipe network, the pipe network crosses with the municipal pipeline, which buries large number of hidden dangers, which is not conducive to the rational development of the urban pipe network. With the development of current information technology, visualization technology represented by VR technology has been paid more and more attention and has been widely used in various aspects. For example, the visual monitoring of power facilities is completed by VR technology, and then, the visualization of power equipment monitoring is improved. At the same time, in the monitoring of power equipment because of its complexity, how to monitor the equipment in different areas is the focus of the current thinking. In this paper, with the help of the current mainstream GIS technology and VR technology, a new type of power pipeline management information system is proposed, and its implementation is described in detail. Through the realization of the system, it provides basic ideas and reference schemes for the visual management of power pipelines as well as for the management and construction of urban power pipelines.

3.1. Visualization Technology. Geographic Information System (GIS) technology mainly establishes the geographic database by computer, stores the relevant data of geographical environment elements, and uses its own data analysis and processing functions to comprehensively analyze the multielements in the database. Through a series of analysis and processing, the relevant geographical environment information is obtained, and the graphic or digital results are displayed to provide a basis for related applications and research. VR is a technology that uses computers to build a variety of perceptual virtual environments for people, which can enable people to have an immersive experience in the virtual environment only through switching devices. So far, the main achievement of GIS technology is expressed as real-time images, and the construction of the virtual environment by VR technology must rely on the achievement of the GIS. From this, we can see that the relationship between GIS and VR technology is cross and continuation. If the GIS technology and VR technology are combined reasonably, it will bring a breakthrough to the research work of the three-dimensional world. According to all kinds of visualization technologies on the market, GIS and VR can be called the most advanced visualization technologies. If they are applied to power channel management, they will effectively improve the existing problems of traditional power channel management. Because GIS technology contains a variety of statistical information features and geo-spatial features, it has significant advantages in information management and spatial analysis. Applying the GIS to power channel management cannot only manage all kinds of abstract power pipeline data graphically but also realize the network analysis of power pipeline, which will provide convenience for a series of power channel management. VR is a new technology based on various advanced mainstream technologies. The most representative mainstream technologies are computer network technology, simulation technology, and interpersonal exchange technology. The changes of the design and documentation happened in the workflow, as shown in Figure 5. The application of VR technology to power channel management can build virtual environments for customers, such as spatial layout of ambient and power channels, and improve customer experience and power channel perception. GIS and VR technologies are applied to power channel management, which can display power channel sites, resources, and spatial layouts and, based on this, analyzes and manages power using the GIS's network analysis function and improves the resource utilization of power pipelines. The structure of the simulation system based on the integration of GIS and VR technology is shown. Based on the characteristics and requirements of power pipeline management, the visual management of power pipeline business can be realized by applying CIS and VR technology to each business of power pipeline.

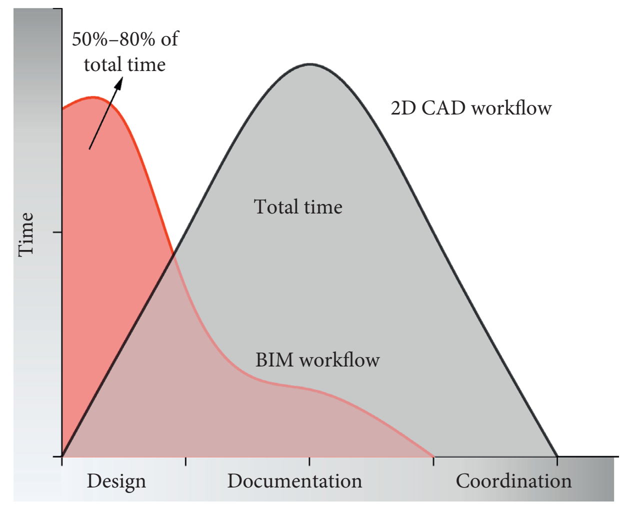

Figure 5: The changes of the design and documentation happened in the workflow.

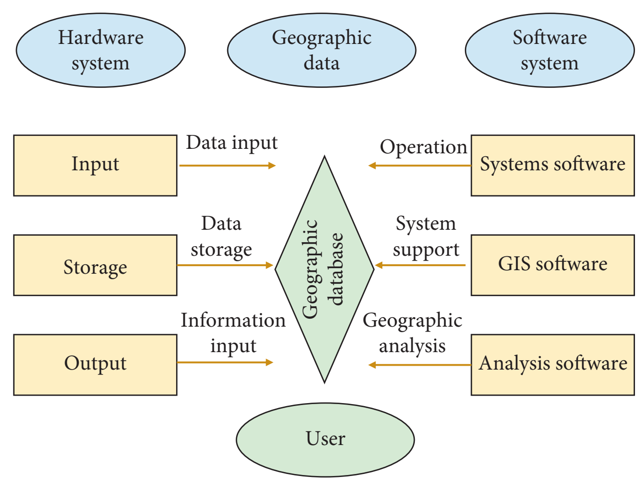

Figure 6: The mechanism model of hardware and geographic data and software systems.

3.2. Idea of System Construction. In order to meet the needs of different levels of users, the overall architecture of the system should be designed as a multitier architecture, such as server, client, and server and browser. Under this multitier architecture, the tasks of each layer are different. Through this reasonable division of labor, it cannot only reduce the cost of the client and the cost loss of the system but also meet the needs of many users for the functions of the system, so as to achieve the goal of killing two birds with one stone. In addition, in the design process, the system can also use the low-to-high multitier architecture as the overall architecture of the system, with different software functions of each layer structure to meet a variety of needs of users, as shown in Figure 6. In the business management of the system, workflow technology can be introduced to process management. In this way, the integration ability and expansion ability of the system will be further improved, and the purpose of adjusting the configuration business process according to the needs of users will be achieved. It is a JavaScript class library package, and it is a 3D engine. The introduction of technology into the design process of the system will enable this technology to realize the map data access function of standard format publication and provide support for the application of GIS technology. The introduction of Three.js technology will contribute to the construction of the 3D scene of power channel management.

The data resource layer is at the center of the technical model. It consists of data warehousing, data mining, cloud computing, information push, and semantic analysis technologies. It is mainly responsible for user data storage and format conversion, user data resource mining and calculation, and user-personalized information needs. Task functions such as prediction, recommendation, and management. The smart application layer relies on the data analysis provided by the data resource layer and is mainly constructed by virtual reality technology, multimedia, data visualization, and other technologies to realize library scene-based recommendation services, user-personalized services, virtual reality services, and multimedia services. The improvement of smart space services and visualization services and the innovative development of smart libraries have realized the service process from sensing information to digging information, processing information, and finally to discovering wisdom.

Virtual reality technology has computer-generated three-dimensional effects that integrate visual, tactile, and olfactory functions, allowing users to enjoy interactive services immersively with realistic and visual scenes. The multiple senses, visibility, permeability, and immersion characteristics of virtual reality technology make it popular in the library field. At present, virtual reality technology is mainly used in the virtual official buildings of libraries, allowing users to "walk" among them, freely associate with the virtual space, and obtain a three-dimensional and realistic user experience. When users "walk into" the virtual space of the library, they can understand the overall layout of the library and can also obtain information consulting services and browse the operation mode of the library in the most direct way of expression, allowing users to understand at a glance and fully embody the superiority of the smart library. It also appropriately compensates for the one-sided and localized information obtained on the library website and increases the user's affinity for the virtual reality of the smart library. The application of visualization technology in smart libraries can realize the service functions of explicit tacit knowledge, clarification of fuzzy knowledge, and concrete abstract knowledge.

The introduction of the graphic text-integrated information system into the system design process can closely combine the system business examination and approval process with graphic data so that the system can provide graphical support for business examination and approval work when aiming at the core tasks of power pipelines. In order to achieve the purpose of the integration of picture and text in business examination and approval, the VR technology is applied to the system design to create a virtual environment related to the power pipeline for users, and its lifelike on-site effect shows the surrounding environment and spatial layout of the power pipeline for users. The whole system architecture is mainly divided into five layers, which are user layer, application layer, service layer, data resource layer, and infrastructure layer. The architecture is mainly composed of the standard system and security system.

3.3. Visualization of Information Retrieval. After the system is completed and put into practical use, the power channel can play a role in two aspects of visual management. Meanwhile, the power channel management staff will be able to fully grasp the current situation and future plans of power management to maximize the use of power pipeline resources. On the contrary, the system can determine the accurate location information and related trends of power pipeline planning projects for urban planning departments and reduce the professional pipeline damage caused by location misjudgment so that other urban construction projects are not affected by power channel management. At the same time, through the application of the above visual management system, it brings the following three benefits to the power company. First, it improves the safety level of the overall transmission channel. Through visual management, the protection level of the line is improved, and then, the tripping of more than 2 times for a certain reason is ensured; at the same time, differential reinforcement is adopted to ensure the safe and stable operation of transmission lines in extreme weather. Second, the level of safety identification is greatly improved. Through visual management, it not only strengthens the operation and maintenance management and the security protection of the channel but also greatly improves the ability of the transmission channel to resist risks. Third, it improves the entire power enterprise line protection network. Through visualization, the detection rate of defects and hidden dangers is 100%, and the closed-loop rate is 100%, which provides a guarantee for the stable operation of the transmission line.

The similarity between objects classified into the same category is the largest, and the similarity between different objects is the smallest. In the iterative optimization process, the FCM algorithm continuously updates the values of the various centers and the elements of the membership matrix until it approaches the minimum value of the following criterion function:

$$K_x(T) = \sum_{j=1}^{N}\sum_{i=1}^{c} x_{ij} y_{ij}^2. \quad (1)$$

Feature extraction: in the test sample dataset, there are a total of 988 keywords, and the number of keywords that are different from each other reaches 628. After the data dimensionality reduction process, the remaining unique keywords are 113, which greatly reduce the aggregation. The data in the document space vector matrix R is stored in a text file as the data source of the FCM algorithm in Matlab. The number of iterations of running the FCM algorithm is 100, and the clustering result when the clustering objective function value is the smallest is taken out as the final output.

The document similarity matrix $(n * n)$ is defined as follows:

$$\begin{bmatrix} Q_{11}, Q_{12}, \ldots, Q_{1n} \\ P_{21}, P_{22}, \ldots, P_{2n} \\ \cdots \\ P_{n1}, P_{n2}, \ldots, P_{nn} \end{bmatrix}. \quad (2)$$

The similarity of two keywords is defined as follows:

$$q = \frac{\partial}{\partial z}\left(\theta D \frac{\partial c}{\partial z}\right) - \frac{\partial(\overline{q}c)}{\partial z} - \lambda_1 \theta_e - \lambda_2 \rho_0 s. \quad (3)$$

The selection operation is adopted to select good individuals from the current group and decide which individuals can enter the next generation. First, the individuals are sorted according to the fitness function from large to small, and the first h individuals are copied as new individuals directly into the next generation, and the fitness of the remaining individuals is calculated as follows:

$$\begin{cases} q_r = -k(\theta)\dfrac{\partial H}{\partial r}, \\ q_\varphi = -\dfrac{1}{r}k(\theta)\dfrac{\partial H}{\partial \varphi}, \\ q_z = -k(\theta)\dfrac{\partial H}{\partial z}. \end{cases} \quad (4)$$

The value of 207 documents in life is used as a test dataset to test the feasibility and effectiveness of information retrieval in smart libraries. The genetic algorithm parameter is

50, the probability of mutation is represented by P, the value is 0.15, and the intersection value is 0.0002. The city index is 0.76, the maximum number of statistical index is represented by T, and the value is 100. After 50 experiments, the result of the average objective function is shown in Figure 7.

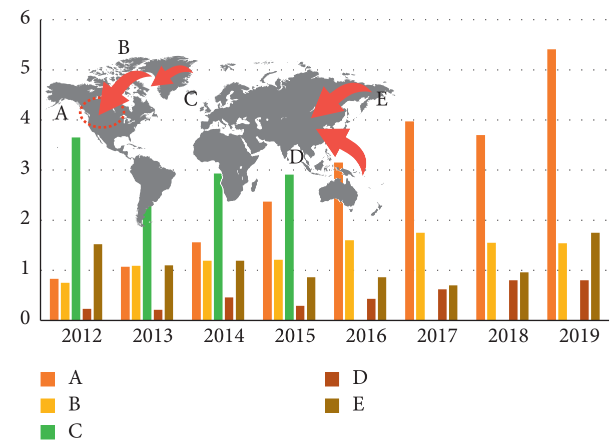

Figure 7: Comparison of the relationship between the city index and statistical index.

3.4. Application in Construction Management of the Pipe Gallery. To promote the mechanical and electrical installation construction of the pipe corridor, it is necessary to start with the actual construction situation, so as to solve the management risk problems. In the specific construction process, it is necessary for the relevant responsible personnel to clarify the risks existing in different stages of construction, effectively evaluate and solve them, and apply the continuous management method to promote the effective improvement of its management work and ensure construction quality. In the process of civil engineering construction, it mainly includes the process of design, construction, and acceptance, while the mechanical and electrical installation of the integrated pipe gallery is mainly used in the construction process. In this case, it is easy to cause most of the construction content to be omitted and even lead to the defect of its main structure. For different majors, it will also have a certain degree of intersection so that the corresponding coordination is relatively difficult. In this case, there are many safety risks in the mechanical and electrical installation project of the integrated pipe corridor, which are mainly manifested in three aspects. First of all, the structure is more complex, and construction management is more difficult. In the process of the installation of the equipment in the comprehensive pipe corridor, the corresponding installation structure is more complex, and it is mainly shown by the way of surface drawings in the actual work, but in the actual development, such a graphic display is not clear, the construction is difficult to effectively grasp the actual situation, and it is easy to have a negative impact on the actual development of the construction work. At the same time, it is difficult to promote the effective coordination and development between different majors, which is not conducive to the improvement of engineering quality. It is easy to lead to quality problems, thus increasing the quality risk in the invisible. Secondly, the amount of interactive information is relatively large, and the corresponding cross-construction operations are relatively large. Information transmission is particularly important in the development of the industry, and its overall transmission rate has no direct effect on the cycle and cost of the pipe gallery electromechanical installation project. However, in the comprehensive pipe corridor installation project, the corresponding amount of cross-engineering work is relatively large, which makes the cross-information volume also relatively large. Cross-problems often occur between the mechanical and electrical equipment installation project and the main structure, signals, escalators, and other systems and specialties, which can eventually lead to the quality problems of professional connection and cross-construction. From the current development situation of related industries, we can see that in the process of transmitting construction information, we will mainly use CAD technology to complete the processing of a large number of drawings. However, this kind of workload is relatively large, which makes the intuitive intersection of its processing, and the professional requirements of this method are high. In the process of processing, it is more difficult to carry out the work, which will have a negative impact on the effective control of many projects. To a great extent, it increases the implementation risk of the project. In the process of the application of BIM technology, its own visibility is relatively strong, and it can effectively transform CAD two-dimensional drawings to build a more visible three-dimensional dynamic model, so as to strengthen the degree of cooperation and coordination among various majors. Finally, there are relatively many uncontrollable risks. In the process of installation and construction of subway machinery and electricity, there will be more construction risk factors, and there is no perfect safety management system, which will hinder the normal exchange of information, and the protection measures are not sound enough. It has brought more hidden dangers to the development of its work; at the same time, in the process of carrying out equipment installation projects, the corresponding operation points are relatively more, the concentration of construction personnel is poor, and the lines and networks are related to each other. The risk is increased to a great extent, and the construction environment is also relatively poor. In this case, the corresponding risk factors of construction are not only many but also difficult to realize the control process, and the hidden safety dangers are not easy to be detected. Then, the information visualization model of the 3D assembly can be obtained, as shown in Figure 8. It will bring more deficiencies for the development of construction. Therefore, the visualization and efficiency of management can be enhanced by using BIM technology and VR technology.

There are mainly three parameters we need to adjust: the region area, adjusting time, and VR sensitivity. In the process of risk management of the pipe gallery equipment installation project, we can start from multiple stages to make it run through all stages of construction. At the same time, as for the risk management work itself, it is also

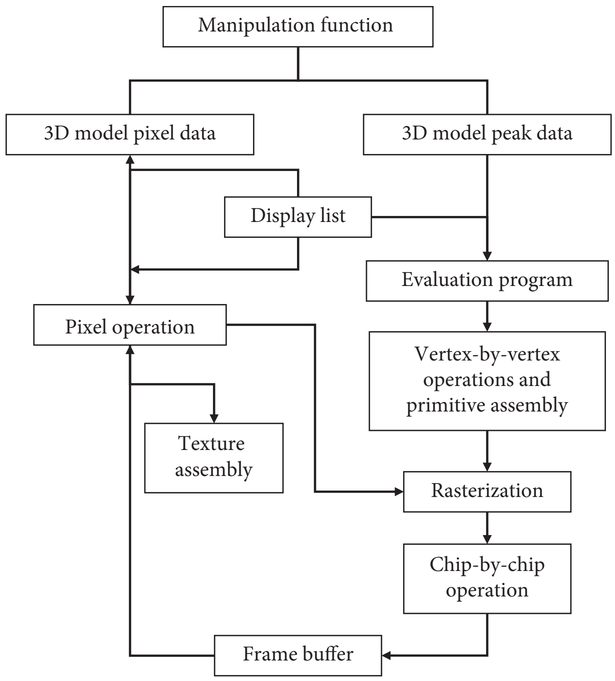

Figure 8: The information visualization model of the 3D assembly.

multistage, and the managers who need the development of the enterprise can start with the risks that may occur in each construction stage, and on the basis of effectively mastering the existing problems, give the analysis and decision. However, in the process of carrying out this work, it is easy to ignore the feedback and communication of risks, and the communication among various construction units is also relatively small. In the process of applying the BIM technology, promote the construction of the sharing platform and use the VR technology of BIM to feedback the information for each participant timely and intuitively, so as to strengthen the level of information exchange between different departments, realize information sharing, and reduce the risks existing in the construction. First of all is the decision-making stage. In this construction process, the application of BIM's VR technology can realize the procedure simulation of all parties' construction plans so that all parties can master their own plans, give timely feedback, effectively analyze and demonstrate their decisions, effectively master the existing problems, better coordinate and take decision-making plans into account, and comprehensively consider all aspects of factors. To enhance the rationality and scientific nature of the scheme, we can also formulate effective risk prevention and control measures.

4. Application of GIS + VR in Operation and Maintenance Management

Due to the overall function of the GIS, the spatial information of the comprehensive pipe corridor in the monitoring area (such as the geographical location of ventilation feeding port, personnel entrance, pipeline outlet and special node, the direction of the pipe corridor, the quantity, category, and geographical location distribution of various professional-related equipment, such as mechanical and electrical equipment and control equipment) can grasp its properties, monitor the safe operation status of the equipment, and effectively manage complex geographic information data. The purpose of this paper is to provide the basis with the spatial information function for the auxiliary decision-making of integrated corridor operation and maintenance. The attributes of the pipe corridor presented by the BIM layer are given to the GIS to display the professional engineering data of the corridor, equipment, and pipelines in the integrated corridor project through 3D models, so as to further enhance the cognitive ability of the business and management personnel to the geographic space of the integrated corridor and realize the spatial data and spatial information services provided by the intelligent management of the integrated corridor. This module solves the facility management based on spatial location and forms a management mode through the restoration of the object at 1 : 1. On the basis of GIS + BIM technology and integration of VR technology, the 3D model can directly display all the information of the underground integrated pipe corridor through VR equipment, as shown in Figure 9. Managers wear VR devices and hand-held remote controls for three-dimensional visual interactive inspection, which can make users feel immersive, as if they are walking and patrolling in the corridor and managing the facilities and equipment of the corridor, and the human-computer interaction has a more on-the-spot feeling. According to the actual demand, the VR system visually displays the information of material consumption, electromechanical equipment quantity, equipment operation parameters, fault indication, and so on in front of the eyes of the staff.

At the same time, the VR system has the functions of visual inspection of the corridor building structure through the wall, three-dimensional demolition and display of the equipment, control of the on-site equipment to start the switchgear, and other functions, which can display the facilities and equipment which cannot be inspected by the naked eye, and there is no monitoring dead corner. This technology enables the operation and maintenance of underground pipeline corridors to achieve information-based, visual, and intelligent management. It can display the optimized virtual map, the sections of the pipe corridor marked in the map, personnel positioning, robot inspection, and so on. We can click on the porch pop-up window to display the corridor environment, personnel, and other information. Important special facilities, such as fire brigades, schools, hospitals, and gas stations can be marked in the GIS map. The operation and maintenance data will mainly display the current equipment status in the integrated management corridor by big data as well as the operation and maintenance work data (such as the number and time of inspection, the number and frequency of maintenance equipment, and maintenance equipment statistics). Visual graphics are used to display information such as corridor operation status, entrance pipeline and toll, comprehensive energy consumption, and operation quality. In the VR virtual inspection, the equipment in the VR field of vision can click and pop up to display specific information such as the

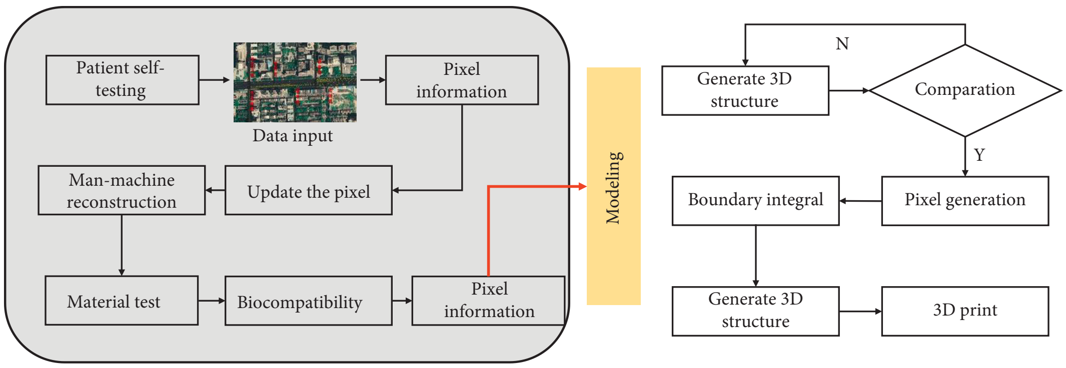

Figure 9: Performance analysis of the city model.

model, status, installation time, use time, maintenance, repair log, and memo of the selected equipment, as well as the disassembly chart of the equipment, in order to provide operation and maintenance personnel on when and what kind of maintenance, how to maintain, whether to replace new equipment, and other operation guidance. The VR perspective can be used to see through the wall and view the internal pipelines, concealed facilities, and equipment of the wall. The relative error of the recommendation service with the modeling time can be different, as shown in Figure 10. And, we carry on the remote control to the equipment in the VR patrol inspection and collect the original independent operation of each equipment to the VR inspection experience system for management and control. On the one hand, understand the operation status of the equipment; on the other hand, carry out remote control.

For example, remote monitoring and acquisition to obtain the operation status of power distribution equipment, fans, water pumps, electronic manhole covers, lighting systems, and other related equipment, whether the normal operation, through the control of remote start-up or shutdown of related equipment, provide emergency management, emergency plan simulation, and drill for integrated corridor managers after equipment failure. The comparison of the relationship between the city index and statistical index can be seen in Figure 11. Through this system, operation and maintenance personnel can quickly find and query the details of the equipment, locate the upstream and downstream components of the faulty equipment, display the macro GIS information and fine BIM information to the virtual operation experience of VR, and guide emergency management and control, emergency plan issuance, personnel deployment, emergency process display, and so on. For example, VR game technology is used to simulate the operation and maintenance personnel to observe and judge the severity of the fire immediately after a fire breaks out such as to find the nearest fire extinguisher box and wear a gas mask, press the manual alarm, determine the nearest escape path, follow the escape guidelines, report to the center in time after escaping from the danger area, and score the reaction time and process of the personnel simulation, so as to facilitate the training of operation and maintenance personnel. In addition, this function can also provide pre-plan analysis for operation and maintenance personnel, such

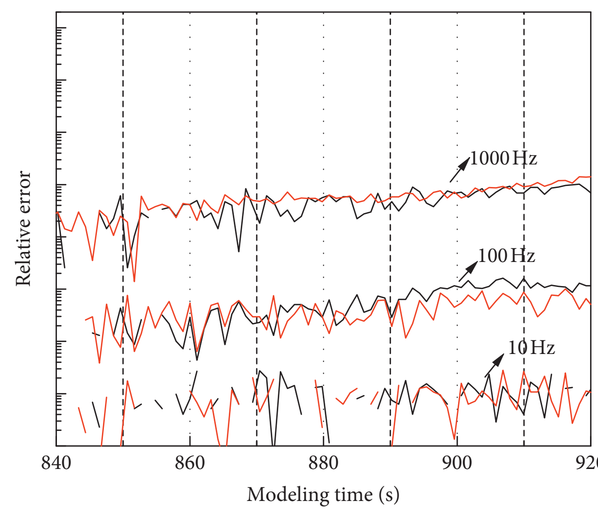

Figure 10: Relative error of the recommendation service with the modeling time.

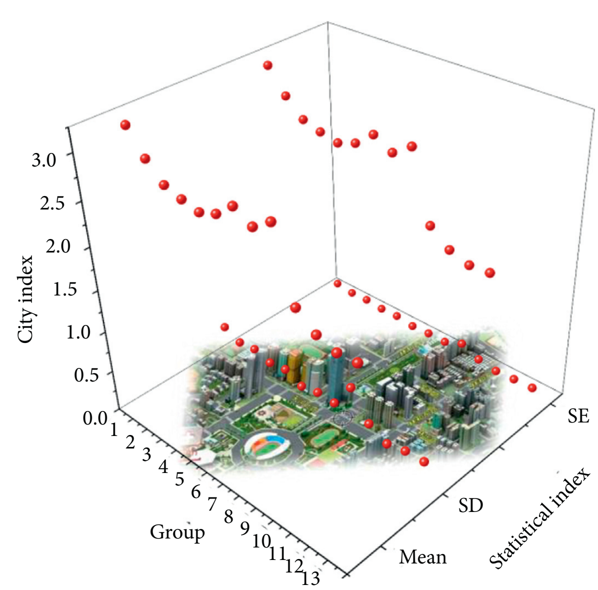

Figure 11: Comparison of the relationship between the city index and statistical index.

as which other equipment will be affected after the distribution switch is controlled. In the future, the technology of 5G robot patrol inspection is adopted in the integrated pipe corridor, and the VR patrol inspection is connected with the patrol robot video system to form a VR-driven inspection robot, and the detailed information of the patrol robot is reflected in GIS and BIM, which achieves the ultimate experience of real-time data, video scene, and real inspection, avoids the harsh environmental requirements of people entering the corridor, and ensures the safety of personnel. The 360° VR camera can be used to collect the solid and surrounding images of the integrated pipe corridor, and the VR real scene can be attached to the BIM presentation layer, which enhances the VR visual effect and brings a better real-scene experience. The VR surround experience is adopted, which abandons the limitations of VR headsets and adopts surround screen, 360° omni-directional treadmill, and body movement recognition technology to experience virtual operation more realistically.

It uses computer technology to create a real-time and interactive three-dimensional image world for users in a simulated way. People interact with the virtual world formed by images by using specific devices to create an immersive feeling. With the current rapid development of intelligence and Internet of Things technology, a technical platform has been created for the bold use of virtual reality technology in libraries, and it has also provided technical innovation and service concept transformation for the diversified transformation of library services.

5. Conclusion

With the development and application of information technology, the digitization of information management and the virtualization of physical models have become very important technical application fields in the world. The establishment of 3D landscape model and the realization of 3D GIS on this basis not only have broad development prospects in many aspects, such as urban planning and management, planning and design, municipal construction, housing industry development, land monitoring and management, environmental monitoring and evaluation, geological hazard prevention, and urban sustainable development strategy research and formulation but also have positive practical significance in other analysis, evaluation, decision-making, and other departments. To sum up, the use of GIS + VR technology integration and complementary advantages and its application in the integrated corridor operation and maintenance management have a certain practical and reference value. This technology puts forward a new solution for the integrated corridor operation and maintenance management, greatly improves the intelligent management level of the integrated corridor operation and maintenance work, and simplifies the complex integrated corridor operation and maintenance management. It is helpful to improve the work efficiency of operation and maintenance, reduce the dependence of personnel, and respond to the long-term construction needs of smart city at the same time.

In the future, this technology is supposed to enable the operation and maintenance of underground pipeline corridors to achieve information-based, visual, and intelligent management. It can display the optimized virtual map, the sections of the pipe corridor marked in the map, personnel positioning, robot inspection, and so on. We can click on the porch pop-up window to display the corridor environment, personnel, and other information. Important special facilities, such as fire brigades, schools, hospitals, and gas stations can be marked in the GIS map.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest regarding the publication of this paper.

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