Research Article

Application of Cloud Computing Combined with GIS Virtual Reality in Construction Process of Building Steel Structure

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In order to ensure that the steel structure of the building can meet the requirements of the strength of the building structure and the strict requirements in the fields of earthquake resistance, fire protection, energy saving, and environmental protection in the construction process, a method based on virtual reality supply chain cloud computing collaborative management technology is proposed. This method analyzes the main technology of building steel structure and establishes personalized cloud computing collaborative management technology based on virtual reality supply chain. Based on the analysis of industry characteristics and personalized service characteristics, the virtual reality control mechanism of personalized data mining is proposed by considering the service time cost and user experience quality. Based on cloud computing and VIRTUAL reality GIS, a collaborative management and control system architecture is proposed to optimize user personalized needs and solve the impact of differentiation on the supply chain. Experimental results show that compared with the noncollaborative management scheme, the collaborative management algorithm proposed by this method reduces the interference of personalized differences on supply chain management by 25%. The experimental results show that this method can greatly guarantee the satisfaction of steel structure construction process.

1. Introduction

According to the general code of Chinese civil building, the building with steel structure as structure is called steel structure building [1]. Compared with traditional concrete materials, steel structure materials have strong advantages in energy saving and environmental protection. On the premise of meeting the quality and safety requirements of high-rise buildings, steel structural materials can meet the requirements of national building energy-saving development and improve the building aesthetics, which is significantly better than traditional building structural materials. In architectural design and construction, the application of steel structure is important, not only can meet the needs of super high-rise building structure strength, in the field of earthquake resistance, fire protection, energy saving, and environmental protection, steel structure is superior to the traditional concrete structure [2]. And as the cloud computing technology began to gradually enter people’s vision, the concept of “cloud” was put forward, by the academic and industrial circles of various countries great attention. Cloud refers to the Internet here, and there is no unified conclusion on the specific meaning of cloud computing so far. But its original meaning belongs to the Internet computing environment. As an interdisciplinary subject applying virtual reality technology, geographic information system (GIS) has been gradually developed with the deepening of human technology research. With the idea of open-source software gradually prevailed, open-source GIS is also beginning to emerge. In the face of vast amounts of geographic information data, how to properly store and manage them is now a hot issue. At the same time, the development of cloud computing technology has given this question a reasonable and high esteemed solution. Storage of GIS data in cloud platform is not only low cost but also high security. At the same time, processing of massive GIS data using cloud computing technology is much more efficient than processing on a stand-alone platform.
Therefore, using cloud computing GIS and other technologies to analyze the construction technology and requirements of building steel structure and develop relevant construction technology can help achieve high-quality development of building construction.

2. Literature Review

In view of the research on the construction process of building steel structure, Luo et al proposed that the application of BIM technology in the construction of building steel structure can not only control the actual construction cost but also achieve a comprehensive understanding of the overall construction of steel structure, which can fundamentally improve the construction quality of construction projects [3]. Yin et al. proposed to reduce the occurrence probability of reverse logistics by analyzing and processing big data, subdividing logistics demand, and combining correlation analysis [4]. Prusov proposed to use virtual reality technology to establish three-dimensional cloud simulation of enterprise field environment, which enhanced users’ actual experience of field operation. They proposed to use cloud computing to transform all network resources into services, and users can access these services online to achieve on-demand computing and collaboration [5]. Liu et al. proposed the establishment of a cloud service platform about GIDS in order to simplify the installation and management of GIS applications, reduce the investment and operating cost of GIS, and improve the variability of GIS applications and underlying facilities [6]. Kim and Kang et al. proposed that cloud GIS is a service platform for collaborative processing of information data for users. Through cloud GIS, users do not need to know the position of the application in the system but only need to use PC or mobile phone and connect to the Internet to query data information through the cloud anytime and anywhere to achieve distributed cross-platform spatial data integration management and processing [7]. Ortega et al. put forward the virtual technology system based on cloud computing. Through the discussion of key technologies, existing resources can be effectively virtualized into services, and 3D cloud simulation of enterprise field environment can be established through virtual reality technology, enhancing users’ actual experience of field operation [8].

Based on the collaborative supply chain system of cloud computing combined with GIS virtual reality technology, the characteristics of the industry and personalized service are firstly analyzed. At the same time, the characteristics of service time cost and user experience quality are comprehensively considered, and the virtual reality control mechanism of personalized data mining is proposed. Implementation includes the management and supervision of construction steel structure construction process, the equipment material selection to the last in the construction process of prophase planning and design to ensure the safety of the building just materials used. Joint virtual reality based on cloud computing and GIS collaborative management control system architecture is presented to optimize the user personalized needs and solve differential effects on supply chain.

3. Research Method

3.1. Technology Platform. The overall platform architecture of cloud GIS is a Hadoop-based cloud GIS platform, in which mass data storage and high-performance computing are based on Hadoop high-performance distributed parallel processing architecture. The platform uses map resynchronization distributed parallel computing architecture to disperse spatial data processing and analysis tasks to each node in the cloud to reduce data computing time [9]. This kind of high-performance computing is especially suitable for the processing of sea data and the analysis and processing of GIS. The specific framework of the platform is shown in Figure 1, which consists of four layers: physical layer, cloud platform layer, service layer, and application layer.

3.1.1. Physical Layer. This layer is located at the lowest level of the architecture and consists of computer servers and network resources.

3.1.2. Cloud Layer. Cloud platform layer is the core of the entire system architecture, which is divided into four layers, namely, operating system layer, cloud platform, environment data layer, and management-layer Cloud platform environment. Distributed storage and computing environment is based on Hadoop, including distributed storage, management, and processing of massive spatial data. In this layer, distributed data storage and management use HBASE and HDFS functional modules in Hadoop to establish corresponding spatial data tables based on HBASE and store multiresolution image data vector data and service data. The final processing result data are stored in HDFS, and HBASE can be accessed using SQL-like languages, such as Pig Hive and Zookeepe, which are responsible for coordinating services [10]. The data layer includes multiresolution image data vector data metadata and other related service data. Image data of various resolutions can be stored in different modes. Image tile data of various resolutions are stored in corresponding tables of HBASE, while unsegmented large-scale image data are directly stored in HDFS. Vector data are directly stored in HBASE tables. Metadata consists of two parts: cloud data such as vector raster data. Second, various service metadata are stored in HBASE tables [11]. In this way, Hadoop Distributed File System (HDFS) solves the problem of inconvenient management of small files. Meanwhile, HBASE timestamp can be used to achieve data version control.

The management layer is the core layer and is responsible for managing all the data and other information that need to be scheduled and managed. The management layer provides distributed data storage interfaces, high-performance distributed computing management interfaces, and cloud platform function aggregation interfaces [12]. Distributed storage interface including transparent storage interface based on data sharing, multiresolution image map
service, and image pyramid storage interface. In addition, it also includes multiresolution image data distributed storage interface, vector data distributed storage interface, cloud data storage interface, and other business data storage interfaces for high-performance distributed computing.

3.1.3. Service Layer. According to the characteristics of cloud computing, cloud computing resources are provided to users in the form of network services [13]. Cloud computing services include LaaS, Paas, SaaS, and Daas. Generally, cloud GIS only provides Paas, SaaS, and Daas layer services. The service layer provides service catalogs for applications, mainly including tile-land country service, query service for points of interest, and internal image management service, class H basic service. As your application expands, you can also provide an interface to add new services.

3.1.4. Application Layer. The application layer provides users with one-stop services directly; all resources and GIS functions are provided to users in the form of basic application services, professional application services, and industrial application services. The application layer mainly combines different services through Mashup data sets and service sets to form application services for different purposes to meet the needs of different users. For clients, cloud GIS can provide different services for different client systems, including C\S architecture desktop, GIS B\S architecture, WebGIS mobile GIS, and so on [14].

In the construction of steel structure, information management framework needs to pay attention to the following problems:

(1) The construction process of the message management framework should ensure that the construction party of the project is involved in it. According to the different parts of the project construction, the steel structure project should be designed first, and the production of the prefabricated parts of the shrinkage agent in the steel structure should be constructed [15].

(2) For steel structure construction process to use the technology to the actual data in real-time to share in the whole process of construction, in the process of data transmission to reduce the error rate of information data, the construction management framework is to fully comply with the principle of the steel structure construction period, to achieve the centralized management of data information, ensure the construction project involves more than one unit can be involved, to facilitate Focus on giving reasonable suggestions and opinions.

(3) In the process of the construction of steel structure message management framework, it is necessary to use technology to collect a number of data information displayed in the construction in real time, so as to facilitate the relevant construction party to have a comprehensive understanding of the construction situation, and to formulate a scheme for the problems existing in the monitoring process, so as to improve the safety of construction [16].
3.2. Personalized Virtual Reality Data Mining Model. Virtual reality technology is a brand-new comprehensive information technology that emerged at the end of the 20th century. It integrates digital image processing, computer graphics, multimedia technology, sensor technology, and other information technology branches. Virtual reality is based on computer technology as the core, realistically build a virtual environment that integrates vision, hearing, touch, and so on. VRML is short for virtual reality modeling language [17].

VRML is not equal to virtual reality completely, but it has an important influence on virtual reality technology. As a modeling language to describe virtual environment on the Web, VRML exists independently. As an independent real-time interactive 3D modeling and rendering tool for distributed multimedia integration platform, VRML provides technology that can effectively integrate 2D and 3D text and multimedia materials into a virtual environment, so that users are immersed in it.

VRML is a modeling language; its basic goal is to build interactive three-dimensional multimedia on the Internet, that is, it is used to describe three-dimensional objects and their behavior, and can build virtual realm [18]. Using VRML to realize the interaction with Internet, virtual reality has the following advantages: enrich the media expression form, visual management of collaborative role, improve the user interface of collaborative environment, and enhance the interaction of collaborative environment. It can be seen that the integration of VRML into the development process of online virtual laboratory can not only enhance the expressive force and user acceptance but also achieve a better collaborative work virtualization environment.

The supply chain personalized data mining system is designed into four submodules, which are user-driven module, data storage module, data mining module, and feedback module, respectively. The user-driven module takes management users as the main body and inputs various supply chain information according to user management requirements. The user information must be set with an upload field, which serves as the weight factor for activating the upper module and is also the most important basis for decision-making for the upper module. The data storage module determines the supply chain data storage mode according to the weight factor of the lower module and sets the database scale and the fields in the table combined with the user scale. The storage module is the hardware platform of personalized data mining and logical processing core; it is the embodiment of the space complexity of personalized data mining model of data mining module focus on the whole the computational complexity of personalized data mining model and logic relation, personalized data, how to accurately draw a supply chain need to choose reasonable mining algorithm. At the top is the feedback module, which not only decides what form to use to feedback personalized data to supply users but also feeds back control information to the three lower modules to further optimize the personalized data mining model, as shown in Figure 2:

The following is the function definition and execution process of the four modules. The functions required by the user-driven module include supply chain user data collection, classification, and polling. To facilitate personalized data storage, it is necessary to accommodate multiple input data types and transparently handle the differences of data types, as shown in the following formula:

\[ D = \sum_{j=1}^{N} \sum_{i=1}^{N} P_D(i, j). \]

\( P_D \) represents the supply chain user data set, \( M \) represents the number of data types, \( N \) represents the data dimension, and \( D \) represents the data source set provided to the data storage module after transparent processing. The personalized characteristics of user data need to be set in real time and diversified based on supply chain requirements. The supply chain management demand is obtained according to user demand, and the personalized data mining evaluation ability is carried out according to the information of the uppermost feedback module, so that the personalized mining model has self-renewal and repairability. To accurately locate system preferences, the system has the personalized data polling function according to the user's personalized needs and establishes cross-layer interaction mechanism with the uppermost feedback module. Supply chain management users' evaluation of personalized data mining can be generated in various forms: according to the effectiveness feedback record of users, users can use the conclusion of personalized data mining to set the record evaluation key points of supply chain, personalized satisfaction information group, user evaluation information collection, and personalized satisfaction information of groups.

Data storage module is the data basis of personalized data mining. It optimizes data sources and addresses before data mining, improves the efficiency of personalized data mining, and optimizes computational complexity while reducing spatial complexity [19]. In this module, data storage needs to consider the following factors:

1. User personalized demand preference.
2. The difference between the relevant supply catalog and the personalized preference is to select the most matched and least matched line catalog.
(3) Evaluation and statistics of personalized differences between group users and some individual users of the group. Data mining module as the key module of personalized data mining model, the static data mining system, it is difficult to solve the personalized needs of users of individual and group conflict, so according to individual differences in evaluation and statistics, a real-time dynamic scheduling the following data mining algorithm improve the robustness of personalized data mining model [20].

(1) When the personalized difference is small, that is, less than 0.5, the line product catalog is analyzed based on the characteristics of individual user needs.
(2) When the personalized difference is lower than 0.5, based on the personalized needs of individual users and group users that maximize part of the difference, the output of personalized preference is maximized from the aspects of the supply chain background, behavior, scenic spot characteristics, and so on.
(3) When the individualization difference is greater than 0.5, it indicates that the individualization contradiction between individual users and group users is large, which is difficult to be solved in a single individual. Based on the analysis of user needs and the linear mapping of supply chain, the preevaluation of product matching is given, and the individualization data mining of group decomposition is carried out.

The feedback module can feed back information to the lower three functional modules in the following ways:
(1) Modify the weight factor and pass it to the user drive module through the feedback channel.
(2) The personalized difference statistical information is modified and transmitted to the data storage module and the data mining module, so that the two modules can obtain the relationship between the four functional modules in the personalized data mining model established by the user’s evaluation information of the supply chain established by the personalized data mining in real time, as shown in Figure 3.

The collaboration steps in Figure 4 are detailed as follows:

(1) Collaborative management of data mining: in the personalized data mining model, collaborative execution is carried out among the four submodules according to the time sequence. Based on pipeline technology, the delay of information transmission between module ports is shortened here. This paper defines the personalized multidimensional matrix of data mining, called $d_{c*m}$ multidimensional matrix, where dimension $D$ represents the mining data result set driven by personalized supply chain, dimension $C$ represents the cloud computing demand set driven by personalized, and dimension $M$ represents the interface set used for collaborative management. The data mining and analysis results of each layer are the elements of the multidimensional matrix. The length of the multidimensional matrix reflects the supply chain scale of the pipeline. The scale of dimension $M$ represents the timing sequence and delay of signals transmitted on the information transmission interface. The scale of dimension $C$ records the collaborative execution force and execution efficiency of the cloud platform. The scale of dimension $D$ can represent the collaborative weight among the four submodules in the personalized data mining model.

(2) Cloud computing collaborative management: cloud-to-cloud computing collaboration between different supply chain personalized data mining modules is established to weaken the interference of differentiation level on supply chain management.

The following two points need to be noted:

(1) The mapping relationship between the pipeline scale of supply chain and the dimension of data mining matrix must be considered when applying multidimensional matrix to the computing collaboration between cloud. Based on this, a cloud platform with high dimensional integration can be obtained between different personalized data mining modules of the supply chain. The cloud platform can obtain the management demand of each assembly line of the supply chain in real time. Then, through the clouds to initialize the $d$, $c$, and $m$ parameters, thus multidimensional matrix from multiple instantiation personalized choose collaborative management needs the strongest of the multi-dimensional matrix elements and their mapping of the cloud, on the basis of further optimization between the cloud and the cloud computing collaborative process. For these collaborative process, cloud platform can optimize data points associated polling of the multidimensional matrix.

(2) For the interference of personalized supply chain management generated in the collaborative management process of cloud computing, the cloud platform weakens the elements of each
The multidimensional matrix, which is defined as the closed-loop graph representation of personalized attributes of data mining. The closed loop defines multiple inflection points according to the element scale and value of the multidimensional matrix. These inflection points tend to cause multipoint interference to personalized supply chain management. Therefore, weakening the differential strength of a closed-loop edge is beneficial to the mapping and consistency guarantee of the multidimensional matrix.

(3) On the cloud platform, cloud servers can allocate computing tasks and coordinate resource management to improve resource utilization and personalized data mining efficiency of the cloud platform.

Among them, the storage data of the server of the cloud platform are bound in the closed loop [21]. The resources consumed by the computing task data mining process of closed loop and cloud server will restrict the resource utilization and data mining efficiency of cloud platform. Therefore, multiple closed-loops are used to organically integrate the result set of multidimensional matrix data mining and personalized supply chain management requirements and follow the closed-loop mapping rules, which can optimize the computing process of cloud servers and the resource consumption of collaborative management and help ensure the stability of collaborative supply chain management [22]. The collaborative management efficiency of supply chain cloud computing is shown as follows:
When the differentiation evaluation factor is greater than 0.5, user satisfaction is lower than 2, indicating that users are dissatisfied with the products in the supply chain. In contrast, the proposed collaborative management scheme significantly weakens the interference of differentiation level on supply chain management by fully considering the contradiction of differentiation of supply chain through collaborative management of data mining and computing collaboration between cloud computing and personalized data mining modules.

5. Conclusion

In this paper, a supply chain cloud computing collaborative management technology based on personalized data mining is proposed. In order to effectively guarantee the accuracy and feedback satisfaction of users' personalized demand, based on the analysis of industry characteristics and personalized service characteristics, and based on the multi-objectives such as service time cost and user experience quality, the collaborative management technology of supply chain cloud computing based on personalized data mining is established. The core of the collaborative management mechanism is to optimize user’s personalized needs and solve the impact of differentiation on the supply chain through personalized data mining and collaborative management architecture. The experimental results show that the proposed collaborative management scheme can effectively weaken the interference of personalized differences on supply chain management, significantly improve customer satisfaction, and further guarantee the satisfaction of steel structure construction process requirements.

Data Availability

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

Conflicts of Interest

The authors declare no conflicts of interest.

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| Parameter                  | Value                        |
|---------------------------|------------------------------|
| The user types            | 10 kinds                     |
| Difference evaluation factor | [0.1, 0.9]                   |
| The cloud number          | [2, 5]                       |
| User satisfaction factor  | [1, 5]                       |
| User data scale           | [0.1, 10]GB                  |

| Table 1: Experiment parameter. |

\[ E = \frac{1}{2} \alpha \left( \sqrt{\sum_{i=1}^{N} t_i - P_D(\beta, i)} \right). \]  

\( E \) represents management efficiency, \( \alpha \) represents the weight of game personalized difference optimization, and \( \beta \) represents the weight of collaborative interaction of personalized data model.

4. Interpretation of Result

The core of the collaborative management mechanism based on cloud computing virtual reality technology established in this paper is to optimize users’ personalized needs and solve the impact of differentiation on the supply chain through personalized data mining and collaborative management architecture using virtual reality technology. Therefore, based on the experimental environment shown in Table 1 and from the point of differentiation, the user satisfaction of the proposed scheme and the noncollaborative scheme was compared and analyzed, and the results are shown in Figure 5. All experiments in this paper are completed on a PC, and virtual reality modeling language (VRML) technology is adopted. As can be seen from Figure 5, the satisfaction of the two management schemes in the case of low differentiation.
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