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Retraction

Retracted: Research on Online Virtual Energy-Saving and Environment-Friendly Building Design and Implementation Based on VRML

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] Z. Lai, Q. Zeng, and S. Zhou, "Research on Online Virtual Energy-Saving and Environment-Friendly Building Design and Implementation Based on VRML," *Wireless Communications and Mobile Computing*, vol. 2022, Article ID 5869037, 7 pages, 2022.

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Research Article

Research on Online Virtual Energy-Saving and Environment-Friendly Building Design and Implementation Based on VRML

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In order to change the status quo of lacking holistic and intuitive research on building energy efficiency in China, an online virtual energy-saving and environment-friendly building system based on VRML was proposed. The two subsystems of virtual simulation technology, "virtual reality" and "energy consumption simulation," were integrated and applied to the design research of building energy efficiency. On the basis of inheriting the advantages of the traditional way, the independent application mode of the two was changed. The application analysis was carried out using a real energy-saving demonstration project as the research object. The experimental results showed that the energy-saving rate of the enclosure structure of the three buildings was 35.742%, 30.408%, and 35.696%, respectively. It was concluded that the system provided a more systematic and intuitive method to the design and research of building energy efficiency.

1. Introduction

With the rapid development of China's economy, many high-tech technologies and products have been widely used in people's daily life and work, bringing great convenience to people. Virtual reality technology is a high-tech technology that has been developing very fast in recent years. It establishes a three-dimensional space through panoramic roaming, so that people can interact with the three-dimensional virtual space as if they were there and can experience various sensory sensations in real life. It is a digital human-machine interface technology that uses various virtual reality devices and virtual environments to bring realistic and intense sensory impact to users and facilitate the planning and design of complex large-scale engineering projects [1]. Virtual reality technology has been widely used in many fields such as architecture, military, medicine, and aviation, which has been favored by many researchers and scholars with the advantage of enhancing human subjective feelings.

Architectural space virtualization refers to the establishment of virtual architectural space through high-tech technology (Figure 1). Architectural space has been continuously developed from the traditional two-dimensional and three-dimensional picture display to virtual reality scenes, with strong realism as well as vividness, which is currently extremely valuable technology applications [2]. Users can use the keyboard and mouse to observe the virtual building space in an all-round way, with many observation perspectives such as overlooking, looking up, distant, and close. The virtual building space established by 3D modeling method has precise dimensions, strong sense of experience, and applicability. VRML is a virtual reality modeling language for establishing 3D interactive scenes, which can be combined with Internet technology and applied to 3D scene models established by virtual reality technology. Internet users can browse 3D virtual reality scenes established by VRML technology by browser, and it is an important tool for establishing virtual architectural space [3]. B/S structure is browser or server structure, through the installation of the server to enable users to use the browser to run all functions of the server. With the development of Internet technology, B/S structure has gradually replaced the traditional

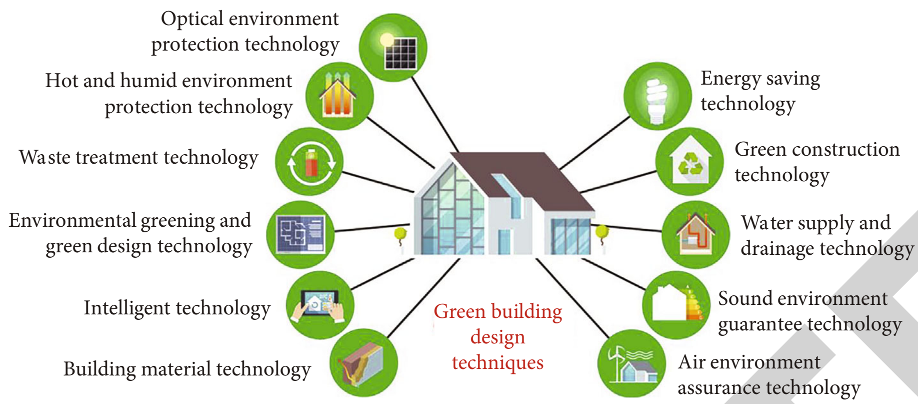

Figure 1: Energy-saving and environmental protection building design.

C/S structure, which is widely used in many fields and the main structure of software system construction.

2. Literature Review

Through the successful application of BIM-based visualization technology in Hangzhou East Station project, Li et al. utilized technologies such as PKPM 3D modeling and construction simulation to solve the complex spatial relationships of the hub project structure and the development of construction plans well [4]. Kong et al. investigated the specific application of BIM technology in the construction process of a large stadium, reflecting the ability of BIM to control the construction of complex-type buildings [5]. Nageib et al. proposed a new visualization and collaborative design method, which was the joint use of the Revit, Fuzor, Civil 3D, and InfraWorks software. Fuzor was used for virtual roaming inside the project to complete the component information viewing and collision detection. And the model information was imported into InfraWorks without loss to complete the visual collaborative design outside the project [6].

Finally, it was concluded that this method could help to proceed more quickly and accurately in the design stage in order to shorten the design cycle, reduce rework, and save costs for the visualized codesign of the subway station. Bai et al. created a virtual architectural teaching environment with the help of VR software Skyline, where the interior and exterior structures of the building were presented in a visualized manner so that students could interact with learning content in a natural way in a virtual environment in real time. It not only greatly increased students' interest in independent learning and facilitated the construction of knowledge but also facilitated the updating and sharing of teaching resources [7]. Dan et al. analyzed a new concept from VR to BIM + VR, proposed to build "BIM+VR teaching application platform," and discussed the implementation and application of the Fuzor software in design teaching and experience summary. The research concluded that BIM + VR jointly assisted planning and design became a direction and the promotion and optimization of VR to BIM would certainly promote its application and development in the field of design teaching and research [8]. Soyaslan et al. reflected on the limitations of VR technology in architectural design teaching by analyzing the current situation in the domestic architectural design field [9]. There are many limitations in today's VR technology, such as high hardware cost and inability to be well compatible with architectural design software platforms. And virtual reality technology is more applied to design expression rather than design process. Its exploration of a teaching practice of BIM-based virtual reality technology-assisted architectural design process provides convenient interoperability between virtual reality and design for many students at the same time in a low-cost way, so that students can master the application of BIM-based virtual reality-assisted design.

With energy and environment issues becoming a global concern, building energy efficiency has become one of the basic strategic plans for sustainable development in China. It has developed rapidly in terms of policy and standard development, product development and promotion, and engineering implementation, with remarkable results. Despite this, there are still many problems with building energy efficiency in China, mainly in (1) insufficient public awareness of energy efficiency, (2) lack of overall consideration in building program design, and (3) insufficient energy efficiency research and implementation. If a more systematic and intuitive design, research, communication, and management platform can be created, it will not only promote the promotion of building energy efficiency concepts, technologies, and products but also provide effective help for the overall design of building programs. Based on this, two subsystems of virtual simulation technology, virtual reality and energy consumption simulation, are proposed to be fully used in building energy efficiency and analyzed in conjunction with actual engineering applications to seek a new approach for the design and research of building energy efficiency [10].

3. Research Methods

3.1. Current Application of Virtual Simulation Technology in the Field of Building Energy Efficiency. Virtual simulation technology is a new technology that uses computers and a variety of specialized physical effect equipment as tools to perform dynamic experimental research of hypothetical or actual systems with the help of system models [11]. It is economical, isolated, safe and controllable, fast, and predictable, which can effectively solve the problem of the connection between abstract thinking and the entities it generates. And its application in the field of building energy efficiency is mainly reflected in the following two aspects.

3.1.1. Aiding Building Scheme Design. Energy-saving, as a performance requirement of modern buildings, has been gradually integrated into the building scheme design. Through software such as 3DMax, virtual simulation technology can create a three-dimensional virtual environment, giving the user a first-person feeling. It also can realize the simulation of building indoor and outdoor temperature and humidity, sunlight, wind environment, thermal environment, etc., and integrates the building energy-saving design into the overall building design. The architect wanders away from the real virtual building scene during building scheme design, making the sense of space in the building design more interactive and flexible, enhancing the authenticity greatly, and providing an active, real-time, interactive design approach for the architect to evaluate and verify the design intent. In the process of energy-saving building scheme design, virtual simulation software such as 3DMax realizes the physical environment simulation of buildings, building simulation and interior design simulation, etc., which assists in energy-efficient building scheme design well [12].

3.1.2. Building Energy Consumption Simulation. Another important application of virtual simulation technology in building energy efficiency is energy consumption simulation. Since a building is a complex system, there are many factors affecting its energy consumption, such as the thermal performance and structural design of the building itself, outdoor climatic conditions, the performance of air conditioning equipment, the distribution of internal personnel, work, and rest patterns, etc. And there are extremely complex interconnections among the factors. This requires a holistic, systematic, and changeable principle to calculate and analyze the energy consumption of the building. It is difficult to obtain accurate and objective conclusions from simple calculations alone, but through dynamic computer simulation calculations, the building energy consumption can be simulated more quickly. And the simulation results can be transformed into energy consumption and thermal comfort indexes that are easily understood by the public with certain standards, which can provide a more comprehensive, realistic, and convenient analysis and evaluation of energy-saving designs. It greatly shortens the design cycle and improves the design quality [13]. Commonly used energy consumption simulation software at home and abroad includes EnergyPlus, DOE-2, TRNSYS, ESP-r, DeST, etc. [14].

3.2. The Integrated Application Concept of Virtual Simulation Technology in Building Energy-Saving with 3DMax. The virtual simulation technology has two subsystems, namely, virtual reality and energy consumption simulation. 3Dmax can realize 3D virtual simulation of buildings, creating an intuitive and interactive platform for building scheme design. Energy consumption simulation software can calculate and analyze building energy consumption, providing effective reference and verification for designers to analyze and evaluate and modify energy-saving schemes. However, these two subsystems are independent of each other. If they are further combined, they will create a more systematic, intuitive, and realistic platform for the design and research of energy-efficient buildings.

The 3D simulation of energy-efficient buildings is realized through 3DMax, so that the proposed buildings, especially the components that have an important impact on energy-saving, are visually and graphically displayed in front of designers and researchers. The computer simulation of building energy consumption is carried out with the help of energy consumption simulation software to study and analyze the energy-saving effect of buildings. Then, the results of building energy consumption calculation and analysis are used as basic attribute information, and the human-computer interaction platform through the virtual reality technology gives the energy efficiency attribute to the 3D building. It can be edited and analyzed and managed in real time, making the research and analysis of building energy efficiency intuitive and visual [15]. All the above ideas can be realized by existing technologies, software, etc. With the integrated application of virtual simulation technology, people will be able to immerse themselves in the building and realize the following functions with just a click of the mouse: (1) a comprehensive and clear understanding of the appearance and structure of building components, material properties, and their impact on energy efficiency; (2) a quick and convenient way to call up the indicators of the overall energy efficiency of the building; and (3) a systematic and intuitive way to grasp the overall effect of the energy-saving scheme. It is an important guide for the design, research, and management of building energy efficiency.

3.3. The Establishment of Building Space Virtual Scene. Using VRML language as the building space virtual scene model building tool, the establishment of building space virtual scene mainly includes the following steps.

(1) Spatial coordinate system and scale are constructed. The required exterior wall of the building space is paved with bricks of the same specification, and the length and width of independent bricks are used as the basic unit of the building space. The bricks of the building space are rendered at the same time, and the scale of the building space is determined by using bricks

(2) The components represent the specific coordinates of the building components in the right-angle coordinate system of the building space, that is, the location of the building components. The minimum coordinate points of building components, namely, the positions built in the building space, can be obtained according to the priority order of x, y,

Table 1: Three schemes of enclosure structure.

Types of enclosure structure	Building I	Building II	Building III
External wall	Polyurethane rigid foam is sprayed on exterior walls	Molded polystyrene panel insulated exterior wall surface	Polyurethane rigid foam is sprayed on exterior walls
Roofing	Polyurethane rigid foam-polyurea elastic	Synthetic polymer membrane	Polyurethane rigid foam-polyurea elastic
	Insulation and waterproof roofing (I)	Coated membrane waterproof roofing	Insulation and waterproof roofing (II)
External window	Tempered hollow louvered glass plastic steel windows	Ordinary hollow plastic steel windows	Tempered hollow louvered glass plastic steel windows

and z axes. After all the components in the building space are established, the physical model of all the components in the building space is summed up to obtain the building space data model, as follows:

$$\text{Building} = \sum \text{Structural}\,(x, y, z). \tag{1}$$

In the equation, Structural (x, y, z) represents the information of the components in the created building space

(3) Building space construction

The steps in the building space are used as an example to analyze the building space entity modeling process, and the steps in the building space are modeled with the following:

$$\text{Steps}\,(a, b, c, d, h). \tag{2}$$

In Equation (2), a and b denote the coordinates of the step position and the length of the steps, respectively. c and d denote the width of the steps and the height of the steps, respectively. h denotes the total number of steps in the building space.

The preliminary architectural space model with contour characteristics is realized through the above process. Based on this, through texture mapping and other steps, the architectural space virtual scene texture, color, environment, and other visual effects of the reality are achieved [6].

3.4. Project Example Design

3.4.1. Project Overview. The three energy-saving demonstration R&D buildings (No. I, No. II, and No. III R&D buildings, respectively) are used as the research objects. The single building design scheme of the three buildings is the same, all of which are 3-story frame structure and 3.6 m high. A single building covers an area of 480 m^2. The ground floor of the R&D building is mainly occupied by exhibition halls, restaurants, and reception rooms, while the second and third floors are mainly occupied by offices. The expected goal of the energy-saving design of the demonstration project is 65% energy-saving for the single building as a whole, with the contribution of the enclosure to the overall energy-saving of the building reaching 20%-30% [16].

3.4.2. Architectural Scheme Design

(1) 3DMax-Aided in the Overall Architectural Design. On the basis of CAD plan design, 3DMax is used to carry out 3D simulation of the building, including virtual simulation of the environment scene around the building and 3D simulation of the building entity, so that the building can be shown realistically in front of people's eyes. Since 3DMax has mature and complete rendering functions, it can achieve good rendering effect with high realism [17]. In the simulation design process, the designer has the freedom to move arbitrarily in real time. According to his own perspective, the scene generated by the system rendering can be changed in time to generate a new scene, thus being able to modify and improve in real time according to his own design ideas.

(2) Enclosure Structure Scheme Design. In order to study and analyze the energy-saving effects of different enclosure structures, the following enclosure schemes (as shown in Table 1) are designed for each of the three buildings according to the requirements of energy-saving design objectives, which are referred to as scheme 1, scheme 2, and scheme 3 in the later part of the research.

4. Analysis of Results

4.1. Simulation of Building Energy Consumption. The DeST-c software was used to carry out the energy consumption simulation [18]. The building model was first established in DeST-c based on the building plan, and then, the following operations were performed.

4.1.1. Parameter Settings

(1) *Parameter Setting for the Enclosure Structure.* The thermal parameters of the enclosure of the three buildings were calculated according to the material construction of the different enclosures, as shown in Figures 2–4, and the parameters were set in DeST-c [19, 20]

(2) *Air Conditioning System Parameter Setting.* Considering the climate characteristics, the indoor relative humidity was set to 60% in DeST-c. The heating season was set from November 15 to March 1 of the

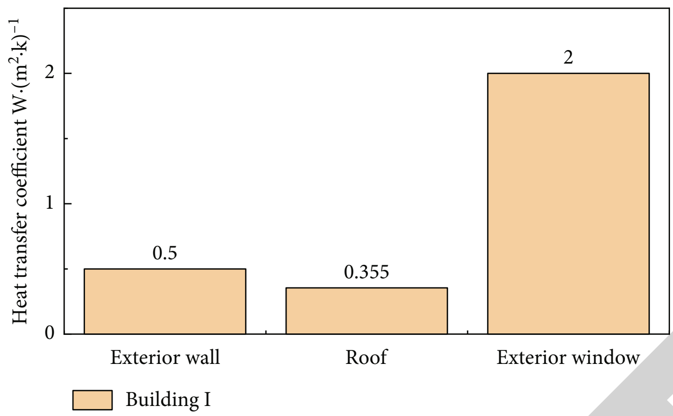

Figure 2: Heat transfer coefficient of the enclosure structure of building I.

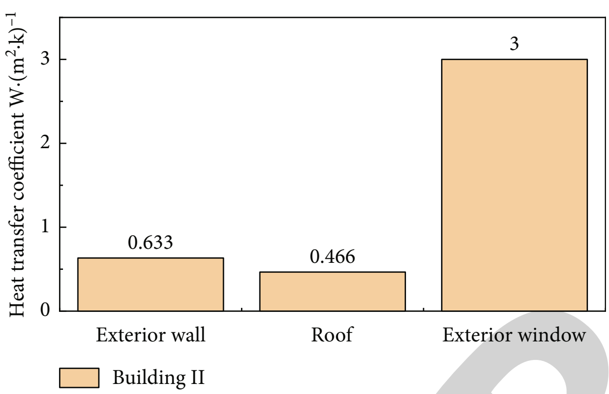

Figure 3: Heat transfer coefficient of the enclosure structure of building II.

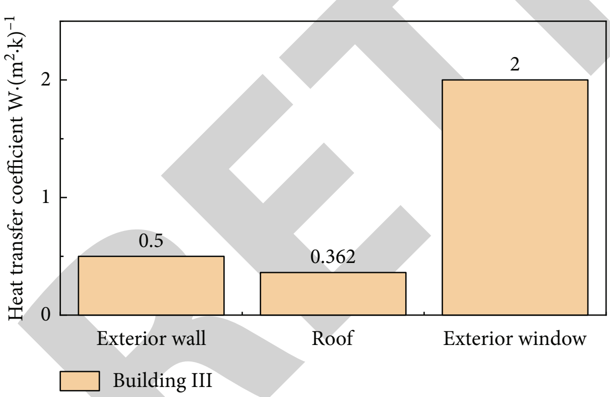

Figure 4: Heat transfer coefficient of the enclosure structure of building III.

following year, and the indoor temperature was set to 18-20°C. The air conditioning season was set from May 15 to October 1, and the indoor temperature was set to 26°C. The number of air changes during the air conditioning time was set to 0, and the number of air changes during the nonair conditioning time was set to 0.5 times/h. According to the characteristics of different rooms in the R&D building, the internal disturbance parameters were set separately in the modeling [21]. According to the characteris-

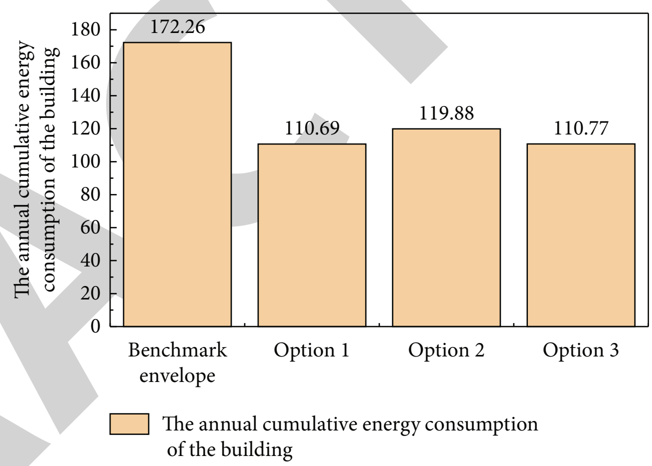

Figure 5: Simulation results of annual cumulative energy consumption of the building.

tics of different rooms in the R&D building, the internal disturbance parameters were set separately in the modeling

4.1.2. Energy Consumption Simulation. Once the various parameters were set, the building could be simulated for energy consumption in DeST-c. In order to analyze the energy-saving effect of the enclosure structure scheme, the enclosure structure under the baseline building conditions specified in the energy-saving design standards for public buildings was used as the comparison scheme, i.e., the baseline enclosure structure scheme [22]. The energy consumption simulation results of the R&D building under different enclosure structure schemes are shown in Figure 5. The energy-saving rates of the enclosure structures of the three buildings for the overall building were 35.742%, 30.408%, and 35.696%, respectively.

4.2. 3DMax-Based Simulation of Building Energy Efficiency. After the 3D simulation of the building by 3DMax, it was imported into the virtual reality software VRP. At the same time, the data of material structure and thermal performance of the enclosure structure were input into the database to realize the management of the properties of the enclosure structure [23]. The energy consumption simulation results were then stored into the attributes of the building scheme. In this 3D visualization platform, there were many function menu buttons. And by dragging and clicking the mouse, the following functions can be realized: (1) arbitrary rotation and scaling of the building model and multiviewing of the building scheme effect, (2) editing and viewing the material structure and thermal performance of different scheme enclosure structures, and (3) viewing and calling the energy-saving effect of different enclosure structure scheme buildings, including annual hour-by-hour energy consumption, all-day hour-by-hour energy consumption, and energy-saving rate [24].

5. Conclusions

The application of two subsystems of virtual simulation technology, "virtual reality" and "energy simulation," in building energy efficiency was analyzed and discussed. It was feasible to combine them with building energy efficiency design and research.

Using 3DMax to assist in the overall design of energy-efficient buildings and combining with VRP virtual reality software, the 3D simulation and property management of energy-efficient buildings fully realized the advantages of predictability, economy, safety, and speed of virtual simulation, which provided a systematic and visualized platform for the design of energy-saving buildings, energy consumption simulation analysis, and energy-saving effect display.

Through the application analysis of the demonstration project example, the energy-saving rate of the enclosure structure of the three buildings to the overall building was 35.742%, 30.408%, and 35.696%, respectively, which met the requirements of the energy-saving design standard of public buildings and the expected energy-saving target of the project. It was feasible. The smaller the heat transfer coefficient of the enclosure structure, the more significant the energy-saving effect.

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 that they have no conflicts of interest.

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