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Computer-Aided Design AND APPLICATIONS

Interactive Design of Interior Environment of Residential Buildings Based on 3D Modeling

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Abstract. With the development of science and technology, Computer-aided design (CAD) is more and more widely used in architectural design. Especially in the interior environment design, its advantages are more obvious. This research takes residential buildings as the object, and realizes the interactive design of indoor environment through computer aided 3D modeling. This paper mainly uses computer 3D modeling technology, combined with the interior environment design theory, and through case analysis, discusses its application in the interior environment design of residential buildings. Firstly, the indoor environment model of residential buildings is established through computer 3D modeling. Then, based on design requirements, interactive design is carried out, including spatial layout, selection of decorative elements, color matching, etc. Finally, the design effect is verified through simulation experiments. The interactive design of the interior environment of residential buildings based on computer aided 3D modeling can effectively improve the design efficiency and design quality. Through 3D modeling, designers can visually see the design effect, making it easy to modify and optimize. Through interactive design, personalized design can be carried out according to user needs to improve user satisfaction. Computer aided 3D modeling has a broad application prospect in the interior environment design of residential buildings. Future research can further explore its application in the design of other types of buildings' indoor environment, and how to combine new technologies, such as virtual reality, artificial intelligence, to carry out higher level interactive design.

Keywords: Computer-Aided; Residential; Interaction Design of Indoor Environment
DOI: https://doi.org/10.14733/cadaps.2024.S7.207-224

1 INTRODUCTION

In today's rapidly changing technology, the application of computer-aided 3D modeling technology in the field of architectural design has become increasingly widespread. The emergence of this

technology provides designers with a new perspective, enabling them to present and understand design solutions more intuitively and deeply. Especially in the interior environment design of residential buildings, the application of computer-aided 3D modeling technology enables designers and users to better understand and experience the design scheme, thus improving user satisfaction. Chen et al. [1] analyzed the edge facilities of home appliance architecture assisted by CAD cloud. The cloud platform can use machine learning algorithms to process and analyze the collected electricity consumption data, in order to identify and predict the patterns and trends of household electricity consumption. For example, time series prediction algorithms can be used to predict electricity consumption for a period of time in the future, providing reference for demand side management. Based on the results of processing and analysis, cloud platforms can send control commands to smart home devices, optimize household electricity efficiency and save energy. For example, adjusting the temperature of the air conditioner and controlling the brightness of the lights can reduce electricity consumption and reduce energy costs. The cloud platform can provide a visual user interface, facilitating users to view and control the status and parameters of smart home devices. Users can interact with cloud platforms through mobile applications, web pages, intelligent voice assistants, and other means to achieve remote and automated control. With the continuous increase of smart home devices and the changing needs of users, the system needs to have scalability and stability to adapt to the growing data volume and processing needs. Computer aided 3D modeling technology can not only help designers and users better understand and experience the design scheme, but also realize the interactive design of indoor environment. This design approach makes the design process more flexible and personalized, and can be adjusted and optimized according to user needs and preferences, thereby improving the satisfaction and acceptance of the design. Fuchs et al. [2] analyzed the key factors in building additive design. Through the analysis of the functions and characteristics of Computer-aided design (CAD) in engineering architecture, it introduces the envisaged design potential process. Using CAD software, designers can create complex geometric shapes and free-form designs, which may be difficult to achieve in the traditional building manufacturing process. Through additive manufacturing technology, these designs can be accurately transformed into physical models or finished products, providing architects and designers with greater creativity and freedom. Additive manufacturing technology can quickly produce complex geometric shapes, allowing designers to iterate and optimize designs more quickly. By combining CAD software and additive manufacturing technology, designers can achieve the entire process from design to manufacturing in a short period of time, thereby improving design efficiency. CAD software and additive manufacturing technology can support customized design, providing unique and personalized design solutions for each customer. This technology can meet customers' needs for specific sizes, shapes, and materials, and provide highly customized interior design solutions. Therefore, it is undoubtedly of great theoretical and practical significance to study the interactive design of the interior environment of residential buildings based on computer-aided 3D modeling. This study explores and realize the interactive design of the interior environment of residential buildings based on computer aided 3D modeling.

In order to achieve this goal, this study will conduct in-depth research from the following aspects: firstly, conduct in-depth research on the basic principles and methods of computer-aided 3D modeling technology; Secondly, it comprehensively analyzes the design elements and design methods of the indoor environment of residential buildings; Then, explore and implement the interactive design method of indoor environment based on computer aided 3D modeling; Georgiadou [3] introduced and analyzed the regional development of Building information modeling. It analyzes a semi structured visual framework for regional architectural information. By combining CAD software and BIM technology, designers can use 3D models for design, enabling faster iteration and optimization of designs. In addition, designers can use visual optimization tools to evaluate and validate the feasibility and effectiveness of design solutions, thereby reducing design errors and repetitive work. Through the application of BIM technology, designers can collaborate during the design process to achieve more comprehensive and accurate design solutions. In addition, designers can use the visualization function of BIM technology to evaluate

and validate the feasibility and effectiveness of design solutions, thereby obtaining more accurate and high-quality design solutions. Designers can conduct spatial planning in three-dimensional space to better manage and optimize the use of indoor space. This technology can help designers better coordinate the relationships between different functional areas and achieve more efficient spatial planning. In summary, CAD Building Information Modeling (BIM) visual optimization technology can bring advantages such as higher design efficiency, more accurate design solutions, lower costs, and more optimized spatial planning to residential projects. However, in order to achieve these advantages, it is necessary to choose appropriate software and equipment, and ensure that designers and teams have the relevant skills and knowledge to utilize these technologies for effective design and manufacturing. Hou et al. [4] used sensors, cameras, and other devices to collect data from construction sites and convert it into digital twin models. This model can simulate actual construction situations, including building structures, equipment, personnel flow, etc. Through the digital twin model, potential safety hazards can be identified, such as personnel intensive areas, equipment operation conflicts, Operational risk risks, etc. The use of digital twin technology can monitor the situation of construction space in real time, identify potential safety issues in a timely manner, and take corresponding measures. Through the digital twin model, the actual situation of the construction space can be displayed to construction personnel, reminding them to pay attention to safety issues and improve their safety awareness. Through CAD digital twin technology, digital twin models of construction sites can be created, providing virtual simulation training for construction workers. This training can be conducted in a safe environment without worrying about the risks and dangers in actual construction. Through the digital twin model, workers can understand the actual situation of construction sites, including the layout of buildings and equipment, engineering processes, and safety regulations, in order to better prepare for actual construction. CAD digital twin technology can simulate and optimize the construction process of construction sites to improve the safety conditions of workers. The digital twin model can simulate different construction schemes and strategies, evaluate their effectiveness and costs, and select the optimal solution. This optimization can involve adjustments to construction plans, arrangement of equipment layout, and path planning for material transportation. In terms of research methods, this study will adopt a combination of theoretical research and empirical research. First, through literature research and theoretical analysis, the basic principles and methods of computer-aided 3D modeling technology, as well as the design elements and design methods of the indoor environment of residential buildings are deeply studied. Then, based on computer aided 3D modeling technology, explore and realize the method of interactive design of indoor environment. Finally, the effectiveness of the proposed design method is verified through case analysis. On the Technology roadmap, this study will first conduct basic theoretical research, then conduct methodological research, and finally conduct empirical research. In the stage of basic theory research, we will deeply study the basic principles and methods of computer-aided 3D modeling technology.

In the phase of method research, we will explore and realize the method of interactive design of indoor environment based on computer aided 3D modeling technology. In the empirical research stage, we will verify the effectiveness of the proposed design method through case analysis. Through this Technology roadmap. In smart cities, fog computing can be applied to multiple systems, such as intelligent lighting, environmental monitoring, garbage management, and other fields. Javadzadeh and Rahmani [5] conducted cloud computing situational awareness analysis for smart cities. Fog computing can be applied to the field of health care, such as health management and disease prevention through real-time monitoring and analysis of Health data of urban residents. In addition, fog computing can also support remote healthcare and medical data analysis, improving the efficiency and quality of medical services. The data collected can be used to optimize the control strategy of traffic lights. By monitoring the lifestyle habits and device usage of family members in real-time, automated control and energy management of smart home devices can also be achieved. This can improve the comfort and energy efficiency of family life.

In the interactive design system of residential building interior environment, CAD image data transmission will occur when image data is called and displayed. Regardless of the image size and

pixel size, noise interference will occur during transmission, affecting image quality. For a decoration design system, if the image information is not clear enough, it is impossible to achieve good decoration design results. In order to improve image quality, CAD digital processing technology is usually used to remove noise from the image, improve the signal-to-noise ratio of the image, and achieve the goal of highlighting image features. The scene matching of interior decoration renderings can not only use people, but also elements such as plants, decorations, and animals. You can choose more suitable materials from people's daily lives. The innovation of this study lies in:

(1) The display control system based on FPGA (Field Programmable Gate Array) is not only suitable for high-speed real-time systems, but also can greatly save hardware resources and avoid design risks due to its simple structure, small delay, and fixed timing.

(2) In the post-processing of rendered images, emphasis is placed on the proportional relationship between the scene and the 3D model to achieve consistency in size, and more emphasis is placed on the relationship between matching the scene and the angle and crosscutting degree in the perspective to maintain high consistency.

Section 2 describes the relevant research on the Interaction design of architectural interior environment in the context of digital development. Section 3 conducted CAD computer and integrated circuit analysis on the system design of digital image processing technology. Find the most reasonable digital image enhancement method by analyzing the results obtained by applying different processing methods. Section 4 elaborates on the relevant content of stereo image resolution algorithms. Section 5 adopts the digital processing based virtual indoor modeling method designed in this article for virtual display. Section 6 summarizes the research results. This design method not only helps designers to more intuitively display and understand the design scheme, but also improves the efficiency and quality of the design.

2 RELATED WORK

Kaewunruen et al. [6] conducted railway construction and maintenance for digital twins. It constructs building information monitoring applications for specific project assets. Based on the analysis results of Digital Twin, develop a maintenance plan for railway bridges. For example, based on the results of structural analysis, determine the parts and times that need to be strengthened; The time and content of maintenance that needs to be carried out. Digital twins can develop elastic management plans for railway bridges by simulating and predicting potential disasters, unexpected situations, etc. This includes dealing with situations such as natural disasters, traffic congestion, safety accidents, etc. that may cause damage to railway bridges. Khan et al. [7] conducted the construction of blockchain smart furniture for the Internet of Things. Use a distributed neural network model to train and learn user behavior patterns and device operation status, predict and identify potential network attacks or abnormal behaviors. A trained machine learning model needs to be evaluated and optimized to improve its prediction accuracy and robustness. Through blockchain technology, incentive mechanisms can be designed to encourage users to participate in network security management and protection. For example, a blockchain based reward mechanism can be designed to motivate users to provide secure and reliable data and feedback, and jointly improve and optimize machine learning models. In addition, attention needs to be paid to the compatibility and interoperability between blockchain and smart home devices, as well as how to address issues such as data ownership and privacy protection. When implementing machine learning methods for blockchain based smart home network security, it is necessary to comprehensively consider technical and management perspectives to ensure the reliability and security of the system. Liu et al. [8] carried out the application of virtual VR Thematic analysis for industrial development and design. The Interaction design system of industrial buildings based on virtual reality technology can be combined with behavioral Robotics to study and optimize architectural design schemes. Firstly, it is necessary to clarify the research issues and objectives. For example, study how to optimize the workflow in industrial building

design, improve work efficiency and safety, and consider the application of behavioral Robotics. Determine the design variables and parameters that need to be optimized based on research objectives and problems. For example, it can include the robot's movement path, the layout of the work area, and the interaction between the robot and human workers. Use virtual reality technology to create a virtual environment for industrial buildings. You can use software such as Sketchup and 3ds Max to create a 3D model, and use virtual reality headwear devices for interactive experiences. Import the behavioral robot model into a virtual environment. Liu et al. [9] continued to focus on the spatial design of smart building homes. It has constructed and analyzed an intelligent spatial residential technology framework. It collected information from home sensors using the Internet and support vector machines. The digital twin model needs to have a certain degree of scalability and flexibility to adapt to changes in different building structures and safety requirements. At the same time, it is necessary to consider the optimization and maintenance of the model, as well as how to cope with the increase in data growth and complexity. By integrating with other building management systems, cross departmental information sharing and collaborative work can be achieved. Máder et al. [10] conducted a simplified survey on the construction of building measurement spaces based on information. Indoor positioning systems can accurately locate devices by receiving signal strength, radio waves, Bluetooth signals, and other methods. Through indoor positioning systems, the position and movement trajectory of equipment within the building can be obtained, thereby obtaining spatial information and layout of the building. Laser scanner is a fast 3D modeling tool that geometric shapes of buildings. By scanning the surface of buildings, which can then be converted into 3D models through software. Intelligent sensors and IoT technology can obtain spatial information and environmental data of buildings by monitoring various parameters such as temperature, humidity, lighting, etc. These data can be monitored and analyzed in real-time through IoT platforms. Nicoletti et al. [11] conducted an analysis of infrastructure asset management control for bridges. Operational modal analysis can be used to determine the structural dynamic characteristics of bridges, including natural frequencies, vibration modes, and damping. This information is crucial for establishing digital twin models and predicting structural responses. By analyzing this data, developers can better understand the structural characteristics and performance requirements of bridges. Operational modal analysis can be used to study the response characteristics of bridges under different vibration conditions. This helps developers understand the response of bridges under different frequencies, amplitudes, and load conditions, as well as potential vibration issues. Through these analysis results, developers can optimize the dynamic response prediction ability of the digital twin model and develop corresponding vibration control measures.

Parn and Edwards [12] elaborated on the cyber threats faced by digital building environments. We conducted network asset fusion analysis on common data environment vulnerabilities and blockchain deterrence. The digital building environment involves a large amount of sensitive data, such as building design, construction plans, and operational data of building equipment. Once these data are obtained by unauthorized third parties, it may lead to serious problems such as intellectual property infringement and construction safety impact. There may be various malicious software and viruses in the digital building environment, which may attack building equipment and systems, leading to system crashes, device damage, and other issues. In order to address these network threats, a series of security measures need to be taken in the digital building environment, such as data encryption, access control, firewalls, intrusion detection systems, etc. At the same time, it is also necessary to strengthen internal management and training, improve employees' safety awareness and skill level, to ensure the security and stability of the digital building environment. Pepe et al. [13] conducted high-resolution spatial structure restoration through two-dimensional and three-dimensional orthophoto photographs of building structures. Using different directions of architectural projection for multi view stereoscopic model application. It analyzed the development of image acquisition and analysis applications for ancient buildings. Complex buildings require a variety of technologies and tools, including stereo photogrammetry, Structured light scanning, laser scanning, multi view photogrammetry, etc. These technologies can

provide accurate 3D models and 2D representations, thereby helping us better understand the structure and appearance features of objects. Multi perspective photogrammetry is a method of obtaining images of objects from different angles using multiple cameras, and then reconstructing a three-dimensional model of the object from these images. This method can be used to establish a three-dimensional model of a building and reconstruct its structure and appearance through images from multiple angles. Rasmussen et al. [14] constructed a high-level model of building structure with topology ontology as the core. The architectural elements it contains play an important role in the distributed interdisciplinary information exchange under the development of the Internet. The architectural topology ontology can identify and link various elements of a building by using resource identifiers (URI) in the W3C linked data cloud. These URIs can be used to link building topology ontology with other ontologies and datasets, thereby achieving the sharing and integration of building information. The architectural topology ontology also includes some attributes to describe the attributes and relationships of architectural elements. For example, a room can have attributes such as its name, size, purpose, decoration, etc. In addition, the architectural topology ontology can also define some constraints and rules to describe the logical relationships and behaviors of architectural elements. By using architectural topology ontology, architects, designers, and engineers can better manage and share architectural data, thereby improving design efficiency, reducing costs, and improving quality. At the same time, this ontology can also provide basic data and information support for the development of intelligent buildings and smart cities. Sepasgozar et al. [15] analyzed the spatial efficiency of home development in an intelligent building environment. This system can achieve intelligent management and control of the home environment by connecting various intelligent devices to a unified IoT platform, improving the living experience and comfort. The smart home system needs to process and analyze the collected data, and make decisions based on user preferences and needs. By processing and analyzing data, the system can automatically control and adjust the home environment. By combining artificial intelligence and Internet of Things technology, intelligent management and control of the home environment have been achieved, improving the living experience and comfort. At the same time, the system also needs to consider user security and privacy protection, as well as how to improve energy efficiency and equipment lifespan through data analysis and optimization algorithms.

Shim et al. [16] constructed a digital bridge information maintenance and analysis system for 3D information. By using digital twin virtual space simulation and combining digital images, the quality cycle of the bridge has been enhanced. By establishing a 3D digital twin model, real-time monitoring and diagnosis of bridges can be achieved. The model can simulate the structure and behavior of the bridge, and by comparing it with actual monitoring data, the state and health status of the bridge can be determined. This can help bridge maintenance personnel identify potential problems and damages in a timely manner, and take necessary measures for repair and maintenance. The model can predict the possible faults and damages of bridges based on historical data and current monitoring results. The models can improve the safety and reliability of the bridge, reduce maintenance costs and downtime, and also enhance the skills and abilities of maintenance personnel. However, in order to achieve these advantages, it is necessary to choose appropriate software and equipment, and ensure that maintenance personnel have the relevant skills and knowledge to utilize these technologies for effective maintenance and management. Wang et al. [17] conducted a construction analysis of the production safety of optical digital technology. Through the construction of spatial information model of digital technology, it has established the building Big data blockchain under virtual reality. The use of laser scanning technology can quickly obtain the three-dimensional coordinates and models of buildings. By converting laser scanning data into data format in 3D modeling software, a digital model of a building can be accurately established. Zhou et al. [18] conducted a virtual interaction analysis of the functional modules of intelligent furniture. A data model for intelligent home scenarios was constructed using Sketchup software. In the Layers panel of the program, create a new layer to store different parts of the model. For example, you can create one layer to store furniture models and another layer to store wall and floor models. Before importing, it is necessary to adjust the

position and size of the furniture model. Accurate position and size adjustments can be made to furniture models. Afterwards, add textures and colors to different parts of the model. For example, you can add wallpaper textures to walls and wood grain textures to floors. Zhu [19] analyzed the imaging measurement of indoor design lighting by constructing a data embedding control architecture for CAD intelligent images. Embedded digital images are also widely used in smart home systems. For example, the door opening method of Smart lock follows the development of Biometrics, including fingerprint identification technology. This kind of technology enables the Smart lock to identify and verify the user's identity, improving the security of the home. In addition, embedded digital image technology can also be applied to other interior design fields. Zielonka et al. [20] conducted a home remote development control system that integrates the Internet of Things and computer intelligence. The home control device of the home was optimized by optimizing computer intelligent parameters. Use CAD software to simulate and optimize the smart home environment, and determine the optimal convection plan by simulating temperature, humidity, air quality, and other conditions under different conditions. CAD software can provide a visual interface for users to simulate and optimize. Based on the simulation and optimization results, control through smart home devices to achieve the best convection effect. For example, the optimal convection effect can be achieved by controlling parameters such as temperature and wind speed of the air conditioner, as well as controlling the switch and position of windows. Through the Internet of Things technology, smart home devices are connected and integrated with other devices to achieve data sharing and collaborative work. For example, smart home devices can be connected with smart watches, Smart speaker and other devices to achieve remote control and automatic control of smart home devices. The implementation of the CAD intelligent Internet of Things system for the optimal flow of smart homes requires comprehensive consideration of multiple factors, including hardware device selection, software system design and implementation, user needs and feedback, etc. At the same time, it is also necessary to continuously update and improve the system to adapt to the constantly changing user needs and market environment.

3 ABOUT DIGITAL IMAGE PROCESSING TECHNOLOGY

3.1 Image Processing and System Design

Image processing technology has played a very important role in promoting the process of industrial digitization, effectively improving production efficiency, product quality, and safety. On modern production lines, machine vision systems are widely used for detecting, recognizing, and tracking objects to achieve automated production. Image processing technology can help machine vision systems accurately recognize and locate objects, thereby ensuring the accuracy and efficiency of the production process. Usually, digital image acquisition of actual objects is combined with sensor devices, and digital expression of image processing results. Through the computer, the picture can be changed from two-dimensional to three-dimensional to enhance the reality of the picture and make people immersive. On modern production lines, machine vision systems are widely used for detecting, recognizing, and tracking objects to achieve automated production. Image processing technology can help machine vision systems accurately recognize and locate objects, thereby ensuring the accuracy and efficiency of the production process. Image processing technology is widely used in product quality control, which can detect defects and defective products, classify and grade them. Through image processing technology, the appearance and quality of products can be quickly and accurately detected, thereby improving production efficiency and product quality. 3D modeling technology can help engineers and designers create real-world 3D models in computers for simulation, design, and analysis. Image processing technology can help extract features and details from 3D models, thereby improving the accuracy and authenticity of the model. What the computer needs to complete is to run related programs in order to get the required image processing results, which provides a simple platform for image processors. Using computer graphics technology to draw sketches in the computer, modification and editing become

convenient and quick, avoiding repetitive work, and improving drawing speed and drawing precision and accuracy.

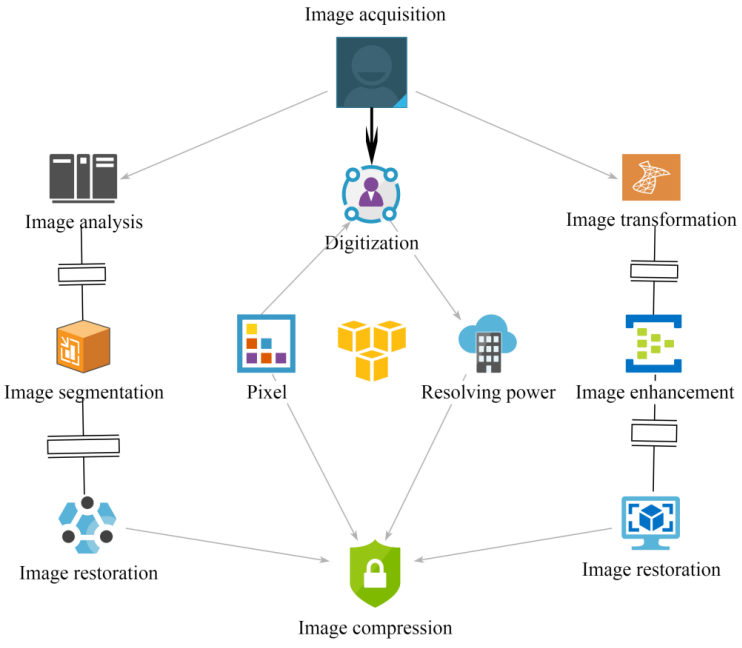

Figure 1: Digital image processing technology.

Figure 1 shows digital image processing technology. Generally, there are two basic methods for digital image processing: one is to process the image in the spatial domain, that is, to directly optimize the image itself in the image space, so as to improve the image quality. Another method is to transform the spatial image from the spatial domain to the frequency domain, so as to improve the image quality. C/S structure mode is used to meet the needs of high security, big data transmission and frequent data processing of interior design system, while B/S structure mode is used to meet the overly complicated management process and extensive management scope of the system. Apply image processing technology to interior decoration design to realize the construction of interior design system (as shown in Figure 2).

Real-time digital image signal processing algorithms often use different levels and different kinds of processing such as image summation, difference calculation, two-dimensional gradient calculation, filtering, image segmentation and regional feature extraction.

When users operate, they need to drag and drop the model picture from the material library to the corresponding position. In order to ensure the fluency of hardware equipment, they need to match the terrain network and terrain grid. In the virtual scene, the area terrain is made into 500 m×500 m specifications. In order to adapt to the matching of terrain and model, the material model should be made uniformly in planning, so as to prevent the model shape gap from being too large.

3.2 Image Enhancement Technology

In order to obtain a better enhancement effect for an image, it is not enough to use a single enhancement method in many cases. At this time, it is necessary to play the advantages of each method by comprehensively using multiple enhancement methods, so that the processed image can have a better enhancement effect (Figure 3). Due to different digital images and different

image processing effects, the digital image enhancement processing methods to be used will also be different. At this time, it is necessary to give play to people's subjective initiative to analyze specific images, and find the most reasonable digital image enhancement means by analyzing the results obtained by applying different processing methods.

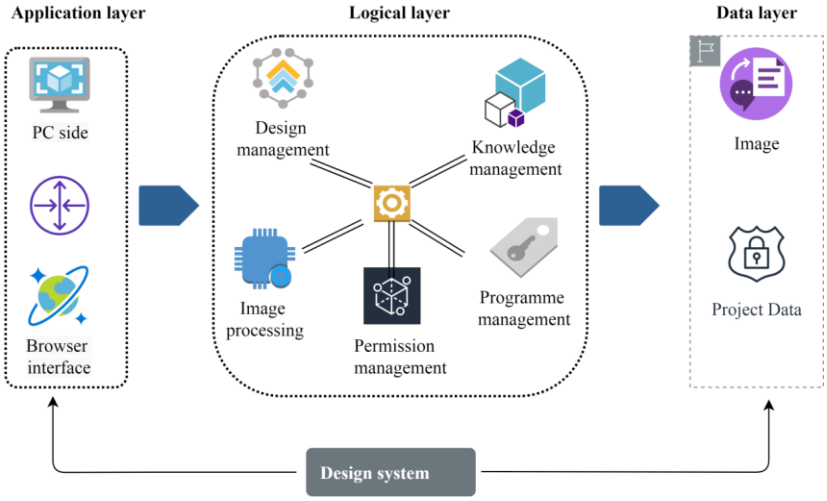

Figure 2: Overall structure of image design system.

Figure 3: Comparison of plan before and after treatment.

In order to ensure that the interior design system reaches the ideal state, it is essential to detect whether all the characteristics and functions of the system are operating in the expected way according to the test indicators in the experiment. The test content of the interior design system of image processing and virtual reality technology and the traditional interior design system is the support of the scene.

4 ALGORITHM ANALYSIS

4.1 Median Filtering

The noise is often mixed with the edge of the image, and the detail features of the edge of the image will inevitably be weakened when the noise is removed. Thereby reducing the contrast of

the image, leading to blurred image and difficult identification. Therefore, how to design the image filter so that it cannot only remove the noise but also keep the details of the image is the difficulty of image denoising. Median filtering can often play a good role in eliminating salt and pepper noise points in digital images. Using digital processing technology to reduce the noise interference of images in the system. Suppose there is an image containing noise in the system:

$$S(i,j)=f(i,j)+n(i,j) \tag{1}$$

Where, $i,j=1,2,\cdots,N$. $f(i,j)$ and $n(i,j)$ represent the original image signal and white Gaussian noise with zero mean value respectively.

After the virtual image is established, color correction and color difference comparison are also required. The correction relationship is as follows:

$$\Delta\mu=2\pi\frac{\Delta L}{\varphi/N} \tag{2}$$

The spatial method is used to operate the pixels in the image. The formula is as follows:

$$f(a,b)=s(a,b)\cdot t(a,b) \tag{3}$$

It is the key to ensure the image recognition to match the feature attributes in the established 3D image. If two images are extracted consecutively, if there are the same attributes in the middle, the texture pattern mapping algorithm can effectively extract features and improve the speed of attribute matching. Before use, the corresponding relationship matching is required:

$$E_r=J_\alpha J_\beta J_\vartheta E_{\exp}(-\Delta i) \tag{4}$$

4.2 Histogram Processing

Histogram processing is an important method in image processing, which can express and process images from the perspective of internal grayscale levels. Histograms contain rich information and can be used to enhance image display, adjust image contrast, perform image segmentation, and more.

$$S=\int_0^x P(t)dt \tag{5}$$

$$V=\int_0^x P(z)dz \tag{6}$$

$$Z=G^{-2}(V) \tag{7}$$

It is the most basic statistical characteristic of an image. Actually, the gray image histogram is a discrete function:

$$p_f(f_k)=n_k/n \tag{8}$$

$$S_k=T(f_k)=\frac{L-1}{n}\sum_{i=1}^{k}n_i \tag{9}$$

Where, f_k represents the gray level of the image to be enhanced, and S_k represents the corresponding new gray level after f_k equalization transformation. n is the total number of pixels of the original image, and L is the total number of gray levels of the image.

The geometric transformation of image can also be used for geometric correction of deformed image to obtain accurate image. The geometric transformation of an image does not change the pixel value of the image, but changes the position of the pixel. The geometric transformation of images can be described by a set of linear equations:

$$X=a_0x+a_1y+a_2 \tag{10}$$

$$Y = b_0 x + b_1 y + b_2 \tag{11}$$

4.3 Algorithm of Stereo Image Resolution

To find a boundary between marginal and non-marginal, we can use the concept of variance completion. The variance of a variable mathematically represents the distance it deviates from the expected value, describing a degree of dispersion. The standard deviation is the average deviation of each data from the expected value. Calculate each gradient value and variance on the gradient image, and then sum them to the square root. As the total standard deviation, it can be expressed as:

$$\delta_{\max} = \sqrt{\frac{1}{N}\sum_{i=1}^{k}(M_i - M_{\max}{}^2)} \tag{12}$$

Where, K is the maximum value of the gradient whose pixel is not 0, and N is the total number of pixels in the image.

Accurate texture pattern mapping algorithm can describe the spatial feature information of indoor landscape, and optimize the indoor landscape effect and light. The actual visual effect of the presented virtual sample image of interior design is almost the same as that of the simulated virtual image. The selection of moving times of foreground, middle and back scenes in a stereoscopic image manuscript is obtained after the resolution of the image is determined. Table 1 shows the number of moves corresponding to different layers:

Image Width	*Prospect*	*Medium shot*	*Background*
10-20	17	9	19
20-30	3	6	41
30-40	3	3	44
40-50	27	10	29
50-60	2	5	39
60-70	14	5	18
70-80	30	2	42
80-90	21	7	30
90-100	6	9	25

Table 1: Movement times corresponding to different layers.

$$g(x,y) = f(\text{int}(a+0.5), \text{int}(b-0.5)) \tag{13}$$

Where, int(x) is the rounding operation.

The main application in image processing is to observe and process images by using the basic operations of morphology.

$$e = 2\left[\int_w I(x+d) - I_i(x)\right]^2 \delta(x)dx \tag{14}$$

As the distance from the original pixel gets farther and farther, the adjacent pixel's weight becomes smaller and smaller. Generally, in order to realize simplicity, the local arithmetic mean can be used as the mapping relation, which can be expressed as:

$$f_k(i,j)=\frac{1}{2}\sum_{i=1}^{1}\sum_{j=1}^{1} f_{k-1}(2i,2j) \tag{15}$$

In order to realize the above functional algorithms, the image production software tool shall be able to realize the functions of modeling and drawing, product portfolio and two-dimensional and three-dimensional view switching. In order to reduce the calculation amount of image processing in the spatial domain, digital image processing technology processes images in the transform domain through Fourier transform, Walsh transform, discrete cosine transform and other image transformation methods, which greatly improves the efficiency of image processing.

5 EXPERIMENT

In order to verify the effectiveness of the virtual design method of interior decoration based on digital processing designed in this paper, comparative simulation experiments are designed. Virtual presentation of the interior decoration process of a residential area. First, the traditional virtual interior design method is used to create virtual images, and then the virtual interior design method based on digital processing designed in this paper is used for virtual presentation. Then the quantitative analysis and comparison of the two methods were carried out. After the image acquisition card converts the optical signal into a digital signal and sends it to the image preprocessing module, the data image is processed to eliminate various interferences, and then the corresponding image information is extracted from the processed digital image and converted into numbers and symbols. A communication protocol similar to circular data transmission is used to assemble a frame, which is transmitted to the data processing module of the visual equipment through the data switch. See Table 2 for the comparison between the traditional design method and the digital processing effect in this paper.

Number of experiments	*Noise removal time(s)*		*Rendering time (s)*	
	Polytropic limit system	System of this article	Polytropic limit system	System of this article
1	4.27	3.39	6.96	3.68
2	4.54	3.97	4.77	3.63
3	4.93	2.36	5.18	2.71
4	5.51	2.48	6.96	2.12
5	5.31	4.59	5.62	3.61
6	4.84	3.71	5.02	3.19

Table 2: Comparison of image processing efficiency.

It can be seen from Table 2 above that the system in this paper spends less time in rendering and denoising. The denoising time is kept below 5s, and the rendering time is kept below 4s. The system is efficient in digital processing and image processing.

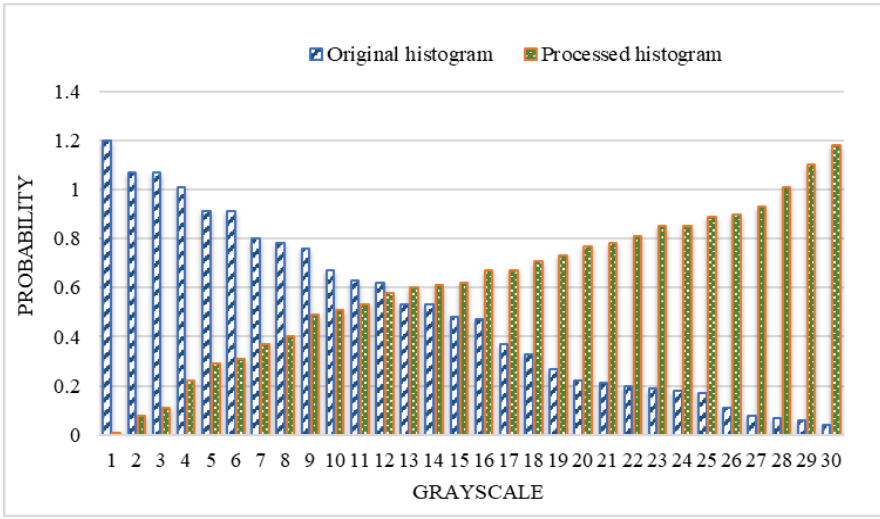

Figure 4: Gray level change of histogram before and after processing.

The mapping relationship between the grayscale level of the original image and the grayscale level of the processed image refers to the corresponding grayscale value between the two. In image processing, it is often necessary to adjust the grayscale level of the image, such as adjusting the image to black and white, adjusting the brightness and contrast of the image, and so on. Scale the grayscale level of the original image to a certain ratio, so that the grayscale level of the processed image is within a certain range (Figure 4). This article scales the grayscale level of the original image from 0-255 to 0-128, which means dividing the grayscale value of the original image by 2. According to nonlinear mapping, the gray level of the original image is converted. For example, using the sigmoid function to perform nonlinear transformation on the grayscale level of the original image to achieve grayscale level adjustment. Compare the grayscale level of the original image with a threshold, map grayscale levels greater than or equal to the threshold to 1, and map grayscale levels less than the threshold to 0, thereby achieving binary processing.

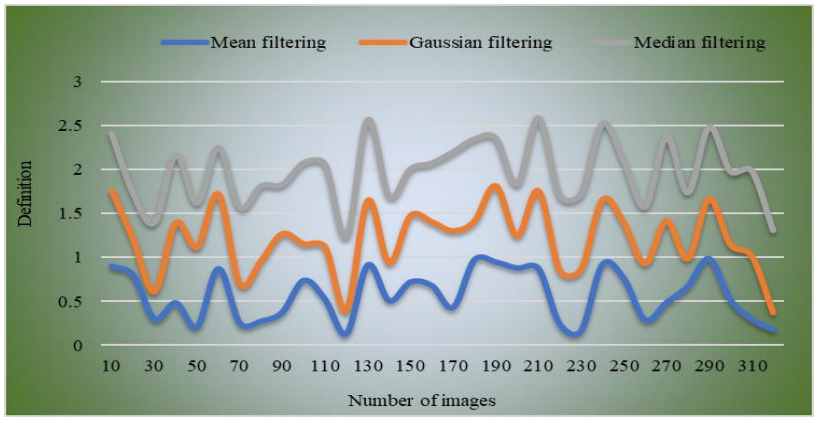

Figure 5: Comparison of three filtering results.

By comparing the above effect picture (Figure 5), it is obvious that the effect picture definition of mean filtering and Gaussian filtering is lower than that of median filtering. In addition, the contrast

between the effect of Gaussian filtering of template A and that of template B shows that, except for the slight change in the blur, there is no obvious change. Unlike the average filter, which will cause the image edge to blur when removing noise, the median filter can not only effectively remove the particle noise, but also better preserve the edge characteristics of the image, so as to obtain a satisfactory filtering effect.

First, use the production tools in the software to cut the scene matching picture to an appropriate size, so that the significance of the scene matching picture can be more highlighted in the process of use. However, to achieve this, it is also necessary to have a good control ability in the use of the overall library materials, which can make a more reasonable use of the use and production of selected areas.

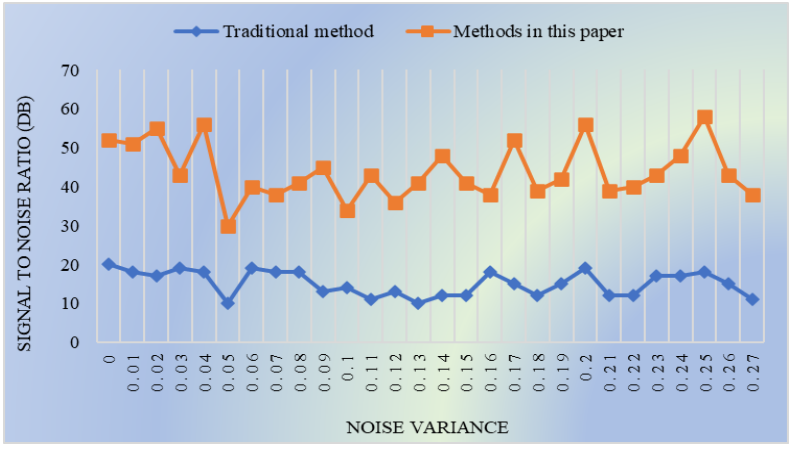

Figure 6: Comparison of noise removal effects.

Under different noise variances, the peak signal to noise ratio of the method in this paper is the highest, which further shows that the method in this paper has better image denoising effect (Figure 6). After denoising, the image effect is clear, the image details are well saved, and there is no unclear situation such as mosaic grid.

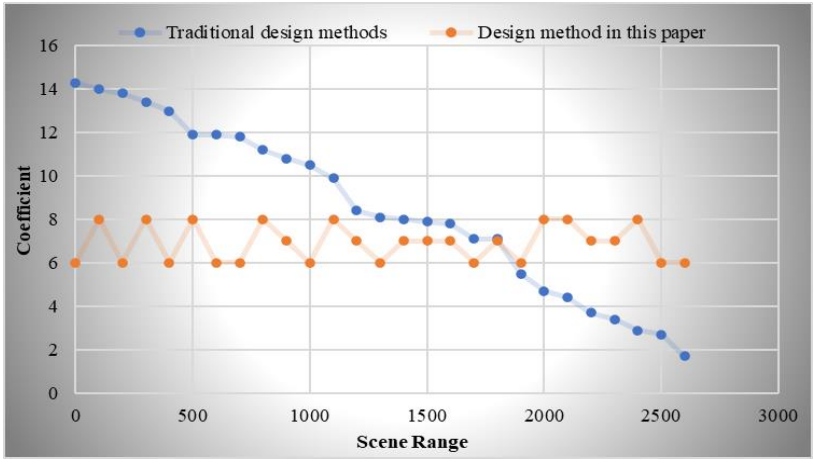

Figure 7: Coefficient test results of two design system support scenarios.

The key step of establishing the overall environment is the construction of light environment. Adjust materials and lights. Material and light are mutually affected. Material is very important for highlighting the overall decoration texture. Light not only has the lighting function, but also is an important part of setting off the scene atmosphere. When adjusting, the designer should consider the overall material and lighting, and adjust according to the actual needs, so as to highlight the sensory effect of the interior and exterior design of the whole building.

As can be seen from Figure 7, the range of test scene coefficients of the interior design system used in this paper fluctuates between 6.0 and 8.1 with the increase of scene area, while the traditional design method decreases with the increase of scene area. This shows that this method can meet the design requirements, and its application range is more stable.

In the final post-processing, after the stereo image original is cut, because each part of the image (especially the overlapping area between the layered parts) will make the subsequent picture incomplete after separation, and then the incomplete part of the image needs to be repaired. If there is no defect in the layered image, it is not necessary to supplement the image. In Photoshop, the main tool for copying stamps is to complete the supplement of images. Because the image background in the original image has some defects, it is only necessary to supplement the background layer (as shown in Figure 8).

Figure 8: Image integrity processing comparison.

Compared with the plane image, the effect presented by the three-dimensional image is more lifelike and gives people a strong visual impact. Generally, a stereo image produced by an image manuscript with bright colors, clear layers and not too complicated scenery can better simulate the stereo effect. After the 3D model is established, the next step is to establish a moderate environment and analog camera to improve the overall indoor scene design requirements. It can be seen from Figure 9 that the indoor effect designed by the system in this paper has a clear visual effect, approaching to the peak value of 1. The light effect is connected with the light effect in the real environment. The details of the furniture are clear and obvious, and there are arrow marks in the effect picture. When browsing the effect picture in the system, you can switch the interface by clicking the corresponding control button. If you need to print, you can cancel the button display and browse the effect picture directly.

On the basis of the above calculation results, using computer image processing technology, the internal structure data of the hotel is converted into images, which are spatially processed through modeling and rendering, so as to improve the living and working environment inside the hotel. Therefore, we compare the traditional graphic design method with digital design as a whole, and get the following table 3 analysis.

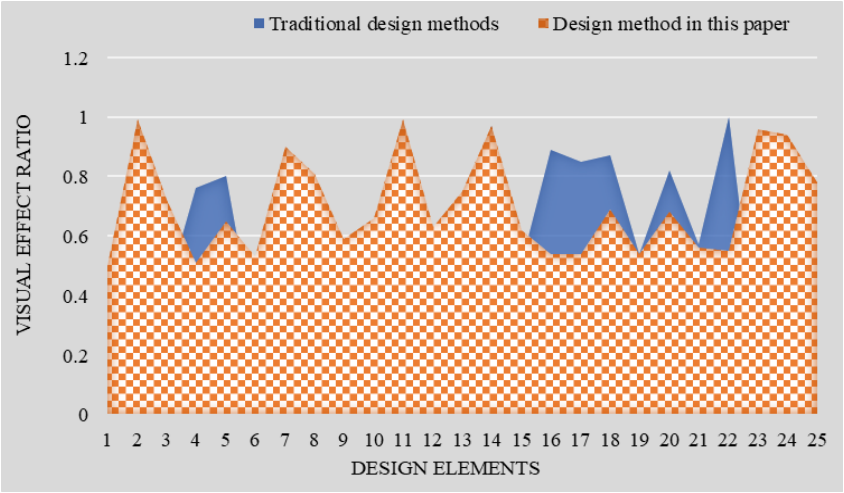

Figure 9: Comparison of visual effects.

Method	*Experiment time*	*Definition*	*Image magnification capacity/multiple*	*Need to modify*
Traditional method	300	900	1.5	REQUIRED
Methods in this paper	200	1980	5	NOT REQUIRED

Table 3: Overall comparison results.

From the above analysis, it can be seen that the interior design method used in this paper takes a shorter time, the imaging resolution of the system reaches 1980, and the image magnification is increased by three times, which ensures the quality and efficiency of virtual imaging. Compared with the traditional plane interior decoration method, the application of image processing technology to the interior decoration of home stay hotel can enrich the application of decorative effect colors and increase the design efficiency by 36.98%.

6 CONCLUSIONS

This research deeply studies the basic principles and methods of computer aided 3D modeling technology, as well as the design elements and design methods of the indoor environment of residential buildings. A method of interactive design for indoor environment of residential buildings based on computer aided 3D modeling is successfully proposed. The effectiveness of the proposed design method was verified through case analysis. This design method can not only help designers more intuitively display and understand the design scheme, but also improve the efficiency and quality of the design. Moreover, it can enable designers and users to better understand and experience the design scheme, and improve user satisfaction. In addition, this design method can also realize the interactive design of indoor environment, making the design process more flexible and personalized., The case analysis of this study is mainly based on a single design case, which

fails to fully consider the diversity of different types of residential buildings and different user needs. Secondly, the interactive design method in this study mainly relies on computer aided 3D modeling technology, and fails to make full use of other Interaction design technologies and tools. Therefore, future research can be improved in the following aspects: firstly, expanding the scope of case analysis to consider more types of residential buildings and more diverse user needs; The second is to explore and use more Interaction design technologies and tools to improve the efficiency and quality of interactive design. Future research will continue to deeply study the application of computer aided 3D modeling technology in residential building interior environment design, especially in interactive design. At the same time, we will also explore and study other Interaction design technologies and tools to enrich and improve the methods and means of interactive design. In addition, we will also attempt to apply interactive design methods to other types of architectural designs to verify their universality and applicability. Overall, future research will focus on promoting the widespread application of computer-aided 3D modeling technology in the field of architectural design, in order to improve the efficiency and quality of architectural design. Satisfy user needs and promote innovation and development in architectural design.

7 ACKNOWLEDGEMENT

This work was supported by 2023 Hunan Provincial Social Science Achievement Evaluation Committee General Self raised Project: Research on Activity Space Design Strategies Based on the Psychological Needs of Rural Children (No. XSP2023YSC040).

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