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Computer-Aided Design AND APPLICATIONS

# Construction of Computer Aided Instruction System for Indoor Design Based on VR 3D Modeling

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**Abstract.** With the gradual growth of modern sci & tech, the use of 3D graphics technology in indoor design is more and more extensive. Bringing more realistic experience and interactive immersive experience into indoor design teaching through VR technology can make the original boring and abstract one-way indoctrination education lively and interesting, and greatly improve the teaching quality. In this article, an optimization algorithm for 3D modeling of virtual reality (VR) based on multi feature detection is proposed, and a real-time and interactive virtual interactive indoor design system is developed according to interactive indoor design computer-aided instruction (CAI) system. By selecting the optimization strategy of virtual scene, the system optimizes the indoor virtual scene and provides a new solution for the construction of indoor design CAI system. The system simulation test shows that the VR 3D modeling optimization algorithm based on multi feature detection proposed in this article has better performance and higher efficiency in the indoor design instructional system. The application of VR can not only lower the threshold for students to learn knowledge, but also improve the quality of indoor design CAI. Therefore, VR technology will be the most innovative and promising technology in the field of indoor design teaching in the future.

**Keywords:** Virtual Reality; 3D Modeling; Computer-Aided Instruction; Indoor Design; Instructional System
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## 1 INTRODUCTION

Whether designers and consumers can communicate effectively and meet the needs of users in terms of materials, colors, spatial composition, soft furnishings, light and shadow effects, etc., not only directly affects the daily living standards of consumers, but also is very important for the

indoor design industry to keep up with the market and reach a higher level. Interior design is an important branch in the field of modern design, with its core being the planning and design of interior spaces to meet people's living and work needs. In interior design, the floor plan is a crucial aspect that directly determines the functionality and comfort of the space. However, for beginners, understanding and drawing floor plans is a challenging task. Therefore, to help students better grasp the relevant knowledge of floor plans. Chang et al. [1] explored the practical significance and teaching effectiveness. By comparing traditional teaching methods with AR assisted teaching methods, this study analyzed students' mastery and application abilities of knowledge during the learning process, as well as their evaluation and feedback on the two teaching methods. The research results indicate that the AR assisted teaching method can more effectively help students understand and master the relevant knowledge of interior design floor plans, and improve their learning enthusiasm and practical ability. For interior space design, the introduction improved the overall artistry of design and eliminated the problem of insufficient authenticity in traditional work, so as to achieve better design effect and meet the living needs of people in the new era to a higher extent. Nowadays, with the rapid growth of computer graphics, many thoughts and inspirations that people could not express in words and drawings have been realized. With the intensification of population aging, dementia has become a common elderly disease. Due to the varying degrees of impact on cognitive and behavioral abilities of dementia patients, they require special care and care. Nursing facilities are one of the important places to provide such care services, and interior design is one of the important factors affecting the sense of home for dementia patients. The design of furniture and layout should also take into account the needs of patients. For example, avoid using sharp corners and edges to reduce the risk of injury to patients. At the same time, use materials that are easy to clean and disinfect to ensure hygiene and safety. In terms of layout, private spaces and quiet areas can be set up to meet users' needs for solitude. Chen [2] summarizing the current research status, and proposing future issues that need to be explored. The study used a combination of qualitative and quantitative methods to deeply explore the living environment and sense of home of dementia patients. The research results indicate that interior design has a positive effect on improving the sense of home for dementia patients in nursing facilities, but there are also some problems, such as improper design and poor environment.

Therefore, future research should further explore how to improve the sense of home and quality of life for dementia patients by optimizing interior design. The widespread use of VR technology has changed the processing mode of large-scale data in the computer field, promoted the growth and progress of sci & tech, and created great social and economic benefits for mankind. Bringing more realistic experience and interactive immersive experience into indoor design teaching through VR technology can make the original boring and abstract one-way indoctrination education lively and interesting, and greatly improve the teaching quality. By applying VR technology to the experimental teaching of indoor design, students can experience the "real environment" with wearable devices, and through the interaction with 3D objects and animation environment, the classroom concentration and knowledge understanding can be significantly improved. BIM is a digital technology based on 3D models, which can express all information and elements of buildings in a digital manner. BIM is not only a three-dimensional model, but also contains all relevant information about the building, such as the properties of building materials, the performance of building elements, etc. SAR is an AR technology that combines virtual objects with real-world objects, enabling virtual objects to be presented in a more realistic manner in the real world. Jin et al. [3] explored the application of Spatial Augmented Reality (SAR) based on Building Information Model (BIM) in architectural design collaboration. By combining BIM with SAR technology, a more realistic virtual environment can be created, enabling designers and stakeholders to more intuitively and comprehensively understand and evaluate architectural design solutions. This article provides a detailed introduction to the principles and applications of SAR technology, as well as the design and implementation of a BIM based SAR system. At the same time, this article also explores the advantages and potential issues of SAR technology in architectural design collaboration, and proposes suggestions for future development.

Indoor design is a creative process that combines aesthetics, function and environmental factors. Therefore, indoor design teaching needs a method that can make students understand and feel the design process intuitively and comprehensively. Traditional instructional methods of indoor design are often difficult to achieve this effect, while the emergence of computer-aided design (CAD) and VR technology provides new possibilities for indoor design teaching. CAD system can express the design idea by drawing two-dimensional drawings, but it is difficult to show the 3D spatial relationship intuitively by this method. In contrast, VR technology can create a real virtual 3D environment, so that students can feel the sense of space and texture of indoor design and better understand and master design skills. For example, the rendering speed and interactivity of virtual scene are insufficient, which leads to poor real-time and interactivity of the system; The model details and texture effects in the virtual scene are not realistic enough, which affects students' learning effect. In order to continuously increase the user's sense of reality, the graphic resolution quality and the complexity of 3D scenes of VR system are also constantly improved, so as to provide better fidelity. Therefore, how to use advanced scene processing methods to build a 3D model of an indoor scene and realize the interaction of people in the scene through path planning has become a very important research direction. With the continuous development of computer widely applied in various fields. In animation design, CAD technology can help designers quickly create 3D models, perform animation production and rendering, and improve design efficiency and quality. At the same time, 3D reality technology is also constantly developing, providing new ways of expression and design methods for animation modeling design. Jing and Song [4] use 3D reality technology to create an animated world and characters that look more realistic. This technology can capture and simulate the physical characteristics of the real world, including improving design efficiency, reducing production costs, and enhancing artistic expression. Finally, it summarizes the application research, and points out the directions for further research and exploration in the future. Its aim is to explore the application of the combination of 3D reality technology and CAD in animation modeling design, analyze its advantages and application prospects.

With the continuous acceleration of urbanization, the field of interior design and decoration is facing increasing challenges. As an important component of a city, the importance of interior design and decoration in office buildings is becoming increasingly prominent. Traditional interior design and decoration methods have many problems, such as low design efficiency and unpredictable design schemes. Virtual reality technology has become an important tool in the field of interior design and decoration. Juan et al. [5] proposed a virtual reality-based decision support model for interior design and decoration of office buildings, aiming to improve design efficiency and effectiveness. This model utilizes 3D modeling and virtual reality technology to construct a virtual environment for office buildings. Through this model, designers and owners can evaluate and compare different design schemes in a virtual environment to determine the best design scheme. At the same time, the model can also simulate and predict the implementation of the design scheme to verify its feasibility and effectiveness. This article provides a detailed introduction to the implementation process and specific functions of the model, and verifies its effectiveness and practicality through case analysis. A complete indoor design scheme requires indoor designers to pay a lot of repetitive work, but it is difficult for traditional graphic design renderings and two-dimensional construction drawings to fully express the designer's design concept. With the progress of sci & tech, CAD and VR technology are widely used in the field of indoor design. However, the application of existing CAD and VR systems in indoor design teaching still has some limitations. Therefore, the purpose of this study is to develop an optimization algorithm of VR 3D modeling based on multi feature detection, and build a real-time and interactive virtual interactive system for indoor design, which provides a new solution for the construction of indoor design CAI system. The research has made the following innovations:

(1) In this study, a real-time and interactive indoor design CAI system is developed by using the proposed VR 3D modeling optimization algorithm. The system can not only create realistic indoor virtual scenes, but also realize various interactive operations, such as rotation,

enlargement, reduction and material adjustment, so that students can comprehensively observe and experience all aspects of indoor design.

(2) In this study, an optimization algorithm of VR 3D modeling based on multi feature detection is proposed. Through multi feature detection of indoor virtual scenes, the rendering speed and interactivity of virtual scenes are improved, and the fidelity of model details and texture effects is also improved.

This article first introduces the significance of VR 3D modeling in indoor design CAI, and then combines multi feature detection and DL method to realize the algorithm. Finally, the performance of this algorithm in indoor design CAI system is verified by experiments.

## 2 RELATED WORKS

Lee et al. [6] explored the application of end-user augmented reality in architectural design. Through augmented reality technology, end users can preview architectural design schemes in virtual reality space, and adjust and modify them in real-time. This technology can help users better understand the planning and functionality of infrastructure, reduce delays and additional costs caused by errors in the construction process. At the same time, augmented reality technology can also enhance the effectiveness of design and construction, monitor construction progress in real-time, ensure construction quality, and ensure safety. It listed some application cases and analyzed the advantages and future development trends of augmented reality technology in architectural design. With the increase in urban population density, the probability of emergency situations such as fires also increases. In schools, emergency situations such as crowded personnel and fires pose a huge threat to the personal safety of students and teachers. Therefore, it is crucial for schools to strengthen fire safety education and conduct fire drills. However, traditional fire safety education often relies on written and oral explanations, lacking realism and practical opportunities. Therefore, using virtual reality technology for fire drills has become a new research direction. Lorusso et al. [7] studied the use of an evolutionary virtual reality platform for fire emergency evacuation from school buildings. This study used a high-level virtual environment to simulate a real school building and incorporated fire emergencies. Participants are required to evacuate in the shortest possible time and with the highest efficiency. The research results indicate that the use of evolutionary virtual reality platforms can effectively simulate real emergency situations and provide participants with realistic experiences. In addition, the study also proposed some suggestions to help people evacuate better in emergency situations. The practicality and practicality of virtual reality in the fixed devices and equipment industry have become increasingly important in recent years. Virtual reality technology can provide many advantages for this industry, including interactive and distributed immersive validation, as well as the construction of intelligent and sustainable building environments. Firstly, virtual reality technology can be used to design and plan fixed devices and equipment. By using virtual reality technology, designers can design and test in a virtual environment to discover and solve problems before production. This not only reduces errors and modification costs, but also improves design quality and efficiency. Prabhakaran et al. [8] explored the practicality and practicality of virtual reality in the fixed installation and equipment industry, including interactive and distributed immersive validation, as well as the construction of intelligent and sustainable building environments. The article lists some application cases in the fixed device and equipment industry, and discusses how these applications use virtual reality technology to improve efficiency and reduce costs. Finally, the article summarizes the importance and future development trends of virtual reality practicality and practicality in the fixed devices and equipment industry.

Building Information Model (BIM) is a digital technology used to describe the design, construction, and operation and maintenance processes of buildings and infrastructure. BIM is not only a three-dimensional model, but also contains all relevant information about buildings, such as space, materials, costs, etc. Thereby improving design quality and efficiency. However, BIM still has some limitations, such as a lack of intuition and immersion. Safikhani et al. [9] discussed how

to expand, and architecture by combining immersive virtual reality (VR) technology. It first introduces the basic concepts of BIM and VR, and then analyzes the applications of BIM as well as the advantages of VR in the stages of architectural design, construction, and operation and maintenance. Next, this article proposes a building design method based on BIM and VR, and provides a detailed introduction to the design process, technical implementation, and application cases of this method. Finally, this article summarizes the importance and future development trends of BIM and VR based architectural design methods. With the continuous development of virtual reality technology, more and more fields are applying virtual reality technology to improve work efficiency and experience. Among them, the application of virtual reality technology is particularly prominent in areas such as architectural design, interior design, and industrial design. In these fields, designers typically need to create a virtual environment to better understand and evaluate the feasibility and effectiveness of design solutions. However, traditional virtual reality applications typically only support single user operations and cannot meet the needs of multiple users designing and collaborating simultaneously. Therefore, developing a multi user immersive virtual reality application that supports multi user collaborative operation is particularly important. Tea et al. [10] conducts comprehensive observation and operation in a virtual environment. It imports existing CAD files into a virtual environment for display, editing, and rendering. This application is based on virtual reality technology and multi user collaboration technology, allowing multiple users to simultaneously immerse themselves in a common virtual environment and engage in real-time communication and collaboration. It provides a detailed introduction to the functions and characteristics of the application, as well as how to achieve remote collaboration and collaborative design through the application. In addition, the extensive application and potential of this application in the fields of architectural design, interior design, industrial design, etc. were also explored.

In interior design, the design thinking mode is a systematic way of thinking, which includes multiple stages such as analysis, synthesis, evaluation, and implementation. In interior design teaching, the design of design thinking patterns is very important. Urban social art is an art form that takes the city as the background and social life as the theme. In interior design, urban social art can provide designers with more creative inspiration and innovative ideas. Interior design is an indispensable part of architectural design, and for interior designers, the design thinking mode is very important. In interior design, urban social art is an important design element that can provide more creative inspiration and innovative ideas for interior design. Triatmaja [11] explored the design of design thinking patterns in interior design teaching, as well as the application of urban social art in interior design. Wu and Han [12] conducted a systematic evaluation of the application of artificial intelligence and virtual reality technology in interactive interior decoration design. By comparing the characteristics of traditional and modern interior design, the application effects of artificial intelligence and virtual reality technology in interactive interior decoration design were analyzed. The article also proposes the trend and development direction of future indoor decoration interaction design. 3D computer-aided simulation technology provides an efficient and accurate tool for interior design. This technology allows students to predict and evaluate design solutions before actual design by creating virtual 3D models. This helps students learn in practice and helps them master the core concepts of interior design. Interior design is a comprehensive discipline that involves multiple aspects such as spatial planning, aesthetics, and human-computer interaction. In traditional teaching, students often find it difficult to master these complex concepts, resulting in poor learning outcomes. To address this issue, Yang [13] proposed an indoor design optimization teaching method based on 3D computer-aided simulation. This method provides students with a practical learning environment through simulation technology, helping them better understand and master the key elements of interior design. This teaching method not only improves students' learning outcomes, but also cultivates their innovative thinking and practical abilities. Zhang et al. [14] introduced a geometric structure based computational preprocessing algorithm for developing powder bed fusion additive manufacturing (PBFAM) processes. This algorithm can automatically identify the geometric structure of each powder layer in the powder bed and generate accurate preprocessing data for the PBFAM process. The

development of this algorithm is of great significance for improving the accuracy and efficiency of the PBFAM process. Zhang [15] introduced a virtual indoor landscape design method based on 3D vision. This method obtains image information of indoor scenes through three-dimensional visual technology. Then, image processing and computer vision techniques are used to preprocess and extract features from the images, in order to construct a three-dimensional model of the indoor scene. On the basis of 3D models, virtual reality technology can be used to design and showcase indoor landscapes, providing interior realistic design experience.

In this article, an optimization algorithm of VR 3D modeling based on multi feature detection is proposed. By selecting the optimization strategy of virtual scene, the indoor virtual scene is optimized, which improves the real-time and interactivity of indoor design CAI system and provides a new solution for the construction of indoor design CAI system.

## 3 METHODOLOGY

### 3.1 Interior Scene Understanding and Layout Estimation

In the indoor design CAI system, the understanding and layout estimation of indoor scenes is a very important part. Through the understanding and layout estimation of indoor scenes, so as to better design and teach. Moreover, students can better understand the structure and layout of indoor space through the system, so as to better learn and master the knowledge and skills of indoor design. In the understanding and layout estimation of indoor scenes, the commonly used method is to extract indoor structure and layout information by analyzing and processing the images of indoor scenes. Specifically, the indoor structure and layout information can be extracted by image processing techniques, such as edge detection, region growth, contour analysis, etc. For example, the indoor contour information can be obtained by detecting the edges in the image; By growing the region in the image, the indoor layout information can be obtained.

Traditional image processing technology often has some problems, such as slow processing speed, low accuracy, and easy to be disturbed by the environment. With the gradual growth of modern sci & tech, the application of 3D graphics technology in indoor design has become more and more extensive, especially in the research and application of rendering indoor design realism in recent years, it has become possible to improve the immersion of indoor design modeling by using virtual technology. In this study, an optimization algorithm of VR 3D modeling based on multi feature detection is proposed. By fusing multi-features of indoor scenes, the accuracy and real-time performance of indoor scene understanding and layout estimation are improved. In this article, indoor scene estimation and semantic classification based on multi feature detection are adopted, and two tasks are simultaneously integrated into the algorithm for training, and the results of object semantic classification and spatial layout estimation of the scene are obtained, as shown in Figure 1.

Firstly, the algorithm preprocesses the image of indoor scene, including denoising, enhancement and other operations to improve the quality and clarity of the image. Then, by extracting and fusing various features in the image, such as color, texture, edges and corners, the indoor structure and layout information can be obtained. By fusing the multi-features of indoor scenes, the algorithm can obtain the indoor structure and layout information more comprehensively and accurately, thus improving the accuracy and real-time performance of indoor scene understanding and layout estimation.

The area where the visual information of the regional indoor image is reconstructed is $S^{'}$, and the edge feature point $\left(x^{'}, y^{'}\right)$ is extracted from the edge contour part of the fuzzy regional indoor image. Calculate the texture distribution of indoor images in blurred areas:

$$w(i,j)=\frac{1}{Z(i)}\exp\left(-\frac{d(i,j)}{h^2}\right) \tag{1}$$

Where $Z(i)$ is the first-order and second-order texture distribution operators.

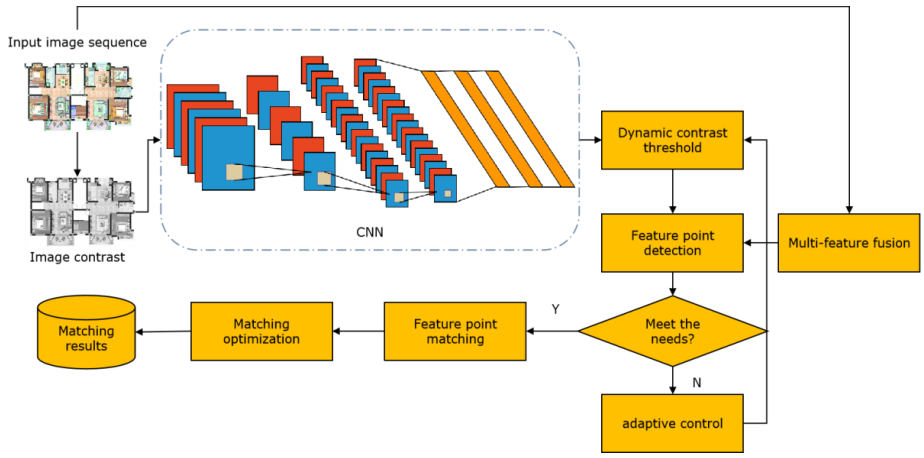


**Figure 1**: Indoor scene understanding and layout estimation.

Analyze the parameters of pixels for visual communication constraints:

$$W^{'} = \frac{1}{2} f\left(x^{'}, y^{'}, z^{'}\right) + E \tag{2}$$

Where: $x^{'}, y^{'}, z^{'}$ is the 3D coordinate value with visual constraint; $E$ represents the weighted component of data.

In the quantitative analysis of image contrast, the image is preprocessed, including noise reduction and enhancement, to improve the quality and clarity of the image. This can help to improve the accuracy and stability of the subsequent contrast analysis. Converting a color image into a gray image is a necessary step in contrast analysis. Grayscale converts each pixel of a color image into a gray value, indicating the brightness of the pixel. By analyzing the contrast matrix, we can get the contrast information of the image. Evaluate the contrast of the enhanced image to check whether the enhancement effect meets the requirements. This process is generally calculated by root mean square:

$$RMS = \left[\frac{1}{n-1}\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2\right]^{\frac{1}{2}} \tag{3}$$

$$RMS = \left[\frac{1}{n-1}\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2\right]^{\frac{1}{2}} \tag{4}$$

$$P\left(x\middle|p\right) = \frac{N\left(dist\left(x, p\right); 0, \sigma_d^2\right)}{N\left(0; 0, \sigma_d^2\right)} * \frac{N\left(\left|N_x * N_p\right|; 1, \sigma_n^2\right)}{N\left(1; 1, \sigma_n^2\right)} \tag{5}$$

### 3.2 Virtual Modeling of Indoor Environment

The virtual modeling system of indoor environment is an important part of the indoor design CAI system which integrates VR 3D modeling. In this study, through the perception and understanding

of indoor environment, the virtual modeling of indoor environment is realized by using convolutional neural network (CNN). Sensing indoor environment is the first step of virtual modeling. In order to obtain the detailed information of indoor environment, we need to use a variety of sensors, such as cameras, lidar, infrared sensors and so on. These sensors can capture all kinds of indoor information, such as object shape, color, material and so on, and provide data support for subsequent virtualization modeling. Understanding indoor environment is the second step of virtual modeling. At this stage, CNN will be used to process and analyze the perceived indoor environment data. CNN is a neural network structure especially suitable for processing image data, which can automatically learn and extract features from input images. Based on the understanding and perception of indoor environment, virtual modeling can be carried out. In this process, 3D modeling technology will be used to build a 3D indoor model according to the indoor environment information. The indoor environment virtualization modeling system based on CNN is shown in Figure 2.

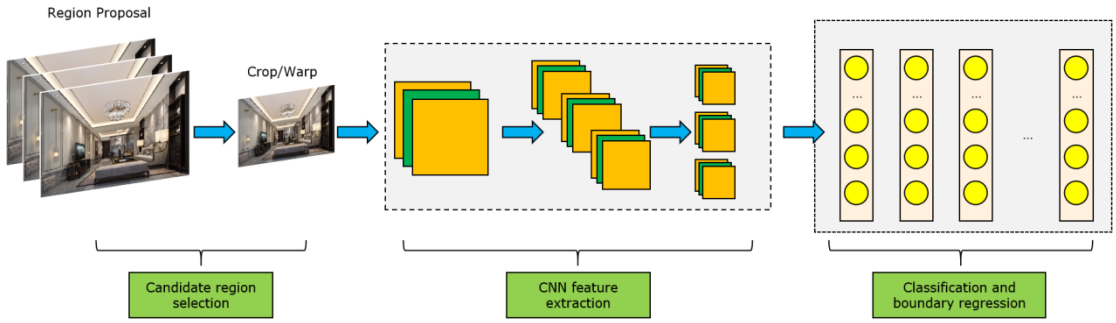


**Figure 2**: Indoor environment virtualization modeling based on CNN.

Assuming that the quantity of images participating in 3D modeling is $n$, and $C_i$ is the internal participation and external parameter of the $i$-th image, $m$ 3D space points are reconstructed, the coordinate of the $j$-th 3D space point is $X_j$, and the objective function optimized by the beam adjustment method is:

$$g(C,X)=\sum_{i=1}^{n}\sum_{j=1}^{m}w_{ij}\left\|q_{ij}-P(C_i,X_j)\right\|^2 \tag{6}$$

Where, $w_{ij}$ is the indicator variable, which represents whether point $j$ exists in image $i$, if point $j$ is in image $i$, $w_{ij}$ is 1, otherwise it is 0. $P(C_i,X_j)$ is the coordinate of point $j$ on image $i$ after projection transformation, and $q_{ij}$ is the actual image coordinate of point $j$ on image $i$.

Iterative optimization for minimum reprojection error:

$$\Delta=-\left(J_f^TJ_f+\lambda I\right)^{-1}J_f^Tf \tag{7}$$

Where $\lambda$ is the weight parameter.

The basic matrix can be deduced from the epipolar geometry constraints outside the two views:

$$F=\alpha\left(e^{'}\right)\times KPK^{-1} \tag{8}$$

Thereby:

$$\left[e^{'}\right]=\begin{bmatrix} 0 & -e_3 & e_2 \\ e_3 & 0 & -e_1 \\ -e_2 & e_1 & 0 \end{bmatrix} \tag{9}$$

$e^{'}$ is the pole on the second image.

Let $\mu=\alpha^2, C=KK^T$, the Kruppa equation can be obtained:

$$FCF^T=\mu\left(e^{'}\right)C\left(e^{'}\right)^T \tag{10}$$

Where $\mu$ is an unknown proportional factor, and matrix $C$ is a positive definite matrix.

In order to improve the real-time and interactivity of the system, it is needed to optimize the generated 3D model. Optimization methods include reducing model complexity, optimizing model texture and illumination, etc. The goal of optimization is to reduce the amount of calculation and storage space as much as possible on the premise of ensuring the visual effect of the model.

## 4 SYSTEM TESTING AND ANALYSIS

VR model generation network for indoor design based on multi feature detection is designed. The data set selects the common data sets in the field of indoor design, including indoor scene pictures and 3D model data of different styles and scenes. These data sets are preprocessed and labeled to train and test the optimization algorithm of VR 3D modeling. In the experiment, the application effects of VR 3D modeling optimization algorithm based on multi feature detection, traditional SVM algorithm and PSO algorithm in indoor design instructional system are tested. By comparing the retrieval matching results of different algorithms, it is found that the algorithm proposed in this article is superior to the traditional SVM algorithm and PSO algorithm in accuracy and running speed, as shown in Figure 3.

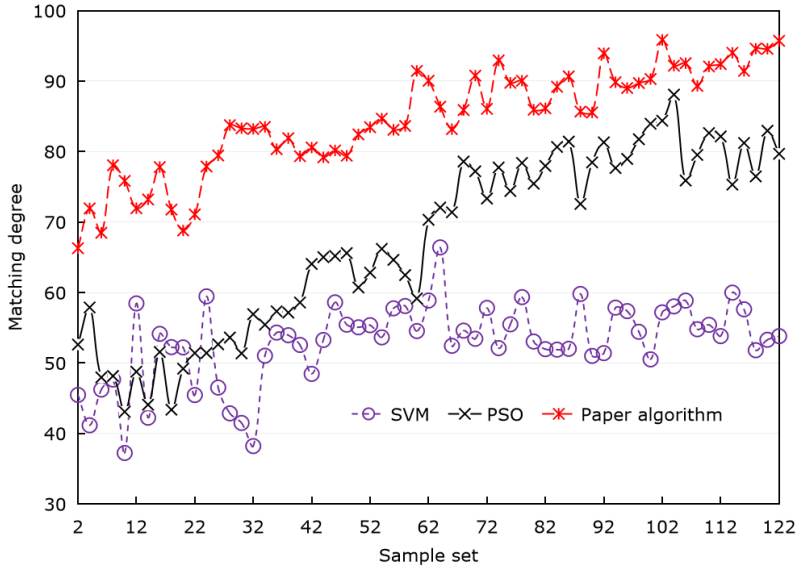


**Figure 3**: Algorithm retrieves matching results.

This article meets the requirements of indoor design teaching in retrieval and matching performance. Based on deep learning (DL) technology, this algorithm can automatically learn and extract the features of indoor scenes, avoiding the tedious work and subjective errors of manual feature extraction.

The feature dimension reduction effects of two DL models are tested, as shown in Figures 4 and 5. For the deep belief network (DBN) model, the greedy training method is used to reduce the dimension of features. This is because layer-by-layer greedy training can more fully explore the hierarchical relationship between features, thus obtaining a more representative feature representation. The results show that, compared with DBN model, this model shows better effect in feature dimension reduction and can improve the efficiency and interactivity of indoor design instructional system.

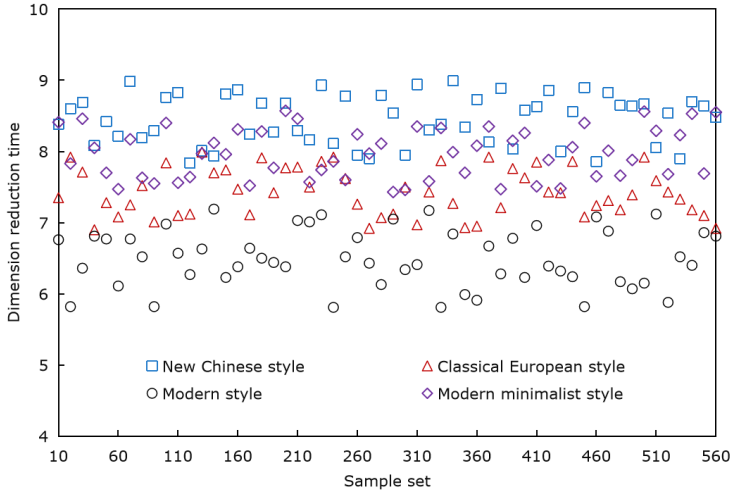


**Figure 4**: Dimension reduction time of DBN model.

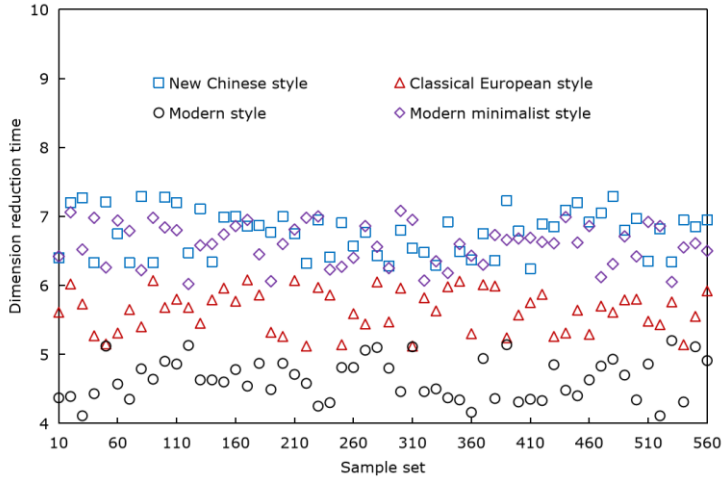


**Figure 5**: Dimension reduction time of the model in this article.

The model in this article adopts the method of multi feature detection, which combines various features, thus improving the ability of identifying and modeling different types of indoor scenes. In

addition, the optimization algorithm is adopted in this model, and the parameters in the process of VR 3D modeling are adjusted adaptively, which improves the modeling efficiency and accuracy. These methods are helpful to extract more representative features and realize more effective feature dimensionality reduction.

Each test sample in the test set is randomly selected from three perspective images for 120 times during each test. When the network training is iterated for 50 times, the mean absolute error(MAE) show that the proposed algorithm has obvious advantages in MAE, and has smaller error compared with SVM algorithm and PSO algorithm. As shown in Tables 1, 2 and 3.

| *Iterations* | *Test 1* | *Test 2* | *Test 3* | *Test 4* |
|---|---|---|---|---|
| 5 | 2.33 | 2.22 | 2.42 | 2.3 |
| 10 | 2.28 | 2.15 | 2.52 | 2.48 |
| 15 | 1.88 | 2.32 | 2.53 | 2.31 |
| 20 | 2.32 | 1.88 | 1.88 | 2.26 |
| 25 | 2.45 | 2.32 | 2.26 | 2.11 |
| 30 | 2.36 | 2.22 | 2.11 | 2.52 |
| 35 | 1.88 | 1.82 | 2.31 | 2.09 |
| 40 | 2.41 | 2.11 | 2.44 | 1.88 |
| 45 | 2.22 | 2.23 | 1.97 | 1.91 |
| 50 | 1.88 | 2.32 | 2.01 | 2.23 |

**Table 1**: MAE of SVM algorithm.

| *Iterations* | *Test 1* | *Test 2* | *Test 3* | *Test 4* |
|---|---|---|---|---|
| 5 | 2.19 | 2.49 | 2.33 | 2.22 |
| 10 | 2.12 | 2.58 | 1.95 | 2.31 |
| 15 | 2.26 | 2.32 | 2.22 | 2.46 |
| 20 | 2.5 | 2.22 | 1.89 | 2.7 |
| 25 | 1.92 | 1.9 | 1.89 | 2.2 |
| 30 | 2.01 | 1.88 | 2.36 | 2.15 |
| 35 | 2.31 | 2.31 | 2.25 | 2.33 |
| 40 | 2.22 | 2.31 | 1.81 | 2.35 |
| 45 | 1.92 | 2.22 | 2.21 | 1.8 |
| 50 | 1.83 | 1.95 | 1.79 | 1.76 |

**Table 2**: MAE of PSO algorithm.

| Iterations | Test 1 | Test 2 | Test 3 | Test 4 |
|---|---|---|---|---|
| 5 | 1.32 | 1.32 | 1.45 | 1.41 |
| 10 | 1.21 | 1.19 | 1.41 | 1.33 |
| 15 | 1.31 | 1.21 | 1.59 | 1.25 |
| 20 | 1.22 | 1.39 | 1.56 | 1.36 |
| 25 | 1.25 | 1.39 | 1.68 | 1.37 |
| 30 | 1.33 | 1.25 | 1.55 | 1.37 |
| 35 | 1.22 | 1.41 | 1.69 | 1.31 |
| 40 | 1.31 | 1.45 | 1.32 | 1.29 |
| 45 | 1.28 | 1.41 | 1.65 | 1.38 |
| 50 | 1.23 | 1.22 | 1.32 | 1.25 |

**Table 3**: MAE of this algorithm.

For SVM algorithm, it is a classification algorithm based on kernel method and support vector theory. Although SVM algorithm performs well in classification, its performance may not be as good as other algorithms in regression. Therefore, in the test of MAE, the error of SVM algorithm may be relatively large, which may be because the adaptability of the algorithm to regression tasks is relatively weak. Although PSO algorithm has good performance in optimization problems, it may not be as good as other algorithms in dealing with complex nonlinear regression problems. Therefore, in the test of MAE, the error of PSO algorithm may be relatively large, which may be because the adaptability of PSO algorithm to the nonlinear regression task of indoor scenes is relatively weak. In contrast, the algorithm in this article adopts the technology based on DL and multi feature detection, which can extract the features and laws of indoor scenes more effectively and has stronger adaptability and generalization ability. Therefore, in the test of MAE, the error of this algorithm is relatively small and it has better performance.

The modeling accuracy of SVM algorithm, PSO algorithm and this algorithm is tested in the experiment. This algorithm has obvious advantages in modeling accuracy, and has higher accuracy than SVM algorithm and PSO algorithm. In contrast, the algorithm in this article has higher precision and can describe the characteristics and laws of indoor scenes more accurately, which is of great significance for improving the efficiency and interactivity of indoor design instructional system. The comparison of modeling accuracy of different algorithms is given from Figure 6.

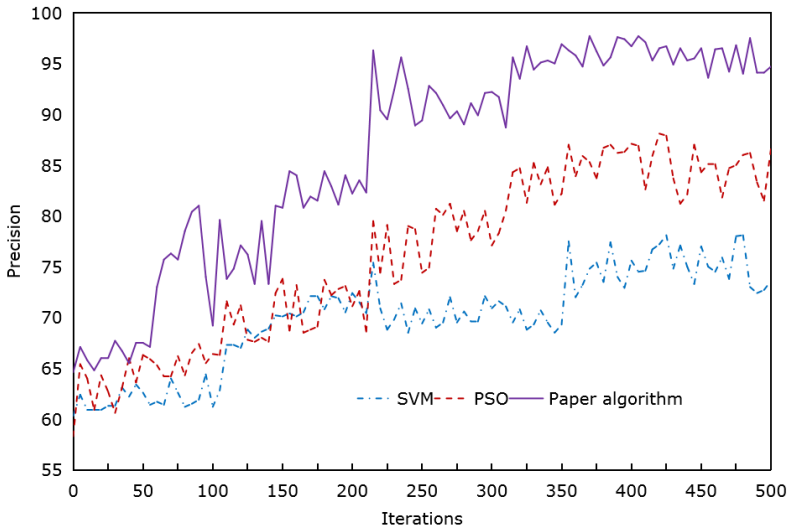


**Figure 6**: Accuracy results of different algorithms.

Compared with the traditional algorithm, the indoor environment modeling method proposed in this article has improved the modeling accuracy to some extent, and can solve the problems of unclear and stereoscopic images in the traditional modeling method to some extent. When SVM algorithm is used to process the data of indoor scene, SVM algorithm may not be able to deal with the problems of nonlinear relationship and feature selection well, which may lead to relatively low modeling accuracy. When dealing with the regression problem of indoor scene, PSO algorithm may not be able to deal with the local optimal solution and convergence speed well, which may lead to relatively low modeling accuracy. In the experiment, PSO algorithm may be affected by the initial particle position and velocity when processing these data, which further reduces its modeling accuracy. DL technology can automatically learn feature representation, avoiding the tedious work and subjective error of manual feature extraction. Multi feature detection technology can comprehensively utilize the information of various features and improve the accuracy and

robustness of feature representation. The combination of these technologies makes the algorithm in this article have higher modeling accuracy.

This article invited 520 target users to experience an interior design CAD system based on traditional methods and algorithms in this article. These users have different experience and skills in interior design, including designers, students, and ordinary users. During the experience process, the study randomly divided users into two groups: one group used an interior design CAD system based on traditional methods, and the other group used an interior design CAD system based on the algorithm proposed in this paper. In the interior design CAD system studied, users can add and combine household items by entering text instructions (such as "add"). The system will automatically parse these instructions and generate corresponding 3D models and scenes based on multi feature detection and DL models. In addition, the system also provides some interactive tools such as moving, scaling, and rotating to help users adjust the position and size of household items.

The study collected feedback from users during the experience process, including task completion time, satisfaction, and operational difficulty. By comparing the feedback data of two groups of users, we found that the interior design CAD system proposed in this paper has higher efficiency and ease of use. In addition, we also invited some professional designers to evaluate our system, and they also believe that our system has great potential in interior design. as shown in Figure 7.

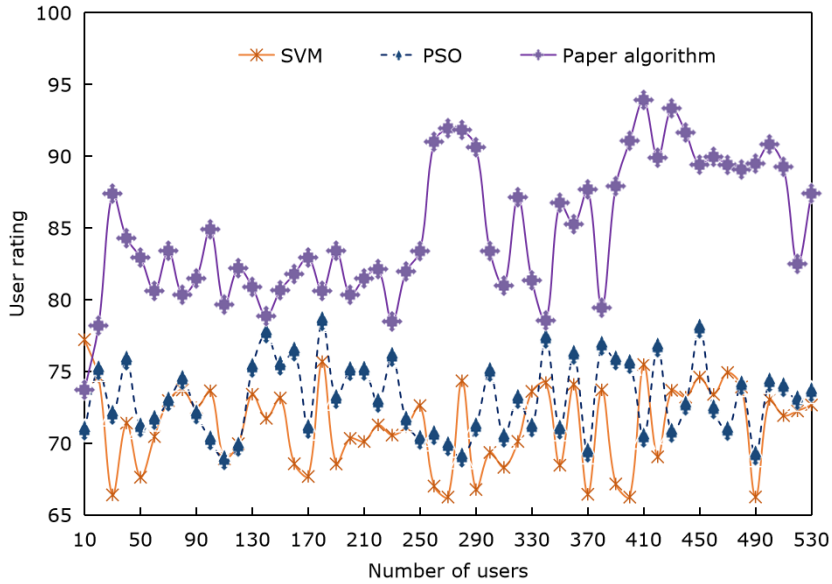


**Figure 7**: Comparison of user ratings of different systems.

As can be seen from the comparison chart of user rating, the indoor design CAI system based on this algorithm is obviously superior to the traditional method in user rating. Traditional methods may not be able to accurately identify users' needs and make effective recommendations, but the algorithm in this article improves the accuracy of recommendations through multi feature detection and DL technology, and gets higher user scores.

The comprehensive results show that the VR 3D modeling optimization algorithm based on multi feature detection proposed in this article has better performance and higher efficiency in the indoor design instructional system. This is mainly due to the fact that the algorithm can take full advantage of the complementarity between different features and improve the expression ability of

features, thus improving the accuracy and running speed of retrieval matching. CAI system of indoor design based on VR technology can not only show the 3D spatial relationship of indoor design more intuitively and comprehensively, but also better stimulate students' interest and participation in learning. This instructional method can also help students master the skills and methods of indoor design, improve their learning effect and design ability, and provide more individualized and differentiated learning experiences according to different students' learning needs and habits. In the future, we can further explore how to combine this algorithm with other advanced technologies and methods to realize a more efficient and intelligent indoor design instructional system.

## 5 CONCLUSIONS

Indoor design is a creative process that combines aesthetics, function and environmental factors. Therefore, indoor design teaching needs a method that can make students understand and feel the design process intuitively and comprehensively. By applying VR technology to the experimental teaching of indoor design, students can enter the "real environment" to experience through wearable devices. In this article, an optimization algorithm of VR 3D modeling based on multi feature detection is proposed, which provides a new solution for the construction of indoor design instructional system. In addition, this article also develops a real-time and interactive virtual interactive system for indoor design, which provides a new solution for the construction of indoor design CAI system. The simulation shows that the VR 3D modeling optimization algorithm based on multi feature detection proposed in this article has better performance and higher efficiency in the indoor design instructional system. This is mainly due to the fact that the algorithm can take full advantage of the complementarity between different features and improve the expression ability of features, thus improving the accuracy and running speed of retrieval matching.

This article only considers the virtual interactive performance of the indoor design instructional system, but does not fully consider other influencing factors, such as user demand and design aesthetics. In the future, it is needed to further study the influence of user demand and design aesthetics on the indoor design instructional system to improve the comprehensive performance of the system. Moreover, the optimization algorithm of VR 3D modeling suitable for different scenes is developed to improve the universality of the algorithm.

## 6 ACKNOWLEDGEMENT

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