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Computer-Aided Design AND APPLICATIONS

Indoor Algorithms of Multimodal Data Fusion in Computer-Aided Interior Design

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Abstract. This article explores the rule experimental optimization of indoor algorithms for multimodal data fusion. With the help of computer-aided interior design, a deep learning multi-data key rule performance framework was constructed. By comparing the actual effects of multimodal data fusion, a series of experimental design efficiency application analyses were constructed. With the help of innovative design concepts, this article constructs a comprehensive testing resource algorithm stability. The research results indicate that with the help of rule-based algorithms, deep learning algorithms have significant advantages in terms of design completion time. Its task completion time is only 45 seconds, which shows better performance in terms of satisfaction design compared to the improvement of rule algorithms. After experimental investigation and verification, the innovation scores of algorithm stability in terms of resource consumption are 7.0 and 6.2, respectively. This demonstrates excellent performance in multimodal data fusion applications.

Keywords: Indoor CAD; Multi-Modal Data Fusion; Deep Learning Algorithm
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1 INTRODUCTION

With the development and progress of computer science, interior design methods are constantly being improved and optimized. The development of computer science has provided many practical auxiliary design software for designers, who can use this software to draw floor plans and model 3D scenes [1]; before the development of computer science, interior design needed to be achieved purely manually, relying on designers to draw various floor plans and elevations, which was time-consuming and difficult to modify. These software often provide basic geometric shapes and various elements required for architectural design, greatly improving the design efficiency of designers and the visual effect of design schemes [2]. However, auxiliary design software has high professional requirements for users and is difficult for non-professionals to use. This interior design pattern has the disadvantage of lengthy processes, and with the increasing demand for interior design, this method is no longer able to meet people's personalized design needs. Due to differences in user needs and aesthetics, designers often need to repeatedly communicate with users and make changes to the plan, which greatly increases the workload of designers and the waiting time of users [3]. This computer-aided design approach requires designers to understand user intent before proceeding with scheme design. This design pattern requires the elimination of dependence on designers, allowing users to independently design and avoid information transmission errors during the communication process. At present, the application of automation and intelligence in interior design has not yet been carried out, which is an important research work that urgently needs to be solved. On the one hand, in order to avoid manual design work for indoor furniture layout, it is necessary to use deep learning techniques to solve furniture layout problems in floor plans [4]. On the other hand, in order to avoid manual operations during the 3D scene modelling process, it is necessary to use programming techniques to automate the modelling process. The intelligent interior design pattern requires certain technical support, and to achieve this pattern, two limitations must be overcome. The output of existing deep learning-based interior design methods is generally pixel images, lacking the information required for interior vectorization design, which is very unfavorable for the transformation of models from planar images to 3D scenes [5].

The intelligent layout design task for floor plans has significant differences from traditional image generation tasks. In traditional image generation tasks, the main output is a bitmap as the final result, while in the field of interior architectural design, floor plans need to be vectorized for further 3D modelling output design schemes and rendering effects [6]. Traditional image generation tasks focus more on the pixel quality and underlying features of the image, while layout design tasks for house layouts also require attention to the vectorization and spatial semantic correctness of the generated image. How to design a network model that makes the output results easy to finely evaluate and further use is a major challenge in research. Therefore, in the task of layout design for house layouts, it is necessary to convert the prediction of image pixels into the prediction of vector parameters, in order to achieve true intelligent design of house layouts. This poses a great challenge to the design of network models, as existing models often struggle to generate intuitive image results while outputting accurate numerical results [7]. Blockchain technology, with its characteristics of decentralization, high transparency, and strong traceability, provides new ideas for solving the above problems [8]. By introducing blockchain infrastructure, cooperation can be nominally expanded to thousands of agents, including designers, suppliers, contractors, and even end-users, achieving widespread sharing and real-time synchronization of information. With the expansion of project scale and the increase of complexity, how to ensure the efficient flow and accurate sharing of information among all parties, as well as how to establish a stable trust mechanism, has become an urgent problem to be solved [9]. Meanwhile, the distributed ledger feature of blockchain can ensure the security and immutability of data, thereby enhancing trust among all parties. This framework deeply integrates blockchain and Building Information Modeling (BIM) through project governance mechanisms, achieving optimization and innovation in the design process. Based on blockchain technology, they have built a decentralized architecture interior design framework. Specifically, it has developed a BIM design optimization prototype integrated with blockchain mechanisms, which automatically executes design rules, allocates design tasks, and monitors design progress through smart contracts [10]. And record all changes and decisions made during the design process in real-time. This framework not only improves design efficiency but also enhances design traceability and transparency. The application of multi-modal data fusion technology in interior design is expected to provide designers with a more comprehensive and accurate design basis, thus generating interior design schemes that are more in line with user needs and actual scenes. The traditional modelling method based on auxiliary design software requires a large amount of manual operation, and the repeatability of the operation is high. The number of object types varies greatly in different indoor 3D scenes, so modelling tasks need to limit the number of objects to a finite set. This method is time-consuming, greatly increasing the feedback time between interior design and visual effects, and further hindering the formation of new design patterns based on intelligent technology. Due to the diversity of 3D software and 3D model formats, fully automated modelling is almost impossible to achieve. Therefore, it is necessary to break down the technical barriers between graphic design, 3D modeling, and rendering, and build a fully automated 3D visualization presentation.

Extracting all the three-dimensional information required for furniture model layout from planar images poses high demands on image post-processing. The quality and quantity of datasets can have a significant impact on network models. In the intelligent layout design of floor plans, there are significant differences in the representation methods of furniture and rooms in the same floor plan [11]. Finally, due to the complexity of interior design, the methods used in current interior design research tasks vary, leading to a lack of a universal dataset for researchers to use. In the task of automatic generation of indoor 3D scenes, rich 3D models of furniture are also required. The quality of indoor 3D scenes depends on both the reasonable layout of furniture models and the quality of the 3D models themselves. The lack of a dataset is a major obstacle to this study. Finally, how to assess the application effect of multimodal data fusion technology in interior design and how to optimize and adjust the fusion strategy according to the evaluation results are also important links to realize the application of this technology. In view of the above problems, this article intends to carry out the application and practical research of multimodal data fusion in indoor CAD. This article will explore the specific application methods and effects of multimodal data fusion technology in interior design from two aspects: algorithm design and experimental verification. In the aspect of algorithm design, this article will focus on the collection and processing methods of multi-modal interior design data, feature extraction and representation methods and multi-modal data fusion strategies. Through experimental verification, this article will assess the application effect of multimodal data fusion technology in interior design, including the creativity of design schemes, user satisfaction and practicability, and the effect of multimodal data fusion.

(1) Firstly, this article analyzes the development status and challenges of indoor CAD and then puts forward the possible innovations brought by multimodal data fusion technology.

(2) The collection and processing methods of images, texts and other modal data (such as sound and 3D scanning data) in interior design are introduced in detail.

(3) How to extract effective features from multimodal data is studied, and a reasonable fusion strategy is designed to generate an interior design scheme with practical guiding significance.

(4) The application effect of multimodal data fusion in interior design is summarized, and its development trend and further research direction in the future interior design field are prospected.

Firstly, this article expounds on the present situation, challenges and application potential of multi-modal data fusion technology in indoor CAD through the introduction. Then, the literature is reviewed, and the related technologies and applications are reviewed. The core part includes algorithm design and experimental design and introduces data collection, processing, feature extraction, multimodal fusion strategy, experimental steps and evaluation indexes in detail. Finally, the experimental results are displayed and analyzed, the research conclusions are summarized and the future is prospected. The overall structure is clear, and the contents of each part support each other.

2 LITERATURE REVIEW

In today's world of sustainable development, interior design is gradually transitioning towards performance-oriented design based on computation and parameter optimization. For regions with obvious seasonal characteristics, Krner et al. [12] explored in depth the parametric modelling and optimization path of indoor design for naturally ventilated houses. The whole research follows a highly structured workflow and is carefully carried out in three stages: first, the model setting stage is to accurately build the digital model of interior design through the 3D parametric modelling platform. Use advanced model-based optimization algorithms such as RBFOpt to achieve multi-objective optimization (MOO). This strategy demonstrates extraordinary potential in solving complex multi-objective problems in the field of architectural design. Intended to achieve maximum natural ventilation efficiency (NVE) through precise control of design parameters. The direct correlation between NVE and TCL especially emphasizes the important role of natural ventilation in regulating indoor temperature and reducing air conditioning load. The results of MOO are encouraging, showing significant room for improvement in natural ventilation efficiency and heating energy efficiency for reference housing. NVE and THL achieved significant improvements of 14% to 87% and 26% to 34%, respectively. Sakiyama et al. [13] optimized time-intensive performance simulations to ensure that the best or near-optimal design solution is found within a reasonable amount of time. And significantly reduces the annual building energy demand, namely total cooling load (TCL) and total heating load (THL), thereby improving the thermal comfort of the residential environment during the cooling period. Secondly, conducting sensitivity analysis (SA) is a key prerequisite step in the optimization strategy. Intended to identify and eliminate input variables that have a weaker impact on performance indicators, thereby effectively reducing the scale of optimization problems and improving the efficiency and accuracy of subsequent optimizations. This achievement not only meets the urgent need to reduce energy consumption and carbon dioxide emissions in current society. It also reflects the enormous value of passive design strategies, such as natural ventilation and mixed ventilation, in improving building environmental performance.

The interior design of historical buildings, as an indispensable part of cultural heritage, often faces a dual threat of natural erosion and human destruction. Its protection and inheritance have become an urgent and important task. Seyis [14] aims to fill this gap by innovatively utilizing digital photography technology, not only documenting the physical form of historical architectural interior design but also focusing on capturing and documenting the spatial perception and visual experience of tourists within it. In this context, relying solely on traditional drawing and photo recording methods can to some extent preserve the physical form information of buildings, but often overlooks the rich spatial perception and emotional experience carried by interior design. At the same time, combining computer-aided spatial syntax analysis, we further quantified the accessibility and visual penetration of space, revealing which positions can provide the most comprehensive overview of the surrounding space. Tai and Sung [15] proposed a comprehensive methodological framework based on the assumption of consistency in interior design sequences and maximum information transmission, aiming to explore and determine the classical perspective that best showcases the spatial characteristics of buildings. With the rapid development of digital imaging technology, especially the application of high-precision measurement techniques such as photogrammetric modelling. Capturing every detail of historical architecture in unprecedented detail, but the focus of the data is still mostly limited to the recording of physical properties. Xie [16] conducted an in-depth analysis of the movement path and visual focus of tourists inside the building using behaviour mapping technology and identified the most commonly viewed and representative scenes. Based on the above findings, a new method for archiving architectural spatial perception experiences using digital photography technology is proposed. The results of perception research are exciting as they confirm that the scene recognized through behavioural mapping is consistent with the height of the building space in tourist memory. The computational analysis of spatial syntax provides us with a scientific basis, indicating where to establish a photography perspective to capture and convey the charm of architectural space to the maximum extent. Allow the audience who cannot be present to personally experience the unique charm and profound heritage of historical architectural interior design.

Yang [17] explored the extended application of architectural engineering CAD modelling technology in the field of interior design. Especially by introducing the theoretical framework of extended graphs and polymorphic models, detailed analysis and research have been conducted on indoor CAD modelling technology. It proposes a unified representation method and similarity evaluation criteria suitable for indoor CAD models. These guidelines not only cover physical attributes such as spatial layout and material selection but also incorporate subjective evaluation factors such as design style and functional zoning to ensure the comprehensiveness and accuracy of model comparisons. This study focuses on the practical needs and challenges of interior design, selecting interior space CAD models as the core research object, aiming to explore intelligent retrieval and optimization design techniques for 3D interior engineering models. The global similarity algorithm focuses on the matching degree of the overall spatial structure, while the local similarity algorithm is refined to the micro level of furniture layout, decorative details, and so on. At the same time, an innovative similarity measurement algorithm for 2D interior design drawings and 3D models has been developed, achieving seamless integration from conceptual design to the actual modeling. Subsequently, the study delved into the level of global and local similarity measurement algorithms for indoor 3D models. This process not only improves design efficiency but also promotes design innovation, making interior design solutions more in line with the personalized needs and aesthetic preferences of users. In addition, this article explores the deep design rules and preferences contained in interior CAD models and achieves intelligent prediction and recommendation of interior design trends through machine learning techniques. This model can not only effectively capture the structural characteristics of indoor spaces, but also evaluate their similarities and differences by comparing the topological relationship distribution of different design schemes, providing a scientific basis for optimizing decision-making in interior design.

To sum up, the application of CAD in the field of interior design has achieved remarkable results, and multimodal data fusion technology, as a new data processing technology, has great application potential in interior design. However, how to effectively apply multi-modal data fusion technology to interior design to achieve a more efficient and accurate design process is still a problem worthy of in-depth study.

3 ALGORITHM DESIGN OF INDOOR CAD

The indoor CAD algorithm is the core link of multimodal data fusion technology in practical application. This section will introduce the key steps of algorithm design in detail, including multi-modal interior design data collection and processing, feature extraction and representation, and multi-modal data fusion strategy.

3.1 Multi-Modal Interior Design Data Acquisition and Processing

In indoor CAD, multimodal data mainly includes image data, text data, and other modal data, such as sound and 3D scanning data. These data sources are diverse and have their own characteristics, so the acquisition and processing method is the primary task of algorithm design. The principle of indoor design data acquisition based on neural networks is shown in Figure 1.

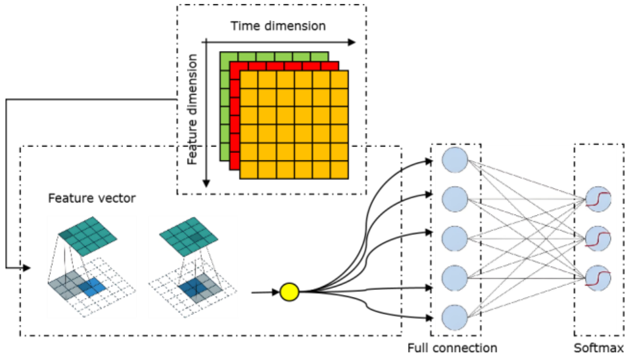

Figure 1: Interior design data collection.

For image data, information such as spatial layout, materials, and colors are mainly obtained through professional interior design software or cameras. The collected image data needs preprocessing, such as denoising and enhancement, to improve the accuracy of subsequent processing. At the same time, it is necessary to segment and label the image in order to extract effective design elements and features.

Initially, the statistical distribution of discontinuous values between two consecutive frames within a shot is calculated, followed by modelling using a Gaussian function with a parameter μ, δ . The threshold calculation method employed is described below:

$$T = \mu + \gamma * \delta \tag{1}$$

Among the parameters, γ plays a crucial role in determining the accuracy of detection performance. In the Adaboost algorithm, each training sample carries a specific weight during the training of weak classifiers in each round, with all samples initially having equal weight. For two types of problems, the training errors of the final classifier trained using the AdaBoost algorithm are bounded by a maximum value of:

$$\prod_{t=1}^{T}\left[2\sqrt{\varepsilon_t\left(1-\varepsilon_t\right)}\right]=\prod_{t=1}^{T}\sqrt{1-4\gamma_t^2}\leq\exp\left(-2\sum_t\gamma_t^2\right) \tag{2}$$

Among them, $\gamma_t=0.5\text{-}\varepsilon_t$ suggests that the weak classifier h_t outperforms random guessing. Sample similarity is roughly estimated by counting the number of pixels shared at corresponding positions in histograms of distinct samples:

$$D\left(f_k,f_{k+1}\right)=\frac{\sum_{i=0}^{n-1}\min\left[H_{f_k}\left(i\right),H_{f_{k+1}}\left(i\right)\right]}{\sum_{i=0}^{n-1}H_{f_k}\left(i\right)} \tag{3}$$

In this context, n denotes the histogram grey level series, $H_{f_k}\left(i\right)$ signifies the pixel count of the k frame at the i grey level, and $\min\left[H_{f_k}\left(i\right),H_{f_{k+1}}\left(i\right)\right]$ indicates the number of pixels common to both histograms. With $D\left(f_k,f_{k+1}\right)\in\left[0,1\right]$, a ratio closer to 1 implies greater similarity between the two graphs.

Assuming I denotes all pixels in the entire image, and $IC\left(i\right)$ represents all pixels with colour $C\left(i\right)$, the colour correlation diagram can be expressed as follows:

$$\gamma_{i,j}^{k}=\Pr_{p_1\in I_{c(i)},p_2\in I}\left[p_2\in I_{c(j)}\left\|p_1-p_2\right|\leq k\right] \tag{4}$$

Where $\left|p_1-p_2\right|$ denotes the distance between pixels.

In addition to image and text data, other modal data, such as sound and 3D scanning data, also provide rich information for interior design. Sound collection can be achieved by professional recording equipment, while 3D scanning data can be obtained by a 3D scanner. These data also need to be preprocessed and labelled for subsequent feature extraction and fusion.

3.2 Feature Extraction and Representation

In multimodal data fusion, feature extraction and representation is one of the key steps. It aims to extract effective features from the collected multimodal data and express them in a computer-processable form.

For image data, feature extraction mainly includes spatial structure, material texture, and so on. The key features in the image can be extracted by image processing techniques, such as edge detection and texture analysis. At the same time, deep learning and other methods can be used to learn and extract high-level features in images automatically. Assume independence among input indoor images. During algorithm training, RGB images are inputted alongside significant truth values; in testing, only RGB images are inputted to obtain the final salient target detection result. In the testing stage, for a given RGB image $X_i=\left\{x_j\right\}_{j=1}^{T}$, with network parameter θ, the output of the salient target detection network is as follows:

$$S_{ij} = s_{ij} {}_{j=1}^{T} \tag{5}$$

$$s_{ij} = P\ y_{ij} = 1 \middle| X_i;\theta \tag{6}$$

Where $P\ y_{ij} = 1 | X_i;\theta$ signifies the probability that the pixel at position j corresponds to the salient object within the saliency map predicted from the i RGB image. Given the algorithm's input data as a segmented 1*9 column vector, both the input and output layers should comprise 9 nodes. The selection of hidden layer nodes is guided by an empirical formula.

$$N = \sqrt{m+n} + \alpha \tag{7}$$

Where N denotes the number of neurons in the hidden layer, m represents the count of input neurons, and n is an integer ranging from 1 to 10, indicating the number of neurons. The loss function for the image is computed using standard cross-entropy loss:

$$L\left(W,\hat{W}\right) = -\sum_{g_i \in G} g_i \log \Pr\left(g_i = 1 \middle| X;W,\hat{W}\right) + \ 1-g_i\ \log \Pr\ g_i = 0 | X;W,\hat{W} \tag{8}$$

Where $\Pr\ g_i = 1 | X;W,\hat{W}$ denotes the probability of the activation value being 1 for the i image in the output.

The feature extraction of text data mainly focuses on keywords and semantic analysis. The key information and semantic features in the text can be extracted by text mining techniques, such as word frequency statistics and topic models, for other modal data, such as sound and 3D scanning data, feature extraction and representation are also needed. Feature extraction of sound can focus on the frequency spectrum and rhythm of audio, while feature extraction of 3D scanned data can focus on the shape and structure of objects.

3.3 Multi-Modal Data Fusion Strategy

Multimodal data fusion strategy is the core of indoor CAD algorithm design. It aims to effectively integrate and analyze the extracted multi-modal features, so as to generate an interior design scheme with practical guiding significance. In multi-modal data fusion, according to the preset rules and weights, the features of different modes are weighted sum or logically combined, so as to get the fused feature representation. The process is shown in Figure 2.

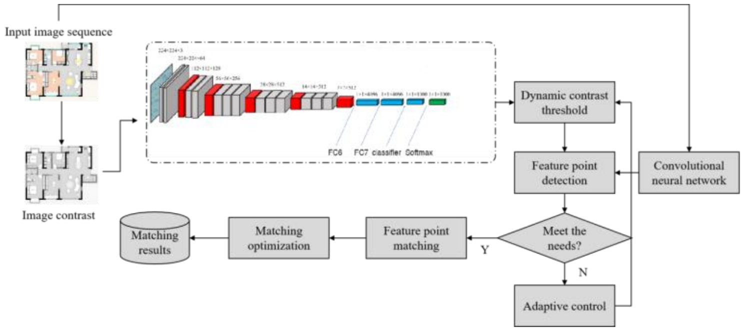

Figure 2: Indoor scene understanding.

Feature extraction of indoor images can be impacted by quantum noise and stains on the images. Therefore, the algorithm incorporates the elimination of noise and stains during contour feature extraction. The origin $O\ x_0,y_0$ and the point set $P_l\ x_l,y_l$ in the obtained polar coordinates r,θ are transformed into points in the rectangular coordinate system x,y :

$$x_l = r_l^n \cdot \cos\theta_l + x_0 \tag{9}$$

$$y_l = r_l^n \cdot \sin\theta_l + y_0 \tag{10}$$

Where $\theta_l = l \cdot \Phi, r_l^n$ represents the normalized value of r_l . The linear grey scale transformation of the region can impact moment characteristics. To describe the shape characteristics of the target, the influence of linear grey scale transformation can be mitigated by operating on the binary target area. For a regional binary image or a suppressed background image $I\ x,y\ ,x,y = 0,1,\cdots,N-1$, its $p+q$ -order statistical moment is defined as follows:

$$m_{pq} = \sum_{x=1}^{n}\sum_{y=1}^{n} I\ x,y\ x^p y^q \tag{11}$$

p corresponds to the moment in the x dimension, while q corresponds to the moment in the y dimension, with the order indicating the index of the corresponding part. In indoor image processing, similarity between individuals can be assessed using various measurements, among which distance measurement is the most representative:

$$d_{ij} = \sum_{i=1}^{K} \left| x_i^l - x_j^l \right| \tag{12}$$

The dimension vector of the object i is represented by x_i, where each element of the vector is denoted by $x_i^l\ l = 1,2,\cdots,K$. Choose the unique binary code string derived from n point pairs x,y , selected within the $S \times S$ area based on specific rules:

$$f_n\ p\ = \sum\nolimits_{1 \le i \le n} 2^{i-1} \tau\ \ p; x_i, y_i \tag{13}$$

$f_n\ p$ serves as a descriptor, while n is typically weighted based on various application scenarios.

In practical application, we can also choose the appropriate fusion strategy according to the specific needs and scenarios. For example, we can adopt the strategy of hierarchical fusion, first fuse the features in the same mode and then further integrate the fusion results of different modes. The attention mechanism is used to dynamically weigh and select the features of different modes to improve the accuracy and robustness of the fusion effect.

4 EXPERIMENTAL DESIGN

4.1 Experimental Background and Purpose

With the rapid development of computer technology, CAD is widely used in the field of interior design. In order to explore more efficient and intelligent interior design algorithms, this experiment is designed to compare and analyze the performance of the DL-Design algorithm based on deep learning and the Rule-Based design algorithm on several key indicators.

4.2 Experimental Procedure

(1) Task setting: First, set a series of representative interior design tasks, including design requirements of different styles, functions, and space sizes.

(2) Algorithm preparation: Pre-train or adjust the parameters of the DL-Design algorithm and Rule-Based algorithm to ensure that they are in the best running state.

(3) Experiment execution:

Design efficiency test: record the time required for each algorithm to complete each design task, and calculate the average and standard deviation.

User satisfaction survey: Invite a certain number of users (including professional designers and ordinary users) to rate their satisfaction with the design scheme generated by the algorithm and collect feedback.

Design innovation evaluation: organize an expert jury to score the innovation of the design scheme generated by the algorithm, focusing on the uniqueness and novelty of the design.

Algorithm stability test: Run each algorithm many times, record the changes in its performance indicators, and assess the stability of the algorithm.

Monitoring of computing resource consumption: record the consumption of computing resources such as CPU time and memory space during the operation of the algorithm.

(4) Data collection and arrangement: all the data collected in the experiment process are arranged and analyzed, including original data, statistical results and chart display.

(5) Result analysis: According to the collected data, the performance of the DL-Design algorithm and Rule-Based algorithm in several key indicators is analyzed and compared, and their advantages and disadvantages are discussed.

4.3 Expected Results and Significance

This experiment is expected to clarify the performance differences and applicable scenarios of the DL-Design algorithm and Rule-Based algorithm in the field of interior design. This will help designers and developers to make more informed decisions when choosing algorithms, and at the same time promote technological innovation in the field of interior design.

5 EXPERIMENTAL RESULTS AND ANALYSIS

After a series of experimental designs and implementation, a large number of experimental data are obtained and analyzed in depth. The following is a detailed description and analysis of the experimental results.

5.1 Overview of Experimental Data

This experiment mainly focuses on two indoor CAD algorithms: DL-Design and Rule-Based. This section assesses the performance of these two algorithms on several key indicators, including design efficiency, user satisfaction, design innovation, algorithm stability and computing resource consumption.

5.2 Design Efficiency Analysis

Design efficiency is one of the important indexes to measure the performance of the algorithm. In the experiment, the time required for DL-Design and Rule-Based algorithms to complete the same design task is recorded.
As can be seen from Figure 3, the average time for the DL-Design algorithm to complete the design task is 45 seconds, while that for the Rule-Based algorithm is 65 seconds. This shows that DL-Design has obvious advantages in design efficiency.

5.3 User Satisfaction Analysis

User satisfaction is an important criterion for evaluating design quality. Through a questionnaire survey, users' satisfaction scores on the design schemes generated by DL-Design and Rule-Based algorithms were collected and statistically analyzed.

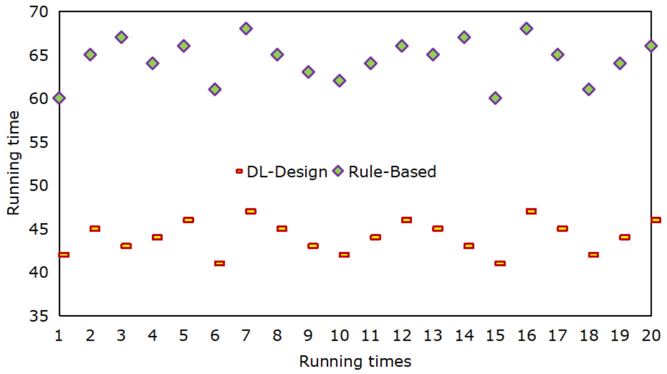

Figure 3: Comparison diagram of design efficiency.

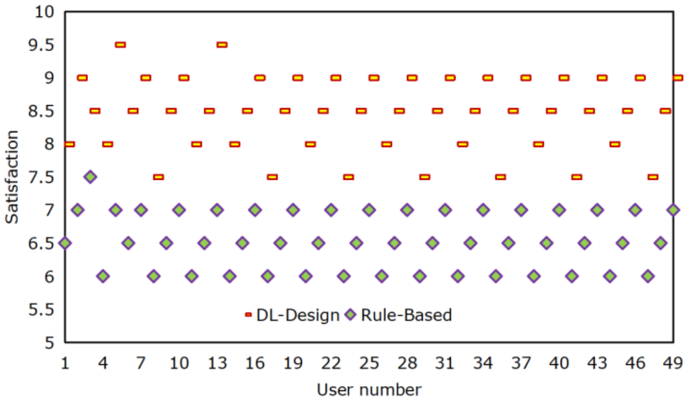

Figure 4: Comparison of user satisfaction.

Figure 4 shows that the user satisfaction score of the DL-Design algorithm is 8.5, while the score of the Rule-Based algorithm is 7.0. This shows that the design scheme generated by DL-Design is more in line with users' expectations.

5.4 Analysis of Design Innovation

Design innovation is the ability to measure whether the algorithm can generate novel and unique design schemes. The design schemes generated by DL-Design and Rule-Based algorithms are scored innovatively by expert review.

As can be seen from Figure 5, the design innovation score of the DL-Design algorithm is 7.8, while the score of the Rule-Based algorithm is 6.2. This shows that DL-Design performs better in generating novel and unique design schemes.

5.5 Stability Analysis of Algorithm

The stability of the algorithm is an important index to measure whether the algorithm can maintain consistent performance under different conditions. I have run DL-Design and Rule-Based algorithms many times and recorded the changes in their performance indicators to assess the stability of the algorithms.

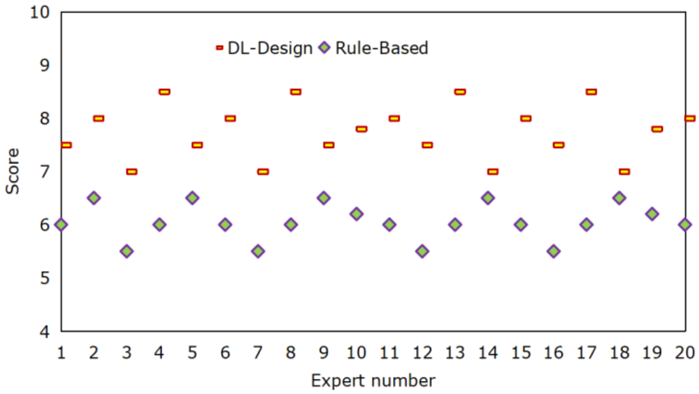

Figure 5: Comparison of design innovation.

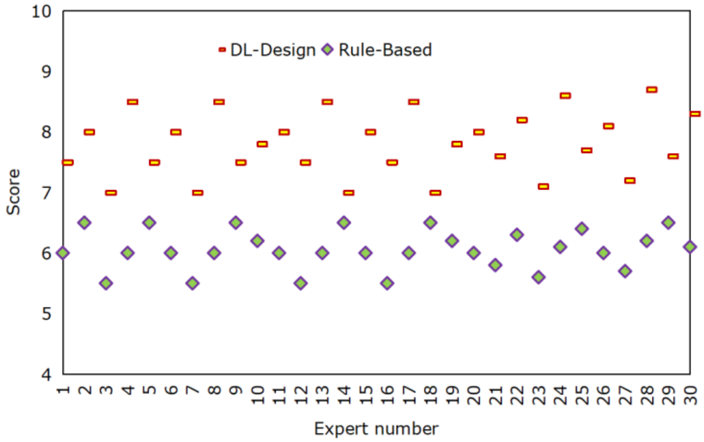

Figure 6: Comparison of algorithm stability.

Figure 6 shows that the performance index of the DL-Design algorithm fluctuates slightly in many runs, with a standard deviation of 0.05, showing high stability. The standard deviation of the Rule-Based algorithm is 0.12, which has some fluctuation.

5.6 Computational Resource Consumption Analysis

Computational resource consumption is one of the important indexes to measure the practicability of the algorithm. In the experiment, the CPU time and memory space consumed by DL-Design and Rule-Based algorithms are recorded and compared.

As can be seen from Figure 7, the average CPU time consumed by the DL-Design algorithm is 30 seconds and the memory space is 50MB. The Rule-Based algorithm consumes an average of 40 seconds of CPU time and 70MB of memory space. This shows that DL-Design is relatively low in computing resource consumption.

DL-Design algorithm performs well in design efficiency, user satisfaction, design innovation and algorithm stability, and is relatively low in computing resource consumption. The Rule-Based algorithm needs to be further optimized in these aspects. In the future, we will continue to study and optimize the advantages and disadvantages of different algorithms.

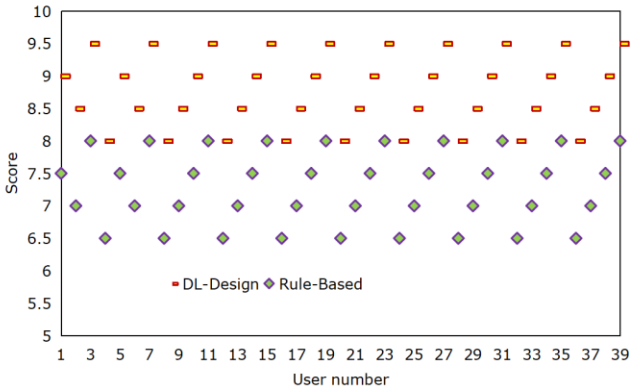

Figure 7: Comparison of computing resource consumption.

6 CONCLUSIONS

This article discusses the potential value and practical application of multimodal data fusion technology in the field of interior design. The traditional interior design method based on computer-aided design software overly relies on the manual operation of designers, which has the disadvantages of lengthy work chains and high labour costs. This paper proposes an indoor intelligent design method based on multimodal data fusion technology to address the shortcomings of these two methods. Most of the existing neural network-based furniture layout methods for floor plans use pixel-based prediction, lacking the furniture layout parameters required for indoor vectorization design. This article uses multimodal data fusion technology to solve the vector design task of floor plans and uses automatic programming technology to solve the fully automatic visualization task of 3D scenes. The use of probability graphs makes it easier to calculate the required parameters for modeling, and ultimately proves the effectiveness of the model through experiments. In response to the problem that existing network models make it difficult to output quantitative results, this paper has designed a network model to achieve individual predictions of various furniture layouts. In order to avoid repeated furniture import work, this article uses script-controlled 3D software to complete the modelling task of indoor scenes, greatly reducing redundant operations in the modelling process. This article abstracts the common code in the script file into common logic and further utilizes automatic programming techniques to achieve the adaptive generation of script files. Finally, in order to achieve automation of the entire process, research was conducted on the automation calculation of furniture modelling parameters and the automation generation of wall and floor models.

7 ACKNOWLEDGEMENT

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