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Computer-Aided Design AND APPLICATIONS

Intelligent Layout of New Chinese Style Interior Space Combining Deep Learning Technology

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Abstract. This article further optimized the layout of the model for feature extraction through deep learning. A deep design layout model that combines interior design is introduced by evaluating the interior design features of computers. Extracting models of indoor layout points integrates the interior more fully on the basis of traditional methods. This not only demonstrates the superiority of the algorithm but also plays a more crucial role in designing user ratings. The role of deep learning algorithms in interior design efficiently reflects the superiority of production design and the value of user ratings. Currently, CAD is a drawing model construction technique that allows for intuitive and interactive design. The method proposed in this article has played a significant role in improving user satisfaction in home design. This has provided convenience for the development of space in traditional technology interiors.

Keywords: Deep Learning; New Chinese Style; Interior Space Layout; CAD Technology; Evolutionary Deep Learning
DOI: https://doi.org/10.14733/cadaps.2025.S1.191-207

1 INTRODUCTION

In the field of information technology in interior architectural design, computer-aided technology has greatly improved the efficiency of manual design and the visual presentation effect of design schemes. The transition from simple manual design to information-assisted design has been achieved, but there are still shortcomings, such as high requirements for professionalism and lengthy design processes. In recent years, with the vigorous development of artificial intelligence technology, a large number of image intelligence technologies have emerged, providing new opportunities for the intelligent development of interior design. By implementing the intelligent design of key modules in interior architectural design, artificial intelligence technology can be used to meet people's personalized and real-time aesthetic design needs without human intervention. Algabri and Choi [1] focus on the intelligent automatic layout of furniture in indoor decoration design. They use deep learning networks to automatically layout commonly used furniture based on any input blank layout map while balancing the rationality of spatial use and aesthetic visual effects. Further targeting the demand for vectorized data in the design process, incorporating probability graph mechanisms into deep learning networks. It can directly output quantified parameter results instead of traditional bitmap results, allowing the intelligent module to seamlessly integrate with traditional graphic vector design processes. In the era of information overload and big data, recommendation systems are developing rapidly. Throughout the traditional interior space design industry, its design work is highly specialized and has a high rate of manual participation, resulting in high costs. The emergence of artificial intelligence technology has created favourable conditions for reducing design costs. Barbieri and Muzzupappa [2] studied an intelligent interior space design algorithm based on a hybrid recommendation model, using an interior space design software platform as the background. The intelligent design work is divided into two parts: matching and layout, and recommendation models are designed separately, which preliminarily realizes the intelligent Interior Space design method and effectively improves design efficiency. Using 2D rendered images of home models as processing objects, Chen et al. [3] used a VGG-16 convolutional neural network to extract image features of home items, and constructed image feature libraries for different categories of home items. Principal Component Analysis was used to analyze the images, The PCA algorithm reduces the dimensionality of vectors in the feature library, preserves the effective features of home items, and improves the efficiency and accuracy of item similarity calculation. Inspired by collaborative filtering recommendation algorithms, a basic matching recommendation model was constructed, combining the advantages of content-based recommendation algorithms in cold start. It used matching data from similar projects to predict zero-value terms in sparse matrices and iteratively updated the matching recommendation model. Appropriate model parameters were determined through comparative experiments, and the final matching recommendation model obtained had a recommendation accuracy of over 80% at TopN=20, which can meet the matching needs of home models.

As a design concept that combines traditional culture and modern aesthetics, the new Chinese-style Interior Space layout has unique charm and value. Fu et al. [4] introduced an innovative interactive system that can not only quickly design and preview colour snapshots of indoor scenes, but also further consider the optimization and personalized design of Interior Space layout. In interior design, spatial layout is a crucial factor that determines the functionality, comfort, and aesthetics of a room. Given the multi-layer grey image pre-rendering of the same indoor scene, our system uses advanced image processing and colouring techniques to colour and merge these images into monochromatic snapshots. Its system aims to improve the efficiency of indoor scene colour theme design and effectively generate indoor scene snapshots with editable colours and high resolution through image colouring technology. Unlike complex 3D indoor scenes that typically require several minutes or even longer to render specific colour themes. The system not only focuses on colour selection but also explores how to create a unique indoor environment through the perfect combination of colour themes and spatial layout. The quickly generated indoor scene snapshot provides users with a preview of interior design solutions under different colour themes and spatial layouts. By collecting and analyzing user preferences for different colour themes and spatial layouts, the system can provide users with recommended solutions that better meet their needs. By collecting and analyzing user preferences for different colour themes and spatial layouts, the system can provide users with recommended solutions that better meet their needs. The new Chinese style emphasizes the refinement and reconstruction of traditional elements and pursues the simplicity, naturalness and harmony of space. In the layout design of Interior Space, the new Chinese style pays attention to the layering and fluidity of space and pursues the openness and permeability of space. Faced with the current bottlenecks of lack of dramatization, low efficiency, and high labour costs in intelligent design technology, in order to simplify the interior space design work of designers. At the same time, in order to enable non-professional users to design works that comply with interior design rules, Fuchs et al. [5] divided the process of intelligent Interior Space design into two parts: home matching and home layout. Design different recommendation models separately and combine the two recommendation models through a hybrid approach of transformation. Trigger different recommendation models under different conditions to provide users with home-matching references and scene layout recommendations. To reduce the workload of home matching between designers and ordinary users, and to demonstrate the professionalism of matching recommendations, Georgiadou et al. [6] used a large amount of design scheme data published by professional designers on Interior Space design platforms as training data. A new hybrid matching recommendation model is constructed by integrating project-based collaborative filtering recommendation algorithms and home project content feature-based recommendation algorithms, and an offline 3D home model's compatibility table is generated. After the user personalizes the selection of some home models that can be placed in the scene, the system combines the categories of home items that can be placed in the scene. Based on the overall style of the placed home models and the offline compatibility table, recommend the top N home models with high compatibility, providing an effective reference for users in Interior Space matching design.

Despite its potential, applying DL to Interior Space layout design presents its own set of challenges. Notably, indoor layout data is intricate, encompassing factors like space dimensions, geometry, furniture arrangement, and materials. Guided by the concept of digital twins (DT), advanced sensing and visualization technologies not only bring new opportunities to improve building health and safety in the workplace but also offer unprecedented possibilities for optimizing indoor spatial layout. Hou et al. [7] conducted a comprehensive review and report on the current state-of-the-art technology and elaborated on key findings. In terms of Interior Space layout, digital twin technology can simulate and predict the impact of different design choices on the indoor environment, functionality, and safety. By integrating advanced sensors and visualization tools, designers and engineers can capture and analyze the usage of Interior Space in real-time. On the one hand, many construction projects still rely on traditional drawings and models in the design and construction process, lacking effective integration with digital twin technology. Although DT technology has great potential to improve Interior Space layout and enhance occupant safety, the current construction industry has not fully utilized and simplified these innovations in practice. Secondly, encourage the government and enterprises to increase investment and support in digital technology, and provide more resources and support for small and medium-sized enterprises and individual designers. Driven by the Internet of Things (IoT) technology, smart home systems have achieved unprecedented convenience and functionality, but at the same time, they also face significant challenges in security and privacy communication. Khan et al. [8] proposed a resource-efficient, blockchain-based security and private Internet of Things solution, particularly in application scenarios of indoor spatial layout. By accurately evaluating the basic security objectives of privacy, integrity, and accessibility in various regions, we can build a blockchain-based security architecture for smart home systems.

The core aim of this article is to delve into the utilization of DL technology in Interior Space layout design. We introduce a novel EDL-based approach for capturing indoor layout features and incorporate CAD technology to facilitate intelligent design. Through this investigation, we aspire to offer fresh perspectives for advancing indoor layout design and fostering its intelligent, automated, and personalized evolution. Our contributions are highlighted as follows:

(1) We pioneer the implementation of the EDL algorithm in Interior Space layout feature recognition. Leveraging the EDL framework, the structure and parameters of DL models can be dynamically adapted to accommodate the intricate nature of indoor layout data, thus enhancing feature detection accuracy.

(2) We integrate the DL-extracted features with CAD technology to realize the intelligent layout of contemporary Chinese-style interiors. This approach harnesses CAD's robust drafting and modelling capabilities to provide an accurate visualization of Interior Spaces.

(3) Through intelligent technologies, we can precisely capture and express the essence of contemporary Chinese design while satisfying modern demands for intelligent and personalized Interior Spaces.

Commencing with an overview of the research backdrop, significance, and challenges, we propose a combined EDL-CAD approach. Subsequently, we review the current utilization of DL, EDL, and CAD in indoor layout design. The article then details the EDL-based indoor layout feature detection method and discusses how CAD technology enables intelligent layout. Experimental validation and comparative analysis are conducted to demonstrate the effectiveness of our approach. In conclusion, we summarize our findings, acknowledge limitations, and propose directions for future research. Our research transitions from theoretical exploration to practical application, ultimately aiming to propel the intelligent evolution of indoor layout design.

2 RELATED THEORIES AND TECHNOLOGIES

Since Nicholas Negroponte first outlined the vision of responsive architecture, research on intelligent environments has made significant progress in multiple fields, particularly computer science and engineering. In order to gain a deeper understanding of how intelligent environments shape and enhance indoor spatial layout, Lee et al. [9] conducted a systematic literature review, focusing on dynamic spatial layout closely related to indoor spatial layout. Research has found that intelligent environments can achieve flexible adjustment and optimization of Interior Spaces through real-time data feedback and user behaviour analysis, thereby creating a more humane, efficient, and adaptable indoor environment. From the perspective of architecture, there is still insufficient research on the application and impact of intelligent environments in indoor spatial layout. Through this method, residents can not only perceive and experience the unique charm of smart spaces but also participate in the design and optimization process of Interior Space layout. This participatory design method helps to enhance the satisfaction and sense of belonging of residents, while also providing more possibilities and innovative space for Interior Space layout design. Lin [10] introduced an algorithm framework aimed at helping architects apply topology algorithms in Interior Space layout design. In order to make the generated 3D scene as accurate as possible, Liu and To [11] analyzed the spatial transformation parameters required for furniture models in 3D scene modelling. Replacing manual operations in traditional modelling methods with script-driven automatic modelling. Automatically extract parameters through a self-designed furniture modelling parameter extraction algorithm. The existing methods for 3D scene modelling based on planar views cannot achieve fully automated generation from images to 3D models, and then to rendered images. In order to validate the technology proposed in this article and enhance the practicality of the research, a set of indoor intelligent design systems has been created in this paper. As this article aims to automate the entire interior design process, it is necessary to extract the parameters required for 3D scene generation from the 2D floor plan, in order to complete the automated generation of the 3D model of the scene. The back end of the system is encapsulated by the intelligent design of the layout and automatic generation of 3D scenes proposed in this article, while the front end is written by PyQt5. Using programming techniques to abstract script code into common logic and function parameters, achieving adaptive generation of scripts and achieving fully automated 3D scene visualization. This method not only inherits the original spline information of the upstream CAD model but also preserves the design intent and modelling history. This enables the optimized Interior Space layout to maintain a high degree of editability and flexibility, making it convenient for designers to make further adjustments and improvements as needed.

The intelligent management of Interior Spaces in buildings is particularly crucial. Especially, the research topic of combining Interior Space layout with safety management is increasingly receiving attention. Liu et al. [12] proposed a DT-based indoor safety management system framework, which enhances the intelligence level of indoor safety management in buildings. Taking a building with a sledge sports field for the Beijing Winter Olympics as an example, we have implemented the indoor safety management system. Real-time operational information such as temperature, humidity, smoke concentration, etc. is collected through IoT sensors and integrated with BIM models to form a complete DT model (DTM). We use BIM technology to construct a digital model of the building, which not only includes structural information of the building, but also detailed information such as indoor spatial layout and equipment location. The system can not only achieve on-site display of operating status, hazard alarm and positioning but also provide targeted hazard classification and level evaluation results for management personnel based on the characteristics of the Interior Space layout. In addition, the system can automatically generate hazard-handling suggestions based on the evaluation results, helping management personnel quickly take effective measures to ensure the safety of Interior Spaces. However, existing indoor safety management methods often fail to comprehensively analyze safety data due to a lack of deep integration with building information. Moreover, the assessment of potential hazards often relies excessively on the experience of safety management personnel. With the digital transformation of the construction industry, Information Modeling (BIM) has become the core of advanced information technology solutions [13].

Parn and Edwards [14] aim to comprehensively examine the network threats faced by asset management in smart city Interior Space layouts. These hackers may exploit system vulnerabilities to disrupt or tamper with key components of Interior Space layouts through remote access or physical intrusion. Through in-depth research on cyber-physical attack cases, it was found that different types of hackers pose a threat to the layout assets of smart city Interior Spaces. Cybercrime and politically motivated online interventions may pose a threat to key infrastructure supporting national wealth creation, protecting population health, safety, and welfare, including indoor spatial layout and its key components. In addition, we have identified and reported various motivations of the perpetrators/actors, including but not limited to economic interests, political purposes, and pranks. These technologies may include information collection, vulnerability scanning, social engineering, etc., aimed at obtaining access to indoor spatial layout systems or understanding system vulnerabilities. Smart cities not only achieve comprehensive integration and network connection between virtual/digital assets and physical building/infrastructure assets but also further promote the development of the digital economy through refined Interior Space layout design. In the construction, engineering, construction, owner, and operations (AECOO) industry, the traditional exchange of building models is usually done in the form of files, which appears cumbersome and inefficient when dealing with complex projects. The BIM method not only improves work efficiency, but also enables more efficient collaboration in various stages of construction projects, including planning, design, construction, and operation. Rasmussen et al. [15] envisioned an interoperable, distributed, network-based interdisciplinary information exchange among stakeholders throughout the entire lifecycle of a building. In the continuous evolution of BIM technology, BIM maturity level 3 has become an important milestone. In order to achieve the goal of BIM maturity level 3, the World Wide Web Consortium Link Building Data Community Group (W3C LBD-CG) has proposed a hypothesis that a seamless information exchange platform can be built in modern network applications using linked data models and best practices. BOT not only provides advanced descriptions of building topology, including floors, spaces, building elements, and their relationships, but also includes network-friendly 3D models of these elements.

The demand for users to better utilize these technologies to optimize Interior Space layouts and enhance the living experience is increasing. Therefore, it is necessary to deeply explore the gaps and correlations of current methods in optimizing Interior Space layout, in order to provide more comprehensive and coherent guidance for the entire design process of smart homes. The combination of energy efficiency and Interior Space layout optimization is not close enough. While pursuing energy efficiency, the impact of Interior Space layout on energy utilization efficiency is often overlooked. Sepasgozar et al. [16] reviewed journal papers related to smart buildings, Interior Space layout, and Internet of Things technology published in Scopus et al. databases from 2010 to 2019. Geospatial data can provide detailed information about the internal and external environment of buildings, which is of great significance for optimizing indoor spatial layout. However, currently, there are relatively few applications in this area. The importance of protecting historical heritage is beyond doubt. It is not only a witness to human civilization, but also a bridge connecting the past and the future. Tai and Sung [17] have developed a comprehensive method that utilizes digital photography technology to record and analyze the indoor spatial layout of historical buildings, as well as the visual perception of tourists within them. The sequence assumption suggests that tourists will browse the space in a certain sequence when visiting buildings, which reflects the importance and functionality of the space. With the advancement of technology, especially the development of digital imaging technology, we have more methods to record and protect these precious legacies. These scenes and locations often contain key information and features of the building and are an important component of the tourist perception experience. Traditional data archiving methods often focus on the physical characteristics of buildings, while ignoring the perceived experience of tourists in the space, especially the impact of indoor spatial layout on the perceived experience. To achieve this goal, we employed behaviour mapping and computer-aided spatial syntax methods. Behavioural mapping identifies the most frequently viewed scenes and locations by recording the movement trajectory and viewing behaviour of tourists indoors.

Triatmaja [18] delved into the challenges faced by interior design students in completing design tasks, with a particular focus on optimizing interior space layout and personalized design. In interior design, spatial layout is not only related to the functionality of the room but also closely linked to user comfort, visual effects, and overall aesthetics. Secondly, we conducted in-depth interviews with students and instructors to collect their first-hand experiences and insights on the process and methods of spatial layout design. Through comprehensive analysis, we have found that when selecting process models and design methods, special attention needs to be paid to whether they can effectively address the challenges of spatial layout. This method combines the innovation of design thinking with the professionalism of interior design, emphasizing the importance of user participation and iterative design in spatial layout design. As a highly practical discipline, interior design constantly develops and updates its design concepts with the progress of the times. The introduction of new teaching methods and the application of new design elements not only promote the optimization of the teaching process but also better meet the training needs of professional talents in today's interior design industry. Yang [19] proposed a structural optimization plan for interior design courses based on 3D computer-aided simulation, including strategic optimization and structural optimization. Structural optimization focuses on improving teaching content and methods by introducing 3D simulation technology to optimize teaching and practical systems, enabling students to learn better and master spatial layout design knowledge in practice. The optimization analysis of interior design teaching practice based on 3D computer-aided simulation deeply explores the teaching optimization mode and its implementation path. By optimizing the teaching system, teachers can better utilize 3D simulation technology for teaching design and implementation, improving teaching effectiveness. In interior design, spatial layout is a crucial aspect that determines the functionality, comfort, and aesthetics of the space.

3 FEATURE DETECTION OF INTERIOR SPACE LAYOUT

3.1 DL Model for Feature Detection of Interior Space Layout

Upon establishing an apt indoor spatial layout dataset, the development of a DL model for feature extraction becomes essential. Given the intricate nature and diversity of Interior Space layout data, this article employs CNN as the foundation. CNN, a DL model, is particularly adept at processing image data, effectively extracting local features from images via convolution operations, reducing feature dimensionality through pooling, and ultimately enhancing the model's generalization capabilities.

In the realm of regenerating visual data from indoor imagery, we designate the domain as S'. From the blurry contours of the indoor scene, edge characteristic points denoted as x', y' are extracted. The next step involves calculating the textural dispersal in those obfuscated regions of the indoor images:

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

The given equation $Z\ i$ signifies the operators that handle both primary and secondary texture dispersion patterns. We further delve into the analysis of parameters that govern the limitations of visual communication at the pixel level:

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

Within the context, x', y', z' signifies the 3D coordinate value that is subject to visual limitations, whereas E represents the component responsible for data weighting.

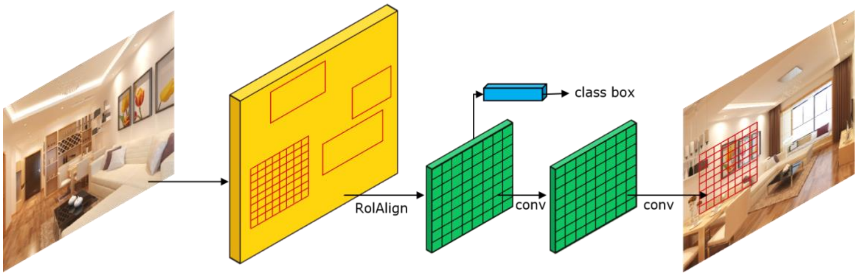


Figure 1: Feature detection model.

When constructing a CNN model, we need to consider the depth, width, convolution kernel size and step size of the model. In addition to the CNN model, this article also introduces the recurrent neural network (RNN) to deal with the sequence information in the Interior Space layout (Figure 1). In Interior Space layout, there are interdependent and restrictive relationships between different furniture and elements, which can be regarded as a kind of sequential information. By introducing the RNN model, this sequence information can be captured.

3.2 Application of EDL Algorithm

Although the DL model has the capacity to extract features autonomously, its parameters undergo continual refinement during training. An imbalance in the speed of these updates can negatively impact model performance. To address this, we introduce the EDL algorithm, which regulates the convergence of key parameters. Additionally, the depth map serves as an efficient representation of 3D scenes in 2D space. Herein, we present a depth map processing approach integrated with EDL technology. By leveraging EDL's intricate analysis of depth maps, designers gain a profound understanding of spatial structures and dimensions, enabling more precise decisions in layout and design. Furthermore, the view generation network, armed with given view parameters, intelligently creates numerous depth maps adjacent to the current perspective. The multi-view fusion network further exerts the advantages of EDL technology, which can effectively fuse multiple depth maps of adjacent views, thus obtaining more accurate depth value prediction. As shown in Figure 2, the multi-view fusion network realizes the efficient fusion of multi-view depth maps through its unique network structure.

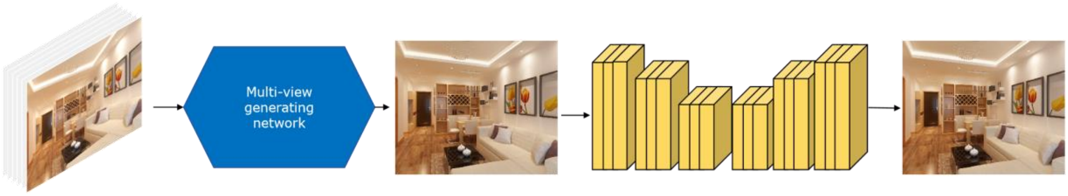


Figure 2: Multi-view fusion network structure.

The EDL algorithm serves as an innovative optimization technique that seamlessly integrates evolutionary principles with deep learning algorithms. By mimicking the natural evolution process, it progressively tunes and calibrates the model's parameters. In this framework, each model's parameters are treated as a distinct entity. Following an evaluation of their fitness, those entities exhibiting superior fitness are selected for crossover and mutation procedures, ultimately leading to the emergence of novel entities. Through this iterative refinement, the algorithm ultimately discovers the most optimal configuration of model parameters.

Supposing a total of n indoor images contribute to spatial arrangement, C_i represents the inherent and extrinsic factors of the i-indexed image. m 3D spatial locations have undergone reconstruction, with the X_j coordinates belonging to the j-designated 3D spatial point. The aim function optimized via the beam adjustment methodology is:

$$g\left(C,X\right)=\sum_{i=1}^{n}\sum_{j=1}^{m}w_{ij}\left\|q_{ij}-P\left(C_i,X_j\right)\right\|^2 \tag{3}$$

In the given equation, w_{ij} serves as an indicator variable, signaling the presence or absence of a point j in the image i. Specifically, if the point j is present in the image i, w_{ij} takes a value of 1; otherwise, it is 0. After undergoing projection transformation, $P\left(C_i,X_j\right)$ represents the coordinate of the point j on image i. In contrast, q_{ij} signifies the genuine image coordinate of a point j on image i.

Minimizing reprojection error through iterative refinement:

$$\arccos\left(N_{new}\cdot N_{ini}\right)\le\varepsilon\Delta=-\left(J_f^TJ_f+\lambda I\right)^{-1}J_f^Tf \tag{4}$$

The parameter λ denotes the weighting factor.

4 INTERIOR SPACE LAYOUT COMBINED WITH CAD

4.1 Design Process of Intelligent Layout

To address these limitations, this article introduces an intelligent layout approach integrated with CAD technology. The design flow of this method mainly includes the following steps:

Data input and preprocessing: input the basic information of Interior Space (such as size, shape, door and window position, etc.) and the user's design requirements into the system. The system preprocesses these data, including data cleaning, data conversion and other operations for subsequent analysis and processing.

Feature detection and classification: Using the EDL-based feature detection method, key features are automatically extracted from Interior Space layout data, and these features are classified and coded. These features include the size, shape, proportion, type, size, and location of furniture.

Intelligent layout generation: According to the extracted features and the design requirements of users, a variety of possible Interior Space layout schemes are generated by intelligent algorithms. These schemes consider many aspects of space, such as functionality, aesthetics, comfort and safety.

Layout scheme evaluation and optimization: evaluate and optimize the generated layout scheme. The evaluation indexes include the utilization rate of space, the rationality of furniture placement and the comfort of space. Through evaluation and optimization, the layout scheme that best meets the needs of users is screened out.

CAD drawing generation and output: import the optimized layout scheme into CAD software to generate high-quality CAD drawings. These drawings include plan, elevation, section and so on, which are convenient for users to check and modify.

4.2 Intelligent Layout of New Chinese Style Interior Space

In the layout design of a new Chinese-style Interior Space, the application of intelligent technology has special significance and value. The new Chinese style emphasizes the refinement and reconstruction of traditional elements and pursues the simplicity, naturalness and harmony of space. Therefore, in the new Chinese style Interior Space layout, intelligent technology can help designers better grasp the combination of traditional elements and modern design, and realize the harmony and unity of space layout.

In order to obtain the feature quantity of Interior Space layout of buildings, it is necessary to extract features on the basis of collecting and preprocessing the pixel data of Interior Space visual images. By means of distributed detection of edge parameters, an analysis model is constructed to study the evolution of degradation characteristics of visual images of the indoor spatial layout of buildings. Finally, the parameter distribution sequence of the building's Interior Space layout is obtained as follows:

$$k\ p\ = k\ p\Delta t\ , p \geq 0 \tag{5}$$

Considering Δt the interval of sampling visual data, p represents the collection of pixels depicting visual feature distribution in the indoor spatial layout of the building. We define b^{er} it as the normalized parameter value within the distribution domain a^{w},a^{m},a^{n} of the indoor spatial layout's visual imagery. $f = 1,2,3,\ldots,n$ signifies the colour attribute of this imagery. The visual distinctiveness elements of the indoor spatial layout are derived as follows:

$$G^{r} = k\ p\Delta t\ +\ fa^{w} + fa^{m} + fa^{n}\ ^{2} \tag{6}$$

The high-order moments in the fuzzy feature distribution area of the visual image of the Interior Space layout of the building are:

$$cHc = \frac{1 - k\ p\Delta t}{\cos^{-1} A + \sin^{-1} B} \tag{7}$$

Among them:

$$A = \frac{k\ p}{2\pi}\sin\left(k\ p\Delta t\ ^{2}\right) +\ fa^{w} + fa^{m} + fa^{n}\ ^{2} \tag{8}$$

$$B = \frac{k\ p}{2\pi}\cos\left(k\ p\Delta t\ ^{2}\right) +\ fa^{w} + fa^{m} + fa^{n}\ ^{2} \tag{9}$$

Using the high-resolution multi-dimensional space block combination method, the visual distribution pixel set of the Interior Space layout of buildings is obtained:

$$R_{r}\ f\ = \frac{G^{r} + v^{r}}{k\ p\Delta t}, v^{r} = 1,2,3,\ldots,n \tag{10}$$

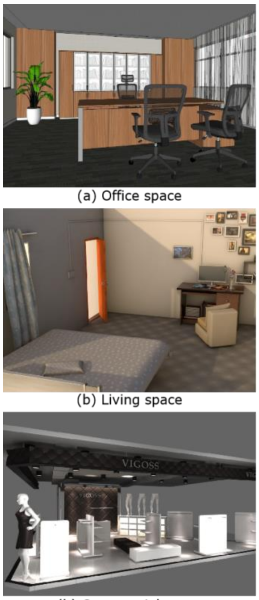
The first-order and second-order parameter analysis models of visual images of the Interior Space layout of buildings are established, and the rule function of visual fusion of the Interior Space layout of buildings is determined by using the hierarchical layout characteristics of buildings reflected by characteristic parameters:

$$ret_{c} = R_{r}\ b\ - \cos^{-1} A \tag{11}$$

In the feature map of k the layer, the visual information component of the Interior Space layout of buildings is extracted, so as to obtain the feature quantity of the Interior Space layout of buildings.

In the process of realizing an intelligent layout, special optimization can be carried out according to the characteristics of the new Chinese style. For example, in the feature detection stage, we can strengthen the extraction and classification of traditional element features. In the generation stage of the layout scheme, more traditional elements and symbols can be introduced to make the generated layout scheme more in line with the aesthetic requirements of the new Chinese style; In the evaluation and optimization stage, we can consider more evaluation indicators related to the new Chinese style, such as spatial layering and mobility.

In the above experimental environment, the indoor office space, residential space and commercial space of the experimental object are simulated and imaged by this system, and the results are shown in Figure 3.



(a) Office space

(b) Living space

(b) Commercial space

Figure 3: 3D simulation imaging results of Interior Space layout.

The system in this article can effectively realize 3D simulation imaging of Interior Space layout, and the imaging effect is good, with obvious visual impact, and the design and use of colour and light are naturally coordinated, which can beautify the visual effect. The highly practical spatial layout and harmonious natural colour and light design show that the application performance of this model is good.

Intelligent technology can also help designers better deal with the complexity and diversity in the layout of new Chinese-style Interior Spaces. For example, in the new Chinese style, different spaces may have different functions and requirements, and intelligent technology can generate diversified layout schemes according to these requirements and constraints; Furthermore, intelligent technology can also consider the influence of furniture materials, colors, textures and other factors on spatial layout, so that the generated layout scheme is more realistic and vivid.

5 EXPERIMENTAL ANALYSIS

5.1 Experimental Scheme

To validate the efficacy of our proposed approach, an experimental analysis was conducted within the scope of this study. The experimentation was executed on the MATLAB platform, utilizing the WINDOWS 11 operating system. The specifics of the test environment's parameters are outlined in Table 1.

Test serial number	*Pixel intensity /dB*	*Poor visual fusion*	*Feature recognition/%*
1	19.5911	5.6433	75.5022
2	20.6716	5.7665	68.8141
3	19.5378	5.5511	69.6554
4	21.2533	5.8748	70.1511
5	18.8521	5.4469	71.8877
6	19.0651	5.5191	68.3345
7	18.1323	5.2511	74.0021
8	18.6418	5.3705	73.0000
9	19.2549	5.5717	64.2585
10	18.1681	5.2325	69.6755

Table 1: Experimental parameter setting.

Drawing from the visual parameter configurations outlined in Table 1 for the indoor spatial layout of the building, a simulation was conducted to detect the salient features of this layout. This resulted in a visual representation of the sampling environment for the indoor spatial layout, which is depicted in Figure 4.

Figure 4: Visual sampling environment for Interior Space layout of buildings.

5.2 Analysis of Experimental Results

To validate the efficacy of our novel approach, we conduct a comprehensive set of experiments in this section. These experiments encompass both the accuracy of our method in extracting image features from sample spatial layouts and a comparative analysis with methods outlined in references [7] and [8]. To ensure the broad applicability of our findings, we select a representative set of sample spatial layout images as our test dataset, encompassing diverse layouts with varying degrees of complexity, lighting conditions, and occlusion.

Subsequently, we apply our method, along with the methods from references [7] and [8], to extract features from the images in our test dataset. As evident in Figure 5, our proposed method exhibits significant advantages in the precision of extracting image features from sample spatial layouts, thus demonstrating its superiority over existing methods.

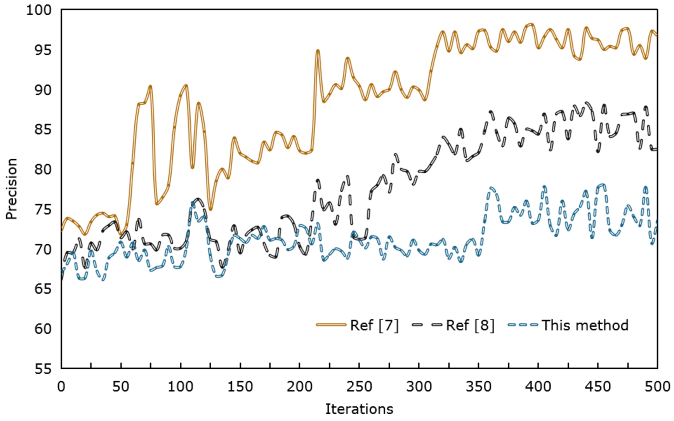


Figure 5: Precision of sample space feature detection by different methods.

As shown in Figure 5, our method demonstrates significant advantages in terms of accuracy in extracting sample space layout features. The curve in the graph visually illustrates the performance of different methods on the same test dataset. As can be seen, our method not only achieves higher accuracy overall, but also exhibits stronger stability and robustness in processing images with different complexities, lighting conditions, and occlusion situations. Further analysis of the data in Figure 5 reveals that the methods in references [7] and [8] often exhibit significant performance fluctuations when faced with complex sample space layouts. This is because they have a strong dependence on specific conditions or factors. Our method effectively reduces the impact of these factors by introducing more advanced algorithms and strategies, thereby achieving more stable and accurate feature extraction.

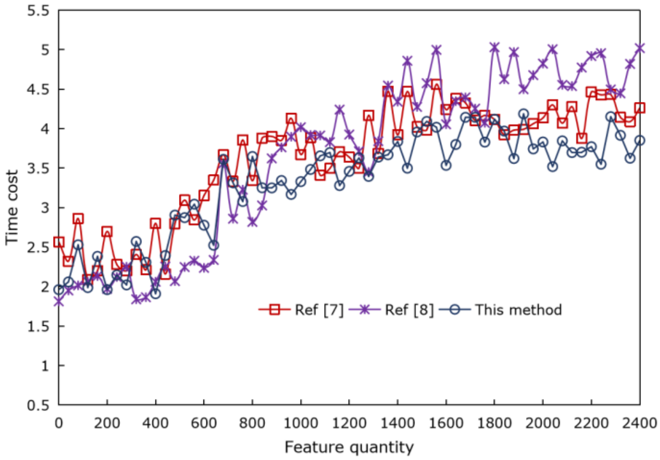


Figure 6: Time analysis of sample feature detection by different methods.

Upon comparing three distinct sample feature detection techniques, we observe substantial disparities in processing time for varying feature quantities. Irrespective of the feature count, our method consistently achieves extraction times under 4 seconds, outperforming the other two methods by a significant margin. Figure 6 clearly shows the different performances of the three methods in terms of sample space feature detection accuracy as the extraction time increases. It is worth noting that our proposed method performs excellently in accuracy, with a peak close to 97%, significantly surpassing the methods in references [7] and [8]. This high-precision feature detection capability is crucial for many practical applications, especially in scenarios that require precise recognition and classification of sample space layout. Further analyzing Figure 6, we can see that although the method in reference [7] has achieved relatively high feature detection accuracy (about 92%), its performance improvement speed is significantly slower than our proposed method. This indicates that our method is more efficient in achieving high accuracy and can adapt and learn features from sample data more quickly. However, the method in reference [8] is slightly lacking in accuracy, achieving only about 89% accuracy, which may be related to the design or parameter settings of its algorithm.

In addition to accuracy, Figure 6 also provides a comparison of the time required for different methods in the feature detection process. This information is crucial for evaluating the practicality and efficiency of the method. Through comparison, we can find that regardless of how the number of features changes, our proposed method can always complete feature extraction within 4 seconds, which is significantly faster than the methods in references [7] and [8]. This high-efficiency feature gives our method greater advantages in processing large-scale datasets or real-time applications. By analyzing the data in Figure 6 in-depth, we can also discover some interesting details. For example, in the case of a small number of features, the extraction time of the three methods is not significantly different, but as the number of features increases, our proposed method maintains high accuracy while the extraction time increases relatively slowly. This indicates that our method has better scalability and robustness when dealing with complex sample data.

Interior Space layout design encompasses vast amounts of data, encompassing multi-dimensional information like spatial dimensions, furniture arrangements, and material choices. These high-dimensional datasets not only augment computational complexity but also introduce potential redundancies and noise, which can undermine the precision and efficiency of layout design. As Figures 7 and 8 illustrate, the EDL model exhibits superior performance in feature dimension reduction compared to traditional DL models. This superiority stems primarily from the EDL model's integration of the benefits of evolutionary algorithms and deep learning.

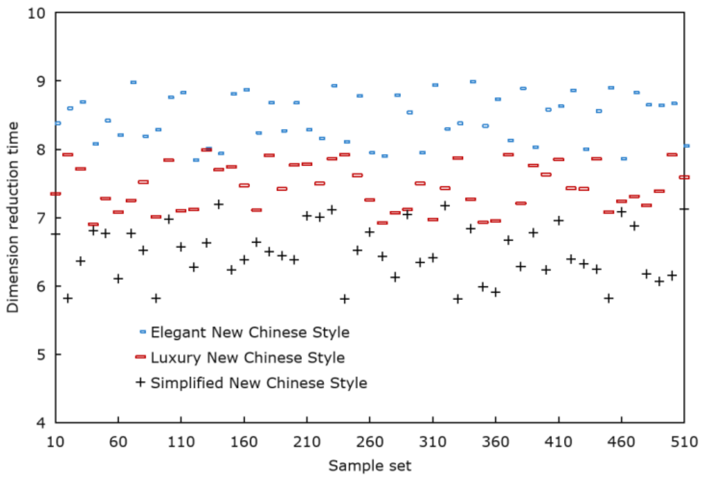


Figure 7: Dimension reduction time of DL model.

Figure 7 shows the dimensionality reduction time of traditional deep learning (DL) models in handling high-dimensional data of indoor space layout design (elegant new Chinese style, luxurious new Chinese style, simplified Chinese new style). From the graph, it can be seen that as the data dimension increases, the dimensionality reduction time of the DL model does not significantly change, indicating that the traditional DL model is more stable when dealing with complex datasets. In addition, the elegant new Chinese style during the long-term dimensionality reduction process has a high response speed and real-time performance throughout the entire design process.

In contrast, Figure 8 shows the dimensionality reduction time of the EDL model under different indoor styles (New Chinese style, Classical European style, and Modern style). From the graph, it can be seen that the EDL model significantly improves the efficiency of feature dimensionality reduction. Regardless of the style, the dimensionality reduction time of EDL models is relatively short, and as the data dimension increases, the growth of dimensionality reduction time is also relatively gentle. This is mainly due to the fusion of the advantages of evolutionary algorithms and deep learning in the EDL model. Evolutionary algorithms can find the optimal solution in a vast feature space by simulating natural selection and genetic mechanisms, effectively removing redundant features and reducing data dimensions. Meanwhile, deep learning models can extract meaningful representations from the reduced features, capturing the essence and underlying patterns of the data. Further analyzing the data in Figure 8, we can see that the EDL model has slightly different dimensionality reduction times when dealing with different indoor styles. The new Chinese style takes the most time, while the modern style takes the least time. This may be due to differences in data distribution and feature expression among different styles of spatial layout designs. However, overall, the EDL model has shown high dimensionality reduction efficiency and stability in various styles.

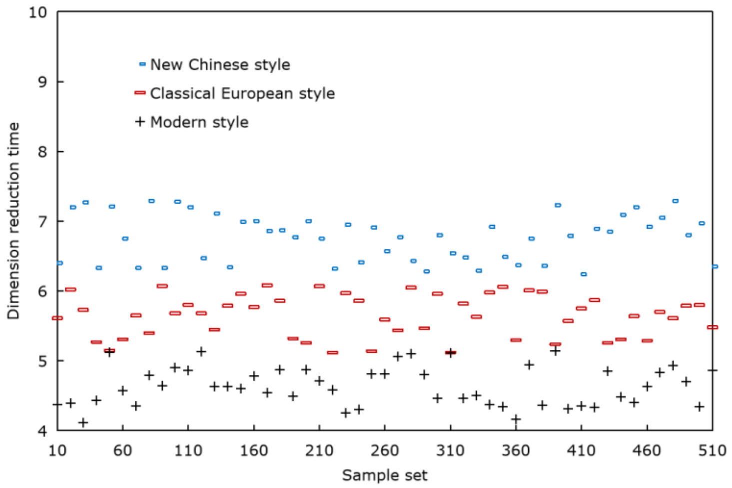


Figure 8: Dimensionality reduction time of EDL model.

Utilizing the training of a DL model, we can seamlessly acquire meaningful feature representations from high-dimensional datasets, thereby capturing the essence and underlying patterns of the data. In the realm of EDL modelling, this DL model is harnessed to extract the intricate features of Interior Space layout design. When integrated with evolutionary algorithms, it achieves a more streamlined and precise reduction in feature dimensionality.

Because this algorithm adopts a global optimization strategy, it can generate more diversified layout schemes to meet the individual needs of different users. The algorithm in this article combines CAD technology and can generate high-quality CAD drawings, which are convenient for users to view and modify. This convenient interactive mode helps users to understand the layout scheme better and improve their satisfaction with the whole design process. In Figure 9, we visually display the results of 550 target users rating the indoor layout optimization method, which provides strong evidence for evaluating the effectiveness of our novel method. From the graph, it can be seen that the indoor space designed using our method has received a generally high rating from users, and its rating significantly exceeds that of traditional methods.

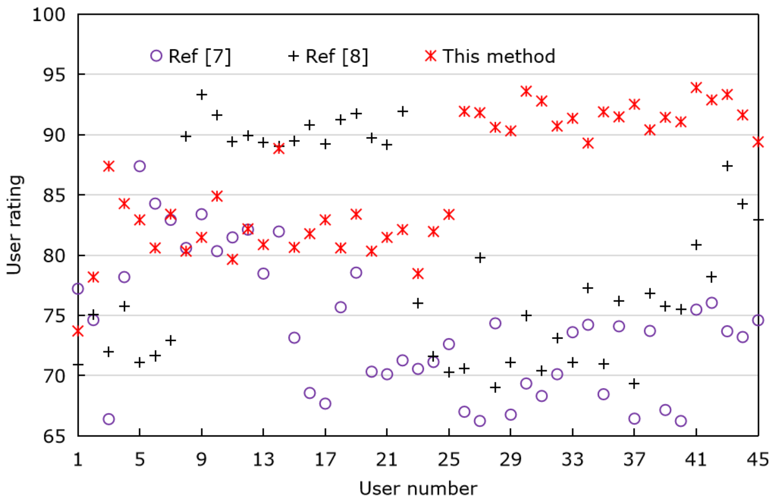


Figure 9: Comparison of user ratings of different systems.

This result not only validates the effectiveness of our method but also reflects the user's recognition of our innovative design. Through the user rating data in Figure 9, we can further analyze the satisfaction of users with our method. Firstly, a high rating indicates that users have a positive attitude towards our design results, believing that our method can generate indoor layout solutions that meet their needs. Secondly, the distribution of user ratings also reflects the stability and reliability of our method. If the rating distribution is relatively concentrated and generally high, it indicates that our method has good consistency and replicability among different users. Finally, by comparing the rating data of traditional methods and our method, we can clearly see the significant advantages of our method in terms of user satisfaction.

6 CONCLUSIONS

In this article, the application of DL technology in the intelligent layout of new Chinese-style Interior Space is deeply studied, and an innovative algorithm based on EDL is proposed, its remarkable advantages in feature reduction and layout optimization are verified in experiments. Compared with traditional methods, this algorithm has an excellent recall rate, and the Interior Space constructed based on the new method is also obviously superior in user rating.

This achievement is due to the efficient feature detection ability and global optimization strategy of the EDL model. By combining the feature detection advantages of the DL model and the optimization mechanism of the evolutionary algorithm, the algorithm can search for the most representative and optimal layout scheme in the complex design space.

This algorithm also fully considers the aesthetic needs of the new Chinese style and provides users with more layout choices that meet their aesthetic standards by integrating traditional elements and modern design concepts. Combined with CAD technology, the algorithm can automatically generate high-quality CAD drawings, providing users with an intuitive and convenient way of interaction, further improving the user experience and satisfaction.

In essence, the EDL-based intelligent layout algorithm for contemporary Chinese-style Interior Spaces presented in this article has achieved remarkable advancements in design efficiency, precision, and user experience. Looking ahead, as technology continues to evolve and refine, I am confident that this algorithm will assume an even more significant role in the realm of Interior Space design.

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