Artificial Intelligence-Assisted Interior Layout Design of CAD Painting

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Abstract. As of today, with the promotion and application of artificial intelligence, a large amount of manual labor the current one, and its application to interior layout design will inevitably promote interior layout. Design innovation and optimization can also ensure the quality of modern interior layout design and effectively improve efficiency. This paper utilizes adversarial learning to design a conditional generative adversarial network (CGAN)-based approach for indoor scene layout estimation to predict the spatial layout structure of a room. Firstly, aiming at the problem that the boundary line of the layout edge map is easily blurred by the interpolation enlargement, a strategy of increasing the depth of the convolution layer and the deconvolution layer is adopted, and a new encoder-decoder network (Encoder-Decoder) is proposed to construct a conditional generative confrontation. A generative network for the network that produces a layout edge map of the same size as the original image. Then, for the difficult convergence problem of generative adversarial network training, a multi-scale strategy is used to build a multi-scale supervised network of generative networks to accelerate the convergence. The experimental results and analysis of the LSUN and Hedau standard datasets show that, compared with other layout estimation methods, this method can understand the indoor scene layout from an overall perspective and more accurately predict the 3D spatial layout structure of the room.

Keywords: Artificial Intelligence; Cad Drawing; Interior Layout Design; Adversarial Network.
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1 INTRODUCTION

There are a lot of layout problems in modern engineering and real life, and interior space layout is one of the very important branches. The interior space layout focuses on the interior scenes that people rely on for production and life. At the same time, films, computer games, and virtual reality technology. Due to its broad application prospects and huge commercial value, indoor space layout has become it. As computer-aided design intelligent, interior space layout has also become it. In the problem of interior space layout, it is often required to create a layout or optimize a layout in a given area or space. Such emergence aims to explore ways to replace human labor with computers. Layout design (Layout Design), generally speaking, is about the reasonable arrangement and proper placement of objects [1]. Such as the arrangement of very large-scale integrated circuits, the container shipping problem in freight terminals, and the architectural layout design problems in the construction field [2]. Because the layout design has broad application prospects and huge commercial value, the layout design problems that can be seen everywhere make the layout research have universal and profound practical significance [3]. Space layout design is the main content of layout design, because most layout design problems are closely related to space, such as the problem of cutting one-dimensional space, the problem of interior layout plan design in two-dimensional space, and the layout of cockpit in three-dimensional space [4].

The research of space layout design proposed by Qin et al. [5] stems from the fact that traditional methods cannot meet the needs of current efficient design. Designers such as Schnhof et al. [6] assisted with interactive modeling software. Tavanapong et al. [7] elaborated its limitations, which are mainly based on repeated attempts and mistakes, as well as design experience and creative intuition. As the traditional design mode mainly relies on manual labor, the design process proposed by Yigitcanlar et al. [8] often consumes a lot of manpower and energy. Therefore, in order to change the traditional layout design mode, Yoo and Kang [9] studied the automatic design of spatial layout. This has become an urgent research topic for the current industry and academia. Since the 1960s, Zhang and Li [10] has carried out intelligent design for computer aided (CAD), and has gradually formed computer aided layout design. Zhao et al. [11] proposed mathematical modeling, modern optimization, artificial intelligence, graphic interaction and other related technologies. With the development of computer-aided design and the rise of artificial intelligence, as an important research field of intelligent design, the application and research of spatial layout.

In the past, when the interior layout design work was carried out, there were often technical problems involved. In the case that some technical personnel lacked sufficient knowledge reserves, it was difficult to ensure efficient and rapid problem solving. In the long run, the quality and effect of interior layout design will inevitably be affected. At present, Auto CAD has become one of the most common drawing tools in various fields. When people choose the interior layout design scheme, they not only pursue the functionality of the building, but also decorative effect of the interior building. Therefore, the design difficulty of the current interior architectural decoration layout is increasing, and a more modern design method is urgently needed, so as to continuously optimize the designer's aesthetic and design thinking orientation. Based on this, this paper combines Auto CAD to carry out research on interior architectural decoration layout design.

2 STATE OF THE ART

2.1 Explanation of Related Concepts

Modern interior layout design refers to the artificial transformation of a certain area of the city by the designer through it and finally creates a city atmosphere where people live in harmony with nature and a beautiful environment. From the perspective of content, modern interior layout landscaping, etc.

CAD software is an important drawing tool in interior design, and layout space drawing technology is a powerful function of CAD. Few people have studied in detail how to draw design drawings in CAD layouts.it will enhance the readability and portability of CAD drawings, the author conducts a systematic study on the skills and methods of CAD layout drawing (drawing specifications). At present, there are two major problems in CAD layout drawing: First, although the function of CAD layout drawing is powerful, there are few designers who can use it systematically, and most of them are limited to the drawing level; second, the method of CAD layout drawing is cumbersome and inefficient is not conducive to the development of design projects.

There are two kinds of drawing space in CAD drawing software: Designers often find that many drawings will appear repeatedly during the drawing process of the model space, so they need to be copied many times. Once these drawing contents need to be modified, the designer must constantly repeat the work will greatly reduce the drawing efficiency. Therefore, some designers classify the work annotations in the layout space. and annotations and drawing frames, etc., and also adjust the size of the sheet during the page setup process, adding a title block, displaying multiple viewports or multiple views of the model, etc.

2.2 The Main Problems in Interior Design

Lack of advanced design concepts. Drawing on experience and imitating is the main way of design. In the context of the application of this design method, it will lead to a lack of innovation consciousness and individualized consciousness in interior layout design. With corresponding environmental protection concepts, they often blindly pursue aesthetics, etc., and it is difficult to give full play to the actual role of indoor layout. At this stage, my country vigorously advocates green economy, which mainly refers to promoting rapid economic development and gradually realizing the sustainable development of human society on the premise of protecting the environment. In addition, due to different cities, there will be differences in culture, and there are similarities and differences in humanistic characteristics. Only by fully reflecting these different characteristics can the interior layout design meet the actual needs of the city. However, when the current interior layout design is carried out, these different properties are ignored, so there is a severe homogenization phenomenon in the interior layout design.

The technical level that needs to be improved urgently. In interior layout design, art and technology are often combined, which not only involves multiple majors, but also requires designers to fully possess multi-professional knowledge and skills to achieve high-quality and efficient interior layout design. However, from the actual situation, designers do not have the corresponding multi-professional knowledge and skills when designing the interior layout. Therefore, the quality and effect of interior layout design will be affected. In addition, at this stage, my country's interior layout construction technology is relatively backward, even if a large number of high-quality design schemes are formulated, it is difficult to implement in the interior layout, which will ultimately affect the interior layout design.

The design scheme does not match the reality. From the perspective of the essence of interior layout design, it reflects a way to design and improve the living environment. At this time, living environment of people due to different regions, as well as the climate and cultural factors in different regions. s difference. Therefore, in the interior layout design, it is necessary to base on the actual local conditions to ensure that the interior layout that is consistent with reality can be designed. Although a lot of manpower, material resources, capital and other resources have been invested in some interior layout design, but no design scheme with good effect has been obtained. When the interior layout design work was carried out, the data was not comprehensively collected, and the actual situation of the city was not used as the main basis, so the effect of the design plan would be affected.

2.3 Application of Artificial Intelligence Technology and Cad Drawing in Interior Layout Design

In order to realize the layout design of interior architectural decoration in Auto CAD software, it is necessary to carry out on-site measurement operations according to the original design drawings. Using Auto CAD software, the basic outline of the interior structure is accurately drawn. According to the house type structure and outline drawing drawn in Auto CAD software, the layout and use of doors and windows and various aspects are designed to obtain a complete house type plan. After completing the above operations, other interior architectural decorations, such as ceilings, floors, lamps, and water supply and drainage structures, should also be designed and drawn. Before the Auto CAD software models the interior architectural decoration layout, it is necessary to set the unit, especially when importing the CAD file, the default unit of the file format is millimeters, which is not consistent with the actual building unit. Therefore, in order to ensure the correct size of the imported graphics and avoid the problem of non-standard 3D models, it is necessary to reset the units.

The layout design of complex systems is a constraint layout problem, of which position constraints are the most typical and common type of constraint problems, such as the layout of machine tools and equipment in workshops, and the layout of workshops. In the position constraint problem, the positional relationship of layout design includes adjacent relationship, visible relationship, reachable relationship, distance relationship, symmetry relationship and relative orientation relationship. Layout problems can be divided into three categories: one-dimensional layout problems, two-dimensional layout problems, and three-dimensional layout problems according to the dimensions of the layout space. The one-dimensional layout problem is relatively simple, and can generally be expressed as a one-dimensional cutting problem, which is usually solved by mathematical programming. The two-dimensional layout problem is the most common and most studied problem in the field of layout design. For example, the layout design of the VLSI module is a typical two-dimensional layout.

3 METHODOLOGY

3.1 The Basic Method of Indoor Space Layout

The traditional interior space layout mainly relies on Artificial, the theoretical application of mathematical modeling is less, mainly based on the designer's experience method, so it is not the focus of our discussion. (Constraint·Satisfaction·Problem,·CSP), that is, to find the optimal solution based on a certain evaluation under the given constraints. Its special feature is that the best result can be selected from a limited number of layout schemes. All interior space layouts are combinatorial optimization problems. Such operations research. The combinatorial optimization problem has a wide range of applications in a large number of practical optimization problems, such as the classic 0-1 knapsack problem (Knapsack) packing problems (Bin Packing Problem) and so on. For ease of discussion, we formulate the indoor:

$$\text{s.t.} \quad g(x) \geqslant 0 \tag{1}$$

Among them, X is the configuration variable in the indoor space layout, realize the function of self-learning by simulating the neural network in the biological brain. The perceptron is the simplest artificial neural network model. It is simple because the perceptron simulates the basic characteristics of a single neuron in the biological brain. Suppose the neuron receives n excitations (or input information), respectively x1, x2...xn, then the perceptron The output function is defined as:

$$\text{output} = \begin{cases} 0 \\ 1 \end{cases} \tag{2}$$

where w1, w2...wn are the weights corresponding to generative adversarial networks, etc.

Convolutional neural networks have achieved outstanding performance in image processing, natural language, and speech recognition, and have become one of the research hotspots in many scientific research fields. The classic convolutional neural networks include LeNet, AlexNet, VGGNet, GoogleNet, ResNet, etc.

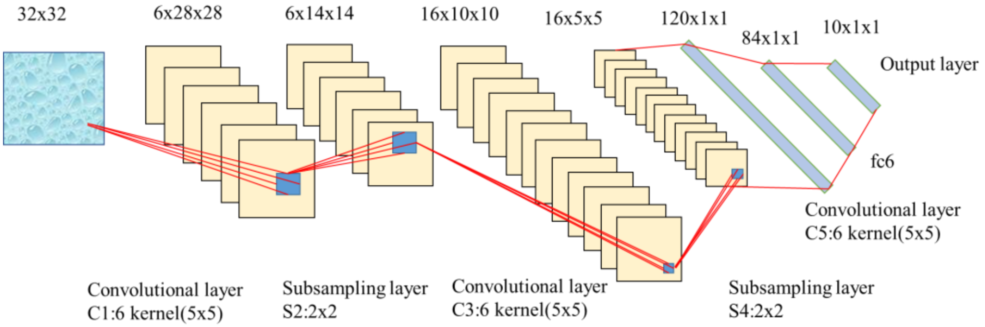

Figure 1: Classical network structure of AlexNet1.

Figure 1 shows the classic network structure of AlexNet1. Given a single-channel image, use a M*N convolution kernel to perform convolution operation with the single-channel image, then the convolution calculation formula is:

$$y_{i,\ j} = \sum_{m=1}^{M} \sum_{n=1}^{N} w_{m,\ n} x_{i+m,\ j+n} \tag{3}$$

where yij output image, and wm,n represents the convolution kernel's. Among them, the ReLu function is the most widely used, and its function form is:

$$f(y) = \begin{cases} 0, & \text{if } y \leqslant 0 \\ 1, & \text{else} \end{cases} \tag{4}$$

The role of the activation layer is actually to nest a nonlinear function on the basis of the convolution result, so the activation layer can establish a nonlinear mapping between the input and the output by introducing nonlinear factors, thereby enhancing the representation ability of the neural network.

3.2 Generative Adversarial Networks

There is a competitive relationship between the two. Through the idea of a zero-sum game, the discriminant network can reach the Nash equilibrium, that is, the difference cannot be discriminated, so as to obtain enough fakes. sample. Generative adversarial networks real samples, that is, learn complex mapping rules between input and output, and the one, which can be equivalent to learning a good loss function, Improve the discriminative ability of this part of the network to form a strong competitive relationship with the generation network. The network structure generator is a probabilistic generation network model, and the discriminator is usually a convolutional neural network or a support vector machine. There is competition between them. The goal of the generator is to generate highly realistic fake samples, i.e. generated samples, to confuse the discriminator.

Figure 2 shows the schematic diagram of GAN network structure. The objective function of GAN is a maximization-minimization game about G and D, where D tries to identify the source of the input data to the best of its ability, and G tries to confuse D by generating samples that one is the good. A mathematical explanation of how D works is as follows:

$$D(x) = \frac{p_{\text{data}}(x)}{p_{\text{data}}(x) + p_{\text{model}}(x)} \tag{5}$$

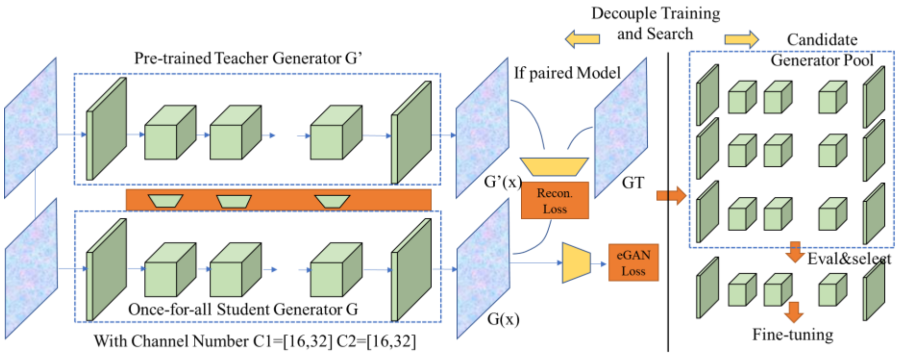

Figure 2: Schematic diagram of GAN network structure.

where x is the real sample and the desired result is D(x) equal to 1/2. When a GAN is combined with a convolutional neural network, there is an objective function to optimize and solve, the objective loss function:

$$\min_G \max_D V(D,G) = E_{x\sim p_{duau}(x)}[\log(D(x))] + E_{z\sim p_z(z)}[\log(1-D(G(z)))] \tag{6}$$

A further breakdown of the above objective function is as follows:

Discriminant Model:

$$-(\log(D(x)) + \log(1-D(G(z)))) \tag{7}$$

Generative models:

$$\nabla_{\theta_d} \frac{1}{m}\sum_1^m \log\left(1-D\left(G\left(z^i\right)\right)\right) \tag{8}$$

Our optimization goal is to generate indoor space layout that can cover the defined area of the layout as much as possible under the premise of satisfying two basic constraints, that is, the smaller the area of the uncovered defined area, the better. Therefore, the energy function of the basic algorithm is defined as:

$$E_{cover}(L) = Area(L) - \sum_i w_i \times d_i \tag{9}$$

If the discriminant model cannot discriminate that the input data is a real sample, D(x) will approach 0. Similarly, for the generative model, when the generative model G has a strong generating ability, it is difficult for D to distinguish the input sample as Whether the generated sample or the real sample tends to be random guessing. The difference between CGAN and GAN is that during training, the data input is not only a priori noise z, but also a conditional input y needs to be added to both the generator and the discriminator. In the discriminator, the input data x and condition y are represented as input function and discriminant function, then :

$$\min_G \max_D V(D,G) = E_{x\sim p_{data(x)}(x)}[\log D(x|y)] + E_{z\sim p_z(z)}[\log(1-D(G(z|y)))] \tag{10}$$

The evaluating the performance of the conditional generative adversarial network proposed in this paper is:

$$G^* = \min_G \max_D V_{CGAN}(G,D) + \lambda V_{L2} + \eta V_{L2}\left(G_{d_4}\right) \tag{11}$$

in,

$$V_{CGAN}(G,D) = E_{x,y\sim p_{data}(x,y)}[\log(D(x,y))] + E_{x\sim p_{data}(x),z\sim p_z(z)}[\log(1-D(x,G(x,z)))] \tag{12}$$

$$V_{L2}(G) = E_{x,\ y \sim p_{\text{dita}}\ (x,\ y),\ z \sim p_z\ (z)}\left[\|\ y - G(x,z)\ \|^2\ \right] \quad (13)$$

$$V_{L2}\left(G_{d_4}\ \right) = E_{x,\ y \sim p_{\text{data}}\ (x,\ y),\ z \sim p_z\ (z)}\left[y - G_{d_4}\ (x,z)^2\ \right] \quad (14)$$

The overall loss function consists of three parts, namely the adversarial loss, the loss of the network that generates the layout edge map, and the loss of the supervision network part.

We use the idea of adversarial training to jointly train two network models in computer vision, the generator defines the 3D structure of the indoor scene layout, and the discriminator acts like an evaluator, labeling the layout edge map input by the network as the one from the generator. Generated fake samples or real samples from the real world. In binary classification problems, we often use cross-entropy to measure the classification effect.

$$C = -\frac{1}{n}\sum_x [y \ln a + (1-y)\ln(1-a)] \quad (15)$$

where n is the number of samples in the training set, y represents the real sample, a represents the pseudo sample, and C represents the distance between the data distributions of the two samples a and y. The smaller the value of C, the closer the data distribution of the two samples is. Update the discriminator D according to the following stochastic gradient ascent:

$$\nabla_{\theta_d} \quad \frac{1}{m}\sum_1^m\left[\log D\left(x^{(i)}\right) + \log\left(1 - D\left(G\left(z^{(i)}\right)\right)\right)\right] \quad (16)$$

Ian Goodfellow's description gives us a more intuitive understanding of the GAN training process, as shown in Figure 3:

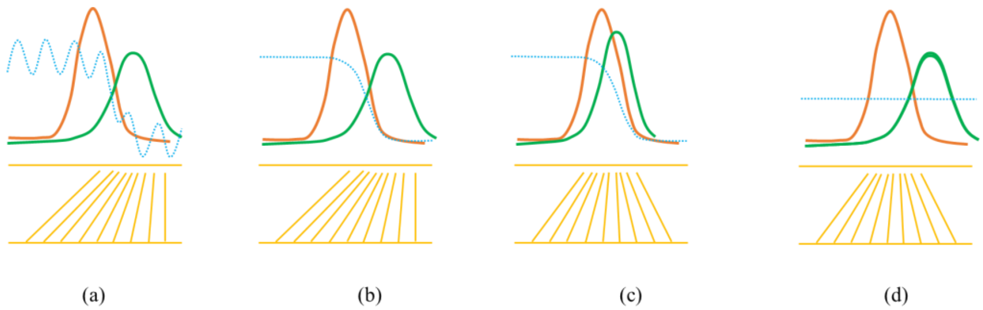

Figure 3: The training process of the generative adversarial network.

4 RESULT ANALYSIS AND DISCUSSION

4.1 Scene Layout Estimation Dataset

We study the automatic design algorithm of indoor space layout the purpose is to facilitate architects to explore different layout design schemes. To verify the performance of the encoder-decoder network, multi-scale supervised encoder-decoder network, and conditional generative adversarial network are mainly evaluated on the LSUN (Large-scale Scene Understanding) dataset and the Hedau dataset. The LSUN dataset is an indoor LSUN dataset is a commonly used standard dataset for indoor scene layout estimation, including training set, test set, and validation set. The LSUN dataset contains 5394 indoor scene images, including validation set is used to tune the parameters in the model. The test set and the training set are mutually exclusive, which are used give the experimental results.

While significant progress has been made model, a large amount of annotated training datasets is required. The training set of the LSUN dataset contains 4000 training images. Compared with the depth of the network used in this paper, the number of sample images in the training set is small, so consider expanding the sample images in the training set. Image horizontal flipping is a common training data expansion method. For example, in the literature, ideal experimental results are obtained by horizontally flipping the sample images in the training set for expansion. Therefore, in the experiment of this paper, the indoor scene images in the training set are flipped horizontally, so that the training images are doubled, that is, the number of sample images in the training set in this experiment is 8000, and the test set and validation set retain the original LSUN data set. number of samples.

The definition of the LSUN dataset is used in this paper to determine the parameters of the generated boundary map. The dataset has 11 types of indoor scene layouts and 20 object categories, each of which has its own type and corner coordinates, covering most possible indoor scene images. The networks experimented and found that they achieved significant performance gains when trained on this dataset.

4.2 Analysis of Experimental Results

Figure 4 shows the performance of the simulated annealing method and our algorithm at different complexity, where complexity the stochastic optimization method takes more than two hours.

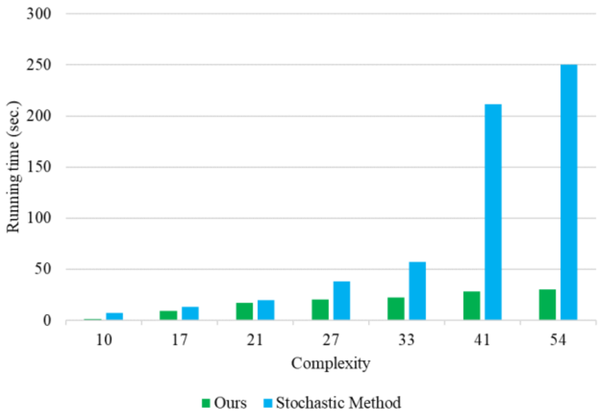

Figure 4: Comparison of Algorithms.

In this paper, a scale-1 detail component image is converted from 1MHz sampling frequency to 2MHz by Pix2Pix. The criterion for judging the accuracy of the image generated by Pix2Pix should be that the arrival time of the traveling wave head generated by the fault to the pseudo.

Figure 5 shows the generator loss value. However, sometimes when the training epoches reaches a certain value, the recognition rate does not detailed component images can be accurately recognized. Figure 6 shows the results of the opponent's network training. In the statistical data set, most of the construction areas of teaching buildings are concentrated. The main range of the training set is 181100 ㎡~295100 ㎡, with an average value of 264428 ㎡; the main range of the test set is 143900 ㎡~281900 ㎡, with an average value of 248110 ㎡. The set is slightly higher than the test set. This is because the overall land area of compressed and then input to the computer for learning, which will lead to inaccurate RGB values of some building pixels, resulting in the loss of model learning information. Part of the loss results in slightly fewer building pixels in the final model-generated image. However, in terms of the relationship between the land area and the construction area of the teaching building, the distribution of the training set and the test set is basically the same, which shows that the overall effect of the model learning is still good. Figure 7 shows the comparison results of the teaching building area between the training group and the test group.

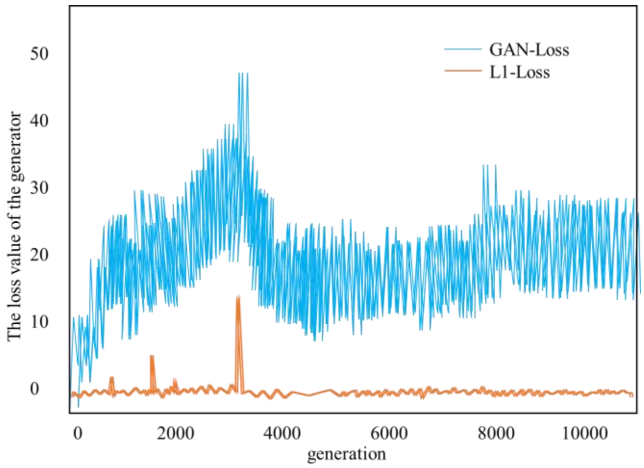

Figure 5: Loss values of the generator.

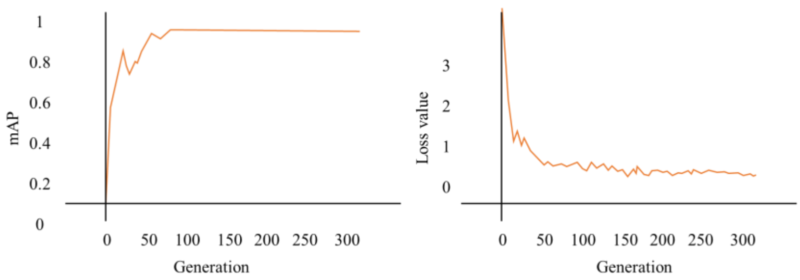

Figure 6: Adversarial network training results.

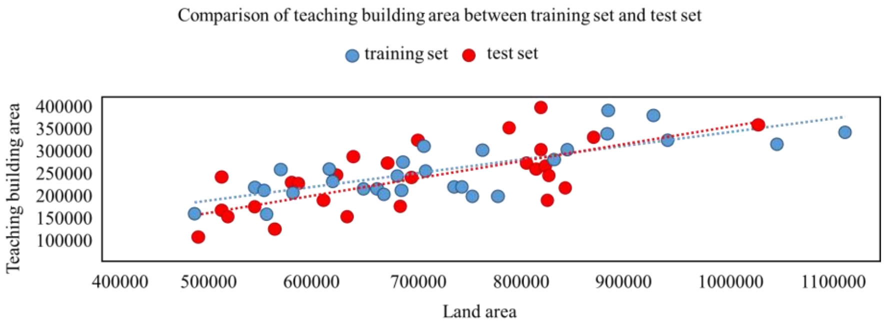

Figure 7: Comparison of teaching building area between training set and test set.

Look at the two functional partitions where the distribution trends of inconsistent. From the perspective of the central area, the training is concentrated, the proportion of the land area in the central area increases with the increase of the total campus area, and the proportion of the land area in the teaching and scientific research areas around the central area increases with the increase in the total campus area The test set is just the opposite of the training set. The proportion of land used in the central area campus, and the teaching and research area is proportional. The comparison results of the distribution of the training set and the test set are shown in Figure 8.

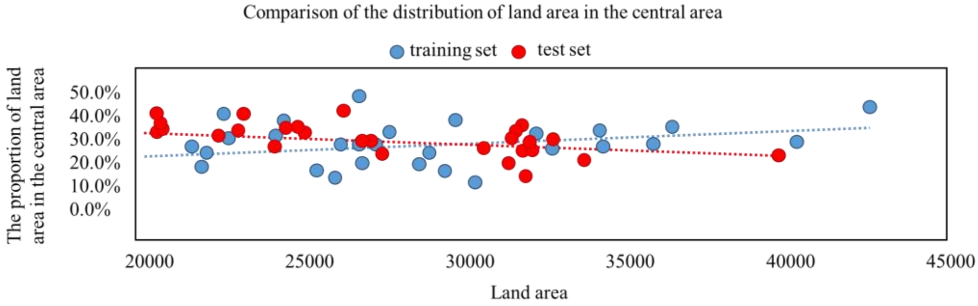

Figure 8: Comparison of the distribution of the central area of the training set and the test set.

5 CONCLUSION

In short, CAD software has been used by designers for many years and is the link between designers and Party A. However, the interior design industry has not always had a unified drawing standard, especially in the drawing method, which is quite different, and the model space drawing and the layout space drawing coexist. The accuracy and efficiency of drawing in the layout space are better, especially in large-scale projects, the advantage of batch drawing of layout is obvious. In the indoor scene layout estimation method based on conditional generative adversarial network proposed in this paper, for an RGB image of an indoor scene, the conditional generative adversarial network model is first trained with the LSUN dataset, and the network parameters are initialized. Conditional ones. There is a competitive relationship between the two. Through the idea of zero-sum game, the discriminant network can reach Nash equilibrium, and the difference between the input sample and the real sample cannot be discriminated, so as to obtain enough fakes. sample. For Generative Adversarial Nets. During the training process of GAN, there will be problems such as gradient disappearance and gradient explosion, resulting in unstable training. The training process is a process of continuous learning and correction of errors by the network. If the training process fails, it is proved that the network The failure of learning affects the experimental results.

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