Innovative Interactive Design Method Integrating Computer Vision Generating Countermeasure Network

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Abstract. This article puts forward an innovative interactive design method combining computer vision, CAD, and GANs and evaluates the effect of this method in improving design efficiency, interactive experience, and innovation. This method integrates many advanced technologies and provides users with a natural, intelligent, and efficient interactive experience. The experimental results support the hypothesis of this article, that is, the innovative interactive design method combining computer vision, CAD, and GANs has obvious advantages in interactive experience, design efficiency, and innovation. Specifically, the score of the method designed in this article is high and innovative, and the score is basically above 93%. The innovative interaction design method proposed in this study can solve the problems in existing interaction design and provide designers with a natural, intelligent, and efficient interaction experience. Moreover, it stimulates the innovative thinking of designers and improves the innovation of design and user experience, thus promoting the upgrading and improvement of related products or systems.

Keywords: Computer Vision; Computer-Aided Design; Generative Adversarial Networks; Innovation; Interactive Design; User Experience
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1 INTRODUCTION

Computer vision, CAD (Computer Aided Design), and GANS (Generative Adversarial Networks) have made remarkable progress in their respective fields. In mechanical design, changes to one component may affect the performance and stability of other components. Therefore, designs with inter-component dependencies require a comprehensive approach to consider all factors in order to achieve optimal design results. Chen and Fuge [1] proposed applying HGGAN to designs with inter-component dependencies to achieve a more intelligent and automated design process. GAN has the advantage of generating sample diversity and authenticity. Hierarchical Generative Adversarial

Network (HGGAN) is an improved GAN model that transforms data distribution learning into multiple subtasks in a hierarchical manner, thereby reducing the demand for data and computing resources.

With the expansion of its application scope, many new challenges and problems have emerged, one of which is adversarial attacks. Adversarial attacks can disrupt the normal operation of recommendation systems by tampering with user behavior data, inserting malicious recommendations, and other means, causing losses to enterprises and users. Therefore, how to improve the robustness and security of recommendation systems becomes a problem. Deldjoo et al. [2] conducted a survey on adversarial interactive recommendation systems, elaborating on their research status, existing problems, and future development trends from two aspects: attack/defense strategies and generating adversarial networks. Adversarial attacks are malicious attacks against recommendation systems aimed at disrupting their normal operation and resulting in inaccurate recommendation results. Model training is a model-based defense strategy aimed at training models that can resist malicious attacks. To improve their resistance to malicious attacks. Interaction design methods are constantly innovating to adapt to new application scenarios and user needs. New interaction design methods such as natural interaction, intelligent assistant, virtual reality, and augmented reality interaction have become research hotspots. Semi-supervised learning is a machine learning method that utilizes unlabeled data to improve model performance. The model consists of a generator and a generator. The task of the generator is to generate new data samples, while the task of the generator is to discriminate the generated data samples. Semi-supervised generative adversarial networks can utilize unlabeled data to improve model performance while also alleviating the problem of data imbalance. However, when data is imbalanced, traditional semi-supervised generative adversarial networks may tend to generate a larger number of class samples and overlook a smaller number of classes. This may lead to poor performance of the model during the testing phase. In practical applications, this makes semi-supervised learning an attractive choice. Semi-supervised learning can utilize unlabeled data to improve model performance while also alleviating the problem of data imbalance. Gao et al. [3] generate new and authentic samples by learning data distribution. In semi-supervised learning, GANs can generate samples of unlabeled categories, thereby increasing the amount of data for that category. However, when the data is imbalanced, generative adversarial networks may tend to generate a larger number of category samples while ignoring a smaller number of categories. This may lead to poor performance of the model during the testing phase.

Computer vision has made remarkable progress in image recognition, target detection, and scene understanding, which provides strong technical support for various applications. With the constant changes in people's aesthetic concepts, modern art visual communication design is facing new challenges and opportunities, which provides new ideas and methods for interactive design. Gu et al. [4] explored how to combine modern art visual communication with generative adversarial networks to achieve more innovative and attractive interactive design. Interactive design is an important part of modern art and design, aimed at allowing the audience to participate, interact, and communicate with artworks. In interactive design, designers usually use various technologies and means, such as sensors, multimedia, network technology, etc., to achieve two-way communication and feedback between the audience and the work. The interactive design of modern art visual communication mainly focuses on the audience's experience and feelings, creating a specific atmosphere and emotion through the use of visual elements and symbols. Designers will select appropriate visual elements and symbols based on the theme and purpose of the work and arrange, combine, and design them to achieve information transmission and expression. At the same time, designers will also consider the ways in which the audience participates and interacts in order to achieve two-way communication and feedback between the work and the audience. Conditional Generative Adversarial Networks (cGANs) have achieved significant results in tasks such as image generation, image restoration, and style transfer. Interactive sketch flow design is an art form that involves a lot of creative thinking and expression, and its process often requires a lot of sketch generation and iteration. Hu et al. [5] proposed applying cGANs to interactive sketch flow design to achieve a more intelligent and automated design process. CGANs are an extension of GANs, under specific conditions by adding conditional information to the generator and discriminator. In cGANs, conditional information can include category labels, text descriptions, image fragments, etc. The generator generates images based on conditional information and random noise, while the discriminator distinguishes. Through this adversarial training, the generator can generate images that meet specific conditions. To verify the feasibility and effectiveness of the interactive sketch flow design system proposed in this article, we conducted a series of experiments. The quality and efficiency of sketch generation enhance the interaction and collaboration between users. At the same time, the system can also automatically allocate tasks and resources according to user needs, improving the intelligence and automation level of the system.

Interactive maps as geographic information systems, urban planning, and traffic flow analysis. However, manually creating interactive maps with rich styles and details is a time-consuming and complex task. The application of Generative Adversarial Networks (GANs) has provided new possibilities for automated map design. Kang et al. [6] proposed a method of using GANs to transfer multi-scale interactive map styles, achieving efficient map generation by transferring high-resolution map styles to low-resolution maps. Map style transfer is the process of applying the style of one map style to another map. A multi-scale map refers to a map with different resolutions or scales. After training, use the GAN model for style transfer. Firstly, the high-resolution map style is inputted as a condition into the generator, and then the generator generates a low-resolution map style. Optimize and improve the generated map style to enhance the quality and stability of the generated map. In addition, as a new DL (Deep Learning) model, GANs perform well in data generation and enhancement and provide new solutions for various applications. Interactive graphic layout has wide fields, such as architectural design, urban planning, visual arts, etc. Design in these fields often needs to consider many complex factors, such as spatial relationships, aesthetics, functionality, etc. With the development of deep learning, adversarial networks (GANs) have been proven to have strong capabilities in image generation and processing. In particular, Conditional Generative Adversarial Networks (cGANs) can control the generated images by adding conditional information. However, most of these methods only focus on pixel-level image generation, and there are still limitations in designing interactive graphic layouts. Li et al. [7] proposed a new method for synthesizing interactive graphic layouts using Vector Line GAN (VL-GAN) adversarial networks. The VL-GAN model can combine adversarial networks with vector wireframes, taking into account not only pixel-level details but also the geometric structure expressed by vector wireframes, thereby better controlling the generated graphic layout. Vector wireframes are an effective way to describe the contours of images or objects, widely used in computer vision and machine learning. The traditional method of generating vector wireframes mainly relies on handmade rules or algorithms, and in recent years, deep learning has also begun to be applied in this field. Some research works apply adversarial networks to the generation of vector wireframes, learning the generation of vector wireframes through training generators and discriminators. However, combining GANs with interactive design, exerting their potential, and improving the user experience are still challenging problems.

Therefore, this study aims to combine the advantages of computer vision, CAD, and GANs, and propose an innovative interaction design method in the existing interaction design and improve the user experience. Through an in-depth study of the principles and characteristics of these technologies, this study hopes to introduce new theories and methods to the field of interaction design and promote development and innovation in this field. Moreover, this study also expects to verify the feasibility and effectiveness of this method through experiments and analyze its potential and application prospects in solving practical problems. This will help to promote the upgrading and improvement of related products or systems, improve users' work efficiency and satisfaction, and bring about the promotion of social value. The key technologies and innovations of this method are as follows:

A. Deep integration of computer vision and CAD: The image is deeply analyzed by computer vision technology, which provides rich design references and constraints for the CAD system and realizes more accurate and efficient design.

B. Application of GANs in innovative design: Using the generating ability of gans to provide innovative design suggestions and schemes for designers and broaden design ideas.

C. Context-aware intelligent decision-making system: Combining AI (Artificial Intelligence) and ML (Machine Learning) technologies, an intelligent decision-making system that can perceive the user's context is constructed to provide personalized service and support for users.

D. Integration of multi-modal interaction technology: By integrating voice, gesture, touch, and other interactive modes, the efficiency and naturalness of interaction are improved, and a more intuitive and convenient interactive experience is provided for users.

This article is divided into six sections. The first section is the introduction, research questions and research assumptions, research methods, and paper structure. The second section is a literature review, which combs and analyzes the research status of computer vision, CAD systems, and GANs. The third section is the theoretical basis and technical principle, which introduces the basic principles and technology of computer vision, the basic functions and characteristics of CAD systems, the basic model and working mechanism of GANs, and the theoretical and technical basis of innovative interactive design methods in detail. The fourth section is the concrete realization process and steps of innovative interactive design methods integrating computer vision, CAD, and GANs. The fifth section is the design and implementation process of the simulation experiment and the processing and analysis methods of experimental data. The sixth section summarizes this study and discusses the future research direction.

2 RELATED WORK

With the rapid development of technology, the application of technologies such as Human-Computer Interaction (HCI) and Generative Adversarial Networks (GAN) in scene art design is becoming increasingly widespread. Scene art is a comprehensive art form that encompasses multiple fields such as spatial design, environmental installations, multimedia art, and more. Liang [8] discussed how to apply HCI and GAN technologies to scene art design from an interactive perspective in order to achieve interaction and communication between people and the environment. Human-computer interaction technology provides new possibilities for scene art design. Through human-computer interaction, designers can better understand user needs and feedback, thereby adjusting design strategies. At the same time, users can also interact with the scene through human-computer interaction, obtaining a richer experience. In scene art design, interactive installations can provide viewers with a richer interactive experience. For example, by utilizing technologies such as touch screens and sensors, viewers can interact with the device to gain a deeper experience. In scene art design, spatial interaction can be achieved by changing the spatial structure, utilizing light and sound, and other methods. For example, using HCI technology, designers can design spatial structures that can adapt to changes in audience behavior. In the fields of computer vision and graphics, multi-view image rendering is an important research direction. It reconstructs a three-dimensional scene by capturing images from multiple perspectives and drawing on a two-dimensional plane. However, this process often involves complex calculations and a large amount of data, thus requiring an efficient solution. Lin et al. [9] proposed an integrated computer vision reverse search matching, which can quickly and accurately draw multi-view images. The research on multi-view image rendering technology has achieved many results. For example, integral-based drawing methods solve shadow and occlusion problems by calculating ray projection integrals, but they require a large amount of computation and high hardware requirements. The model-based approach simulates the surface of an object by establishing a three-dimensional model, but it is difficult to handle complex scenes and dynamic objects. Recently, deep learning-based methods have been applied to image rendering, achieving good results but requiring and accurately drawing multi-view images and having high drawing quality and low computational cost. Compared with existing methods, this method has better performance and wider application prospects.

Interactive design sketches are an important tool for communicating and exchanging design ideas in the early stages of design. However, the process of creating interactive design sketches often requires a lot of time and effort and often requires designers to have high skills and experience. The method of automatic sketch design is gradually receiving attention. Qian et al. [10] proposed an interactive design sketch automatic generation method based on a sparse Generative Adversarial Network (SS-GAN). This method can autonomously generate interactive design sketches with diversity and authenticity based on design requirements, greatly improving design efficiency and accuracy. And Generative Adversarial Networks (GANs) have gradually become important tools in the field of design. The combination of these technologies can effectively improve design efficiency, reduce design costs, and enhance the diversity and innovation of design. Saxena and Cao [11] proposed an interactive design method that integrates computer vision, CAD, and GANs, aiming to achieve a more intelligent and automated design process. Meanwhile, designers can input relevant design requirements or constraints as needed to guide the generation process. Using the trained GAN model for interactive design applications, designers can adjust parameters and conditions as needed to obtain diverse design solutions. At the same time, the generated samples can also be further processed and analyzed to obtain deeper design insights and optimization solutions.

In order to understand consumer awareness of GAN technology, Sohn et al. [12] collected data through online surveys and interviews. The results show that the majority of consumers have a certain understanding of GAN technology, mainly obtaining relevant information through academic research, news reports, and social media channels. When asked if they are willing to use GAN technology, about 60% of consumers expressed willingness to try, but about 20% of consumers expressed uncertainty or unwillingness to use it. Further analysis shows that consumers' acceptance of GAN technology is influenced by various factors, including technological security, application areas, and personal privacy. Firstly, consumers are generally concerned about the security of GAN technology. After understanding the potential risks of GAN technology, such as data leakage and model attacks, some consumers hold a reserved attitude towards its application in the field of computer vision. Secondly, the application areas of GAN technology also have an impact on consumer acceptance. For example, for applications in important fields such as healthcare and education, consumers have higher requirements for their safety and reliability, and their acceptance level is relatively low. Finally, the personal privacy of consumers is also a key factor affecting their level of acceptance. Some consumers are concerned about the potential personal privacy leakage caused by the use of GAN technology. However, the application of existing GAN models in collaborative creation is still relatively rare. Therefore, Sun et al. [13] proposed an interactive drawing system for the collaborative creation of adversarial networks based on generative adversarial networks to achieve a more intelligent and automated drawing process. A generator and a discriminator. Through adversarial training between the two, the generator can generate images that are difficult to distinguish from real data. On the basis of GAN, some researchers have proposed the concept of Collaborative Creation Adversarial Network (CCGAN), which combines GAN with collaborative creation technology to achieve collaborative work among multiple users. CCGAN also enhances interaction and collaboration among users. The experimental results show that the system enhances the interaction and collaboration between users. At the same time, the system can also automatically allocate tasks and resources according to user needs, improving the intelligence and automation level of the system.

Facial expressions are one of the important ways for people to convey emotions and intentions. In the fields of computer vision and artificial intelligence, the recognition and understanding of facial expressions have always been a hot research topic. With the development of Generative Adversarial Networks (GANs), researchers have begun to attempt to use GANs for facial expression synthesis to achieve more natural and realistic facial animation effects. Xia et al. [14] proposed that facial expressions generated by the generator can be made more realistic and natural. Conditional GANs can synthesize corresponding facial expressions based on given facial features. However, these methods often only focus on the perception of global features, ignoring the importance of local features. Interactive art design is an art form that emphasizes audience participation and interaction. By combining intelligent sensors and information fusion technology, its interactivity and experience can be further improved. Zhu et al. [15] explored how to utilize intelligent sensors and information fusion technology to achieve interactive art design. Intelligent sensors are high-tech devices that can perceive and respond to changes in the external environment. In interactive art design, intelligent sensors can be used to monitor audience behavior and reactions, providing richer interactivity for artworks. Intelligent sensors can also be used to analyze audience emotional responses, such as inferring the audience's emotional state by monitoring physiological signals such as heart rate, breathing, etc. These pieces of information can be used to create artistic works that can interact emotionally with the audience. Intelligent sensors can perceive such as temperature, humidity, lighting, etc. These data can be used to create artworks that can respond to environmental changes, thereby enhancing the interaction between art and the environment. Through information fusion technology, audience behavior and reactions can be transformed into visual data, such as dynamic graphics, virtual reality scenes, etc. These data can be used to design more interactive artworks, while also providing viewers with a more intuitive experience and feedback.

3 THEORETICAL BASIS AND TECHNICAL PRINCIPLES

3.1 Basic Principles and Technologies of Computer Vision

The basic principle of computer vision is to simulate the processing process of the human visual system and realize the understanding and recognition of image content through a series of processes and analyses of images. This process includes image preprocessing, feature extraction, classification, and recognition. Among them is image preprocessing, including denoising, enhancement, scaling, and other operations to improve the quality and clarity of the image. Feature extraction: Using different algorithms and models, key feature information, such as edges, corners, and textures, is extracted from the image. DL: Convolutional neural networks, in particular, train a large number of image data, learn high-level semantic information in images, and realize tasks such as image classification and target detection.

3.2 Basic Functions and Characteristics of CAD System

CAD system has the basic functions of drawing and editing graphics, parametric design, assembly and decomposition, and engineering analysis. Through rich drawing tools, it helps users to create and modify two-dimensional drawings and three-dimensional models easily and supports parametric design, so that designers can quickly optimize the design scheme through parameter adjustment. Moreover, it can combine multiple parts into a complete assembly and provide an exploded view to simplify the visual presentation of complex designs. Among them, the engineering analysis function provides structural, fluid dynamics, and other simulation and verification means for the design. CAD system uses high-precision drawing and measuring tools to ensure design accuracy, supports multiple file formats to realize data interaction with other engineering software, allows multi-person collaborative design to improve efficiency, and expands its functions and application fields through plug-ins and API interfaces.

3.3 Basic Model and Working Mechanism of GANs

During the training process, the generator and discriminator will undergo adversarial training. Firstly, the generator will generate some fake data, and then the discriminator will determine whether this data is true or false. If the discriminator determines that these data are true, then the generator loses; If the discriminator determines that these data are fake, then the generator wins. Then, based on the discriminator's judgment results, update the generator's parameters to make it increasingly difficult for the generated fake data to be recognized as fake by the discriminator. At the same time, the parameters of the discriminator will also be updated based on the performance of the generator and discriminator so that the discriminator can better identify real and fake data. Through the trained generator, we can use random noise to generate new data points with a distribution similar to the original data. These new data points can be used for various tasks, such as data augmentation, zero sample learning, etc. The GAN structure constructed in this article is shown in Figure 1.

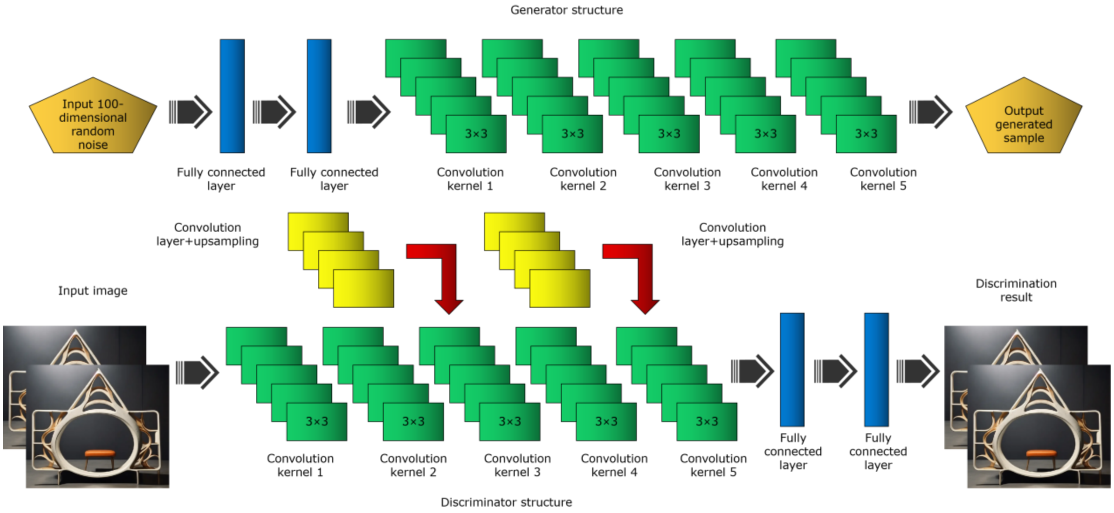

Figure 1: GAN structure in this article.

By introducing conditional variables, loop structure, and other technologies, the application scope of GANs can be expanded, and more complex generation tasks can be realized.

3.4 Theoretical and Technical Basis of Innovative Interactive Design Method

The innovative interactive design method takes "people-oriented" as the core concept, focusing on meeting users' needs, optimizing experience, and ensuring that the design fits with users' cognitive and behavioral habits. This method pursues natural interaction and strives to create an intuitive and human-intuitive interaction mode to reduce the cognitive pressure and learning difficulty of users. Situational awareness is an important feature of this method, which enables the interactive system to have a keen insight into the user's environment, tasks, and emotions, thus providing users with more intelligent and personalized services. In terms of sustainability, this method emphasizes the comprehensive consideration of environment, society, and culture in interaction design. Its technical foundation includes multi-modal interaction, which can integrate voice, gesture, and touch to provide users with a rich and efficient interactive experience. Moreover, with the help of AI and ML technologies, functions such as intelligent recommendation, user intention recognition, and emotional calculation are realized, and the level of intelligence and personalization of interaction is improved. Virtual reality and augmented reality technology bring new displays and interactive platforms for interactive design and deepen users' immersion and participation.

4 INNOVATIVE INTERACTIVE DESIGN METHODS INTEGRATING COMPUTER VISION, CAD, AND GANS

4.1 Overview and Characteristics of Methods

The innovative interactive design method combining computer vision, CAD, and GANs is a comprehensive solution. By combining the advantages of various technologies, this method can provide users with a natural, intelligent, and efficient interactive experience. It integrates the image processing ability of computer vision, the accurate design and engineering analysis ability of CAD, and the innovative generation ability of GANs, showing excellent comprehensiveness. With the help of AI and ML technology, this method endows the interactive system with intelligence, enabling it to perceive the user's situation, make intelligent decisions, and provide personalized suggestions and services for users. In terms of intuition, this method pursues natural interaction and strives to realize intuitive communication between users and design systems, thus reducing learning costs and improving interaction efficiency. Moreover, this method pays attention to sustainability and considers the influence of the environment, society, and culture in the whole design process to ensure the sustainability and long-term value of interactive design.

4.2 Methods Implementation Process and Steps

The implementation process of innovative interactive design methods integrating computer vision, CAD, and GANs involves many steps. As shown in Figure 2.

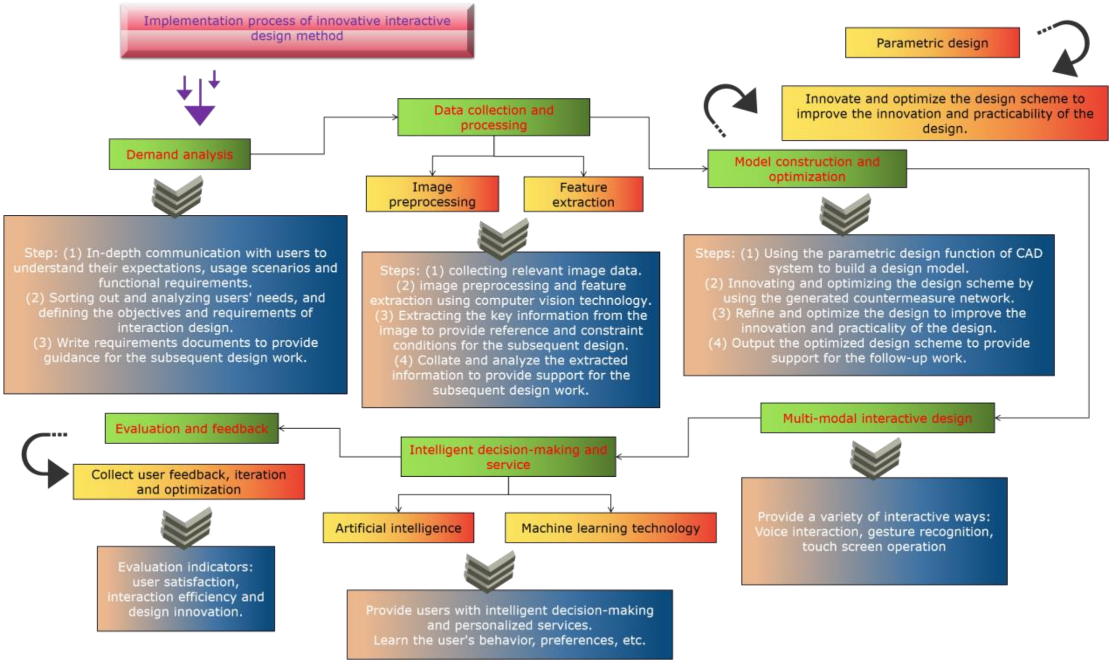

Figure 2: Implementation process of the innovative interactive design method.

Requirement analysis is the initial stage and the most important step of any design method. At this stage, the design team needs to communicate with users deeply to understand their expectations, usage scenarios, and functional requirements. Through requirements analysis, the team can define the objectives and requirements of interaction design and provide guidance for the subsequent design work. The requirements analysis steps of this article are as follows: (1) Communicate with users deeply to understand their expectations, usage scenarios, and functional requirements; (2) Sorting out and analyze the users' needs and define the objectives and requirements of interaction design; (3) Write requirements documents to provide guidance for the subsequent design work. The main task of the data collection and processing stage is to process and analyze related image data by computer vision technology and extract useful information. It includes image preprocessing, feature extraction, and other operations. Through this stage, the design team can obtain the key information in the image and provide references and constraints for the subsequent design. In this article, the following data collection and processing steps are designed: (1) Collect relevant image data; (2) Image preprocessing and feature extraction using computer vision technology; (3) Extracting the key information from the image to provide reference and constraint conditions for the subsequent design; (4) Collate and analyze the extracted information to provide support for the subsequent design work.

In the stage of model construction and optimization, the design team needs to combine the parametric design function of the CAD system to build the design model. In this process, the team can use the precise design and engineering analysis ability of the CAD system to refine the design. Moreover, GANs can be used to innovate and optimize design schemes. Through this stage, the team can improve the innovation and practicability of the design. In this article, the parametric design function of the CAD system is used to construct the design model. The normal vector of a surface S at a point $p\ x,y$ is defined as:

$$n\ x,y\ = n / \left|n\right| \tag{1}$$

Among them:

$$N = \frac{\partial \vec{p}\ x,y}{\partial_x} \times \frac{\partial \vec{p}\ x,y}{\partial_y} \tag{2}$$

$$w\ i,j\ = \frac{1}{Z\ i} \exp\left(-\frac{d\ i,j}{h^2}\right) \tag{3}$$

$$W' = \frac{1}{2} f\ x', y', z'\ + E \tag{4}$$

$$\min_G \max_D\ D,G\ = E_{x \sim p_{data}\ x}\left[\ \log D\ x\ \right] + E_{z \sim p_g\ z}\left[\ \log\ 1 - D\ G\ z\ \ \right] \tag{5}$$

$$Sigmoid\ z\ = \frac{1}{1+e^{-z}} \tag{6}$$

Its discriminator network structure can be expressed as:

$$D_\varphi\ s\ = sigmoid\ \varphi_l^T F_{\varphi_f}\ s \tag{7}$$

$$sigmoid\ \varphi_l^T F_{\varphi_f}\ s\ \ = sigmoid\ \varphi_l^T f \tag{8}$$

$$f = F_{\varphi_f}\ s \tag{9}$$

The main task of the multi-modal interaction design stage is to provide users with various interaction methods by using multi-modal interaction technology. This includes voice interaction, gesture recognition, touchscreen operation, etc. Through this stage, users can communicate with the design system more intuitively and improve the naturalness and efficiency of interaction. In order to realize multi-modal interaction design, the team needs to select appropriate interaction technologies and tools and develop and integrate them accordingly. The main task of the intelligent decision-making and service stage is to make the system aware of the user's situation and provide intelligent decision-making and personalized service for users with the help of AI and ML technologies. This includes learning users' behaviors and preferences through ML algorithm, so as to provide users with more personalized suggestions and services. Moreover, intelligent decision-making is realized by using AI technology, so that users can complete design tasks more conveniently. In order to realize intelligent decision-making and service, the team needs to choose appropriate algorithms and models and carry out corresponding training and deployment.

Finally, the evaluation and feedback stage. The main task of this stage is to evaluate the effect of interaction design, collect feedback from users, and iterate and optimize accordingly. Evaluation indicators include user satisfaction, interaction efficiency, design innovation, etc. By collecting feedback from users, the team can continuously improve and optimize the design to meet users' needs and expectations. In order to achieve evaluation and feedback, the team needs to choose appropriate evaluation methods and tools and conduct corresponding tests and analyses.

5 DESIGN AND IMPLEMENTATION OF SIMULATION EXPERIMENT

5.1 Experimental Purpose and Hypothesis

The purpose of the simulation experiment is to verify the feasibility and effectiveness of the innovative interactive design method integrating computer vision, CAD, and GANs. By simulating a real design scene, we hope to test the potential of this method in improving interactive experience, design efficiency, and innovation. The specific assumptions are as follows:

Hypothesis 1: This method can significantly improve the interactive experience of users and reduce the learning cost.

Hypothesis 2: This method can effectively improve the design efficiency and shorten the design cycle.

Hypothesis 3: This method can enhance the innovation of design and provide more diversified design schemes.

5.2 Experimental Environment and Tools

In order to ensure the authenticity and effectiveness of the experiment, this article chooses the following environment and tools to carry out the simulation experiment: the experimental environment simulates the real design work scene, including offices, conference rooms, and so on. Computer vision tools use open-source computer vision libraries such as OpenCV for image processing and analysis. Choose AutoCAD and other commonly used CAD software to build and optimize the design model; Use DL framework such as TensorFlow to train and generate GANs. In addition, the multi-modal interaction function is realized by combining speech recognition, gesture recognition, and other technologies.

5.3 Experimental Process and Data Analysis

In order to compare the differences between the innovative interactive design method combining computer vision, CAD, and GANs and the traditional design method in terms of interactive experience, design efficiency, and innovation, this section recruits a certain number of volunteers as experimental objects to conduct simulation experiments. First, they should be trained to ensure that they are familiar with the experimental environment and tools. Then, assign volunteers different design tasks, including furniture design and architectural design, to ensure the diversity and representativeness of the tasks. Computer vision technology is used to capture and analyze the behaviors and expressions of volunteers in the design process so as to evaluate the interactive experience and learning cost. Moreover, record the completion time of the design task and the innovation of the scheme. Combining CAD systems and GANs, the design model is constructed and optimized. By comparing the design schemes before and after optimization, the effect of this method in improving design efficiency and innovation is evaluated. Figure 3 shows an example of design using this method.

It can be seen that the innovative interactive design method combining computer vision, CAD, and GANs has good universality and adaptability in different types of design tasks. Whether it is furniture design, architectural design, or clothing design task, this method can achieve significant effect improvement. The method proposed in this article uses GANs to innovate and optimize the design scheme, which provides more design possibilities and inspiration for designers. By combining the parametric design function of the CAD system, the practicability and feasibility of the design are improved. Moreover, this method can capture and analyze users' behaviors and expressions through computer vision technology and can understand users' needs and intentions more accurately, thus providing more personalized services and support. Moreover, by introducing multimodal interaction technology, users can communicate and operate with the system more conveniently.

This section uses multimodal interaction tools to test the volunteers' design tasks and evaluate their efficiency and experience in different interaction modes. In order to understand and show the experimental results conveniently, this section uses the form of a data graph to visualize the data. By drawing charts such as line charts, the experimental results and data analysis results are displayed intuitively. Figure 4 shows the time for volunteers to complete the task.

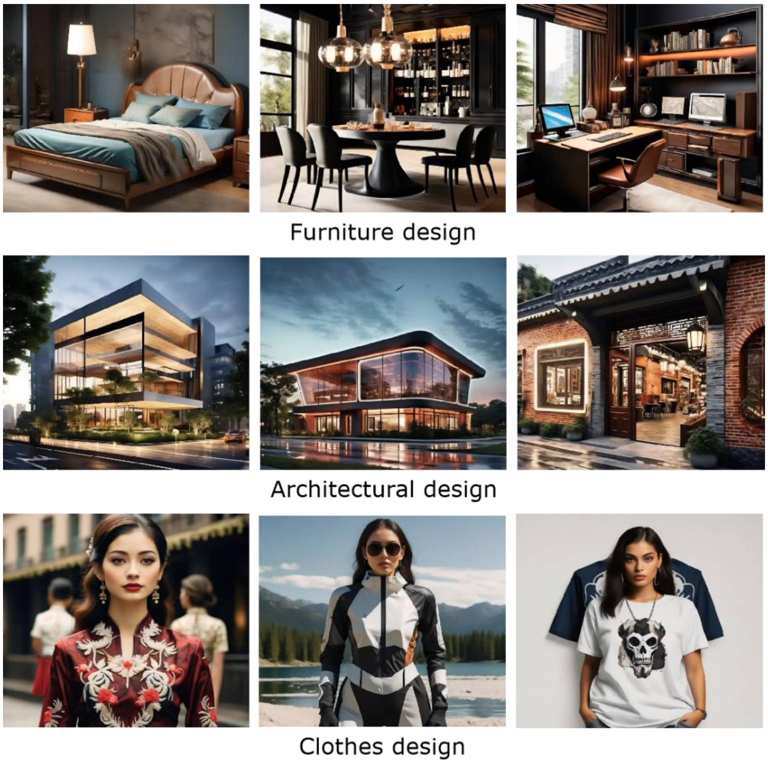

Figure 3: Design sample diagram.

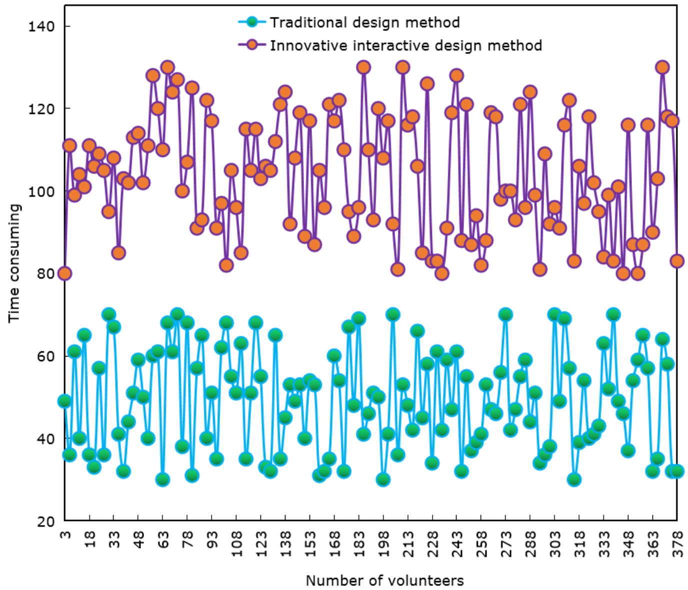

Figure 4: Time for volunteers to complete tasks.

According to the results shown in Figure 4, it can be seen that there are obvious differences in the time for volunteers to complete tasks. Specifically, volunteers who use innovative interactive design methods that integrate computer vision, CAD, and GANs generally complete their tasks in a short time. Among them, the fastest volunteer only took 30 minutes to complete the design task, while the slowest volunteer only took 70 minutes. This shows that the new method has obvious advantages in improving design efficiency. In contrast, volunteers who use traditional CAD systems generally take longer to complete tasks. The fastest volunteers spent 80 minutes, and the slowest volunteers spent more than 120 hours. This further verifies the effectiveness of innovative interactive design methods combining computer vision, CAD, and GANs in improving design efficiency.

The efficiency and experience results of volunteers in different interaction modes are shown in Figures 5 and 6. Through the results shown in Figures 5 and 6, we can see that the innovative interactive design method combining computer vision, CAD, and GANs has achieved remarkable advantages in interactive experience and design efficiency.

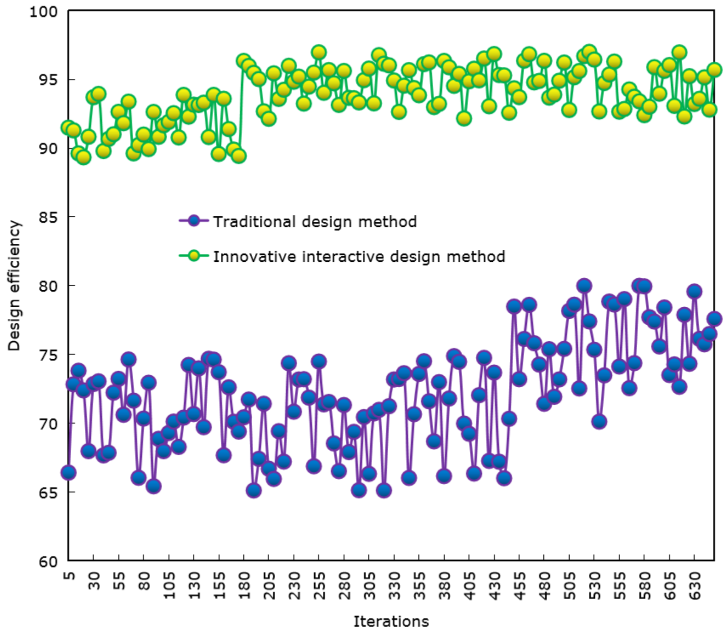

Figure 5: Comparison of design efficiency of different methods.

In terms of design efficiency: Figure 5 shows the comparison of design efficiency between different methods. From the experimental results, it can be seen that the innovative interactive design method that integrates computer vision, CAD, and GANs has significant advantages compared to traditional design methods. In addition, innovative interaction design methods also have better collaborative design capabilities. By introducing multimodal interaction technology, designers can communicate and collaborate in real-time with other team members or stakeholders to participate in the design process together. This collaborative design pattern accelerates the speed of design decision-making and improves overall design efficiency.

In terms of interaction experience, Figure 6 shows the interaction experience ratings of volunteers under different interaction methods. It can be seen that volunteers who use the design method in this article generally give higher interaction experience ratings, generally above 93%. This indicates excellent performance in terms of interactive experience and has been highly recognized by volunteers. In contrast, volunteers who use traditional CAD systems generally give lower interaction experience ratings, indicating that traditional CAD systems have certain shortcomings in terms of interaction experience.

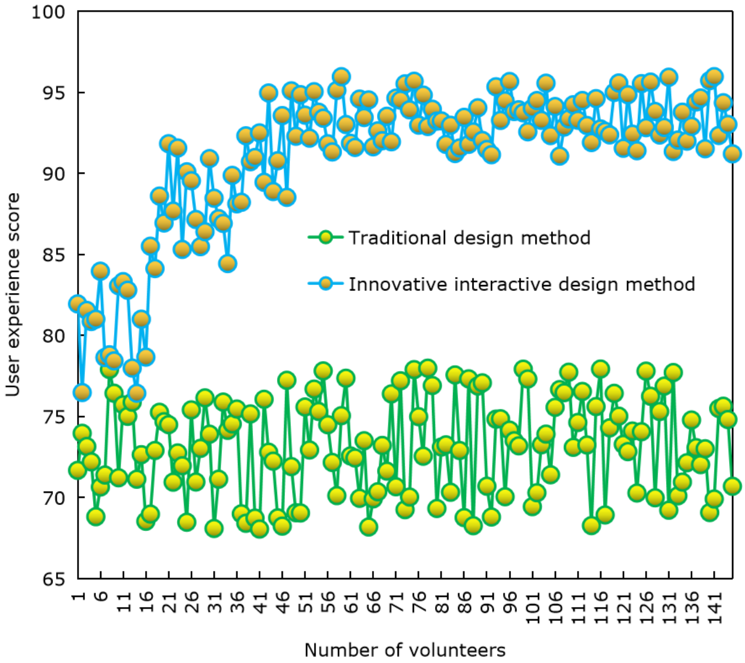

Figure 6: Different methods of volunteer experience scoring.

This section selects three common design methods as comparison objects, namely traditional CAD systems, computer-aided design methods based on computer vision, and innovative interactive design methods that integrate computer vision, CAD, and GANs. The innovative evaluation results of different design methods are shown in Figure 7.

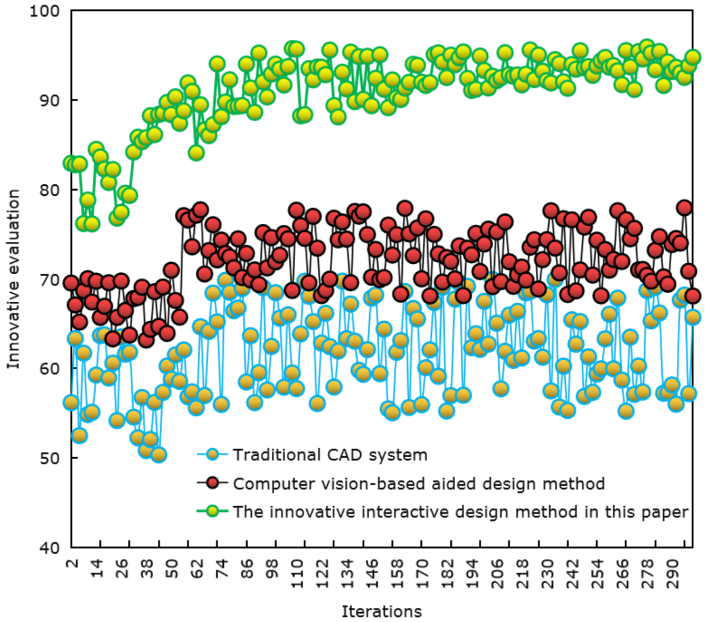

Figure 7: Innovative evaluation.

According to the results shown in Figure 7, the innovative interactive design method that integrates computer vision, CAD, and GANs achieved the highest innovation score, with an average score of 89. This indicates that the method proposed in this article has excellent performance in stimulating designers' innovative thinking and improving design innovation. In contrast, traditional CAD systems and computer-aided design methods based on computer vision have lower innovation scores of 70 and 75, respectively.

By analyzing the experimental data in this section, it can be found that in terms of interactive experience, most volunteers expressed that the new method makes the design process more intuitive and natural, effectively reducing learning costs. In terms of design efficiency, the new method significantly shortens the design cycle and improves work efficiency through automation and intelligence. In terms of innovation, the new method introduces GANs, providing designers with more diverse design solutions and enhancing the innovation of design.

6 CONCLUSIONS

This study proposes and validates an innovative interaction design method that integrates computer vision, CAD, and GANs to solve problems in existing interaction design. The innovative interactive design methods that integrate computer vision, CAD, and GANs, the experimental results were compared and analyzed with traditional design methods. By introducing computer vision and multimodal interaction technology, the design process is more intuitive and natural, effectively reducing user learning costs and improving interaction efficiency. (2) In terms of design efficiency, the new method significantly shortens the design cycle and improves work efficiency through automation and intelligence. This means that designers can complete design tasks faster and improve work efficiency and output quality. (3) In terms of innovation, the new method enhances the creativity of design by introducing GANs to provide designers with more diverse design solutions. This allows designers to be more flexible in creating and exploring more design possibilities.

This article provides an efficient and intelligent interactive environment for designers by integrating advanced technological means, stimulating their innovative thinking, and promoting the emergence of innovative design. The experimental results have verified the reliability and effectiveness of the method proposed in this paper; this article believes that this method has practical value and can make positive contributions to the development of the design field.

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