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Collaborative Mechanism for Creative Design of Cultural IP Based on Generating Adversarial Networks and CAD Technology

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Abstract. Generating Adversarial Networks (GAN) stands as a pivotal subdomain within the broader spectrum of artificial intelligence (AI). Its essence lies in simulating authentic data distributions through extensive learning, ultimately generating fresh datasets that resonate with the originals yet exhibit unique distinctions. The study introduces a collaborative framework for cultural IP innovative design, amalgamating the strengths of Generative Adversarial Networks and computer-aided design (CAD). This synergy aims to strike a harmonious balance between creativity and practicality. The findings reveal that the GAN and CAD-driven IP design approach outperforms traditional methods in terms of efficiency and algorithmic stability, coupled with a notable boost in user satisfaction. This outcome not only underscores the transformative potential of emerging technologies in the design realm but also offers innovative insights and practical guidance for the design industry's evolution. The GAN model's robust generative capabilities inject creativity and originality into the design schemes, while CAD's precision ensures their practical feasibility. In conclusion, this research is poised to propel the continual enhancement and refinement of IP design methodologies, better aligning with the aspirations of designers and users alike.

Keywords: Generative AI; Generative Adversarial Networks; CAD; Cultural Ip; Innovative Design; Multi-Agent System
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1 INTRODUCTION

With the enhancement of China's technological and cultural soft power, there is a higher level of demand for spiritual culture among the people, which has led to the transformation and development of the museum's cultural and creative industry towards new formats. The rise of the emerging industry of digital creativity has accelerated the transformation of museums from "traditional" to "modern." The efficient dissemination of digital cultural creative products, wide audience, interesting interactions, and timely feedback provide new avenues for the dissemination of museum culture. The cultural, and emotional dimension has created a good output environment for digital cultural and creative museums at the emotional experience level. Therefore, how to guide the development and design of digital cultural and creative products in museums based on the theory of flow and emotion is the main content of this research topic. Barrile et al. [1] analyzed the development trends of digital cultural and creative products in museums by examining important factors in the theory of flow and emotion dimensions. Summarize a relatively systematic design approach for museum digital cultural and creative products from user research and case analysis. Through augmented reality technology, we can present detailed information, historical background, and related stories of cultural heritage to users more vividly and intuitively, enhancing their understanding and interest in cultural heritage. Bekele [2] clarified the origin of the digital cultural and creative industry in museums, which is driven by the development of emerging technologies in China and the industry itself. Its core connotation is to use digital technology as support, enhance user experience, and create content with culture as the core. In the form of digital cultural creation, the Internet and other media are used to enhance its cultural communication, to innovate the development path of the museum's cultural creative industry and build a museum IP development model of "science and technology+culture". Through theoretical research, it has been found that museum digital cultural and creative products guided by the theory of flow and emotion have been improved in terms of development form, product function, product connotation, and interactive experience. Based on this, digital cultural and creative products in museums have been endowed with richer cultural value, broader channels of dissemination, and stronger technological support. This shows the trend of the development of the museum cultural and creative industry in the future Through cloud computing platforms, cultural heritage researchers, protectors, and enthusiasts from around the world can share digital cultural heritage resources in real-time and participate in the protection and inheritance of cultural heritage together. The vigorous development of digital creativity and other fields has been listed as important projects in recent years. The development of this industry has been listed as a strategic emerging industry during the 13th Five Year Plan period in the form of an outline, and a lot of energy has been invested to promote its development. Bozorgi and Lischer [3] studied the impact of digital media art on the cultural and creative industries. It takes the construction of the cultural industry park in Rizhao City as a case study, providing insights from several aspects such as an overview of digital media, the cultural industry, the relationship between digital media and the cultural industry, and taking the cultural and creative industry park in Rizhao City, Shandong Province as an example. Systematically sorting out the connotation of digital media, the connotation of cultural industry, and the relationship between the two. It analyzed the economic and social functions of digital media technology in cultural industry parks. The main focus is on providing a detailed description of the role of digital media art in the Palace Museum. The purpose is to reflect the vitality and rich cultural connotations of this technology. 3D and VR technologies, with their unique immersion and interactivity, provide new perspectives and methods for cultural research. Through 3D modelling and virtual reality technology, researchers can construct realistic and restored historical scenes, cultural relics, and cultural environments, allowing researchers to experience the charm of historical and cultural heritage firsthand. This immersive research approach helps researchers gain a deeper understanding of cultural phenomena, explore cultural connotations, and improve the quality and depth of research. However, the traditional CAD design process often focuses on functionality and feasibility, and there may be shortcomings in the creativity and novelty of the design.

In the current process of social development, the use of digital media technology has played a powerful role and is increasingly attracting people's attention. Whether it's vivid movie shots or virtual reality technology that is both real and fake. Even more so, the resource materials that cater to both refined and popular tastes, as well as the magnificent real-life creations, have brought art into the public's view in a silent way. The current level of social science and technology is improving rapidly, and digital media art combines design and various technologies in art. This plays an irreplaceable role in the cultural industry and is the main driving force for its development. In view of this, Chen et al. [4] revealed the connection between digital media technology and the cultural industry by analyzing its connotation. Take the Rizhao Cultural Entrepreneurship Industrial Park and the Palace Museum as examples for analysis. Taking Chinese Cantonese opera as an example, analyze the future growth direction of the cultural industry of Chinese Cantonese opera under the influence of digital media. Chung and Huang [5] analyzed the interactive transformation of Chinese ink painting into real images using boundary-enhanced Generative Adversarial Networks. Chinese ink painting is renowned for its unique brushstroke charm and profound artistic conception, while realistic images pursue a realistic visual experience. There are significant differences in expression techniques and aesthetic orientations between these two art forms, making it a challenging task to transform them. Traditional image processing techniques often find it difficult to accurately capture the artistic characteristics and charm of ink painting, resulting in distorted or lacking artistic sense in the conversion results.

This algorithm organically links the agents in each design link to realize the efficient sharing of information and the collaborative completion of tasks. Through this innovative collaborative design mechanism, it is expected that the following goals can be achieved in the design process of cultural IP: first, the innovation and artistry of design will be significantly improved, and the limitations of traditional design mode will be broken; The second is to shorten the design cycle, reduce manual intervention and improve the automation level of design; The third is to enhance the customization and user participation of the design to meet the increasingly diverse needs of consumers.

Highlights:

(1) Innovative collaborative mechanism: This study puts forward a collaborative mechanism for the innovative design of cultural IP based on AIGC and CAD technology, which provides a new methodology for cultural IP design.

(2) Technology integration and application: This study combines the creative generation ability of GAN with the precise design ability of CAD, which solves the problem that creativity and practicality are difficult to balance in traditional design methods.

(3) Introducing MAS: This study optimizes the communication and cooperation among agents in the design process by introducing the MAS collaborative algorithm.

Firstly, this article introduces the research background and purpose through the introduction and makes clear the importance of the collaborative mechanism of cultural IP innovative design based on AIGC and CAD technology. Then, it expounds on the relevant theoretical basis and technology, including AIGC, CAD technology and the basic concepts of MAS. Then, the collaborative design framework is constructed, and the combination mode of GAN and CAD, innovative design strategy and the application of the MAS collaborative algorithm are expounded in detail. The effectiveness of the collaborative mechanism is verified by experimental research and result analysis, and its advantages and limitations are discussed. Finally, the conclusion is drawn, the research results are summarized, and the future research direction and application prospects are prospected.

The collaborative mechanism of cultural IP innovative design based on AIGC and CAD technology is not only a technical topic worthy of in-depth study but also a practical exploration full of challenges and opportunities. We look forward to more creative achievements in this research field, which will contribute to the sustainable prosperity and development of the cultural industry.

2 RELATED WORK

Cultural and creative digitization has become a popular term in recent years, and some companies and universities are also preparing and developing accordingly. Culture, as a soft power, plays a crucial role in enhancing China's comprehensive national strength. Nowadays, the intelligence of clothing, food, housing, and transportation, as well as the social phenomenon of people becoming accustomed to the internet and various computers, have rapidly promoted the intelligence of the cultural and creative field. It must be admitted that those practical pioneers have provided us with a good blueprint, but most of them are in the exploratory stage. Therefore, in order to make the intelligence of the cultural and creative field enter the formal stage, we have carried out the development work of this article. Digital media and cultural creative communities mainly provide two services. One is the portal of the rendering community, with functional modules mainly including user information management, scene file management, job management, and billing management. The second is media resource library management. The digital media and cultural creative community focuses on providing rendering application services, providing an information management support platform for file uploading, homework rendering, and homework viewing. Guo and Li [6] fully utilized existing software, hardware, and network resources to shape cultural IP. The interaction between digital media, cultural and creative communities, and other systems is completed through interfaces. Implemented rendering services such as scene file upload, job upload, job rendering, and job viewing, providing users with services through a web interface, with clear processes and simple operations. The digital media and cultural creative community has also achieved the expansion of rendering application services, namely the management of media resource libraries. The media resource library backend uses the digital media resource management system Razuna for storage and management of digital media assets, providing users with convenient resource sharing and collaboration. From the perspective of rendering applications, the resource library is divided into three parts for management, including 3D models, materials, and textures. The 3D model is displayed in the form of a file directory, while the materials and textures are presented to users in the form of thumbnails. Whether it is the 3D model or the materials and textures, users can download and use them [7].

Chinese painting has become an important representative of traditional Chinese art due to its unique brushstroke charm and color application. However, the traditional coloring process of Chinese painting often relies on the painter's experience and skills, making it difficult to achieve automation and intelligence. In recent years, with the development of deep learning technology, Generative Adversarial Networks (GANs) have made significant progress in the field of image processing, providing new possibilities for unsupervised coloring of Chinese painting. Jiang and Luo [8] discussed an unsupervised coloring method for Chinese painting based on improved Generative Adversarial Networks, aiming to achieve more accurate and natural coloring effects. From design to implementation, digital media and cultural creative communities meet the information technology needs of CG industry users for rendering services. At the same time, the community has also been improved in multiple aspects. Such as up-to-date functional design, advanced and stable technical architecture, simple and atmospheric interface design, standardized and reasonable humanized services, and good user experience. The successful operation of the community will make a significant contribution to the intelligent development of the cultural and creative field, and will also play a huge role in promoting the development of the country's cultural soft power. In the current society, the use of digital media technology is very widespread and its importance is becoming increasingly prominent. Therefore, it has gained public attention. Whether it's vivid movie shots, both real and fake virtual reality technology, or even more so resource materials that are both refined and popular. The magnificent reality creation has brought art into the public's view silently. The current level of social science and technology is improving rapidly. Digital media art combines design and various technologies in art, playing an irreplaceable role in the cultural industry. This is the main driving force for the development of the cultural industry [9]. Liu and Yang [10] explored the contemporary cultural and artistic computer-aided design model with innovation as the core. The wave of digital information technology is continuously brewing and fermenting worldwide, and its continuous technological changes provide strong energy for innovative cultural formats. The upgrading and replacement of the cultural industry will inevitably accompany the development of the times. Digital technology, as an important source, is driving the innovative development of the cultural industry and giving birth to new forms of cultural industry. Today, 5G and Internet technology, digital technology, mobile communication technology, big data, artificial intelligence and other cutting-edge technologies are widely emerging and strongly saturated. The development of digital information technology in the world is once again at a historical turning point, stimulating the transformation and reform of traditional industries. The deepening development of the digital economy has significantly improved the efficiency of cultural dissemination, promoting the development of the cultural and creative IP industry and cultural education industry towards deeper levels. From painting, and sculpture to architectural design, CAD technology provides artists with new creative methods and expressions. Artists can use CAD software for 3D modelling, rendering, and animation production, achieving richer visual effects and creative possibilities.

As an important form of opera in northwest China, Qin Opera costumes, as an important part of Qin Opera art, have rich historical and cultural connotations and artistic value. However, the traditional way of protecting Qin Opera costumes is often limited by preservation conditions, inheritance methods, and other factors that are difficult to protect and inherit effectively. Therefore, Liu et al. [11] conducted research on digital protection and innovative design of Qin Opera costumes by using a CAD collaboration mechanism. It uses CAD technology to scan and model the Qin Opera costumes in 3D and obtain high-precision digital models of the costumes. Then, through texture mapping technology, the texture information of the costumes is saved in digital form. On this basis, the editing function of CAD software is utilized to modify and optimize the details of the costume model, making it more in line with modern aesthetics and wearing needs. At the same time, it can also combine virtual reality technology to build a virtual display platform for Qin Opera Opera costumes so that the audience can enjoy and experience the charm of Qin Opera Opera costumes in a new way. Luther et al.[12] used high-precision scanning and modelling techniques to transform precious cultural relics, historical buildings, and other cultural heritage in museums into digital models. These digital twins can not only be permanently preserved in digital space but also avoid losses caused by natural factors or human destruction. It can also provide convenient access and research platforms for scholars and researchers [13]. The transformation of museums is urgent in the 5G era, and the development of digital cultural and creative industries has brought new opportunities to museums, becoming a breakthrough point for museum transformation and leading them from "traditional" to "modern." Supported by a series of policies, China's digital cultural and creative industry is experiencing explosive growth. If museum cultural and creative products break through the limitations of time dimension and achieve the inheritance of museum culture. So, the emergence of digital cultural creative products not only breaks the constraints of the time dimension but also breaks the constraints of the space dimension, allowing the inheritance and dissemination of museum culture to advance twice [14]. Multi-source information art and cultural painting integrate various art forms and cultural elements and achieve diversified expression of painting work through digital technology. This fusion not only enriches the artistic connotation of the artwork but also broadens the audience's understanding and cognition of the artwork. Interactive 3D dynamic scenes can provide viewers with a more immersive experience, allowing them to experience the charm of artistic works firsthand. The application of deep learning frameworks has injected new vitality into the protection and innovation of traditional cultural IPs in the protection and inheritance of cultural heritage. Pierdicca et al. [15] have become a hot research topic in recent years using deep learning frameworks for point cloud semantic segmentation of traditional cultural IPs. In traditional cultural IP, many precious cultural relics, historical sites, etc., can be digitally preserved through point cloud data. It first conducts a three-dimensional scan of traditional cultural IP to obtain its point cloud data. Then, deep learning models are used to extract and classify features from the point cloud data, and different parts of the point cloud data are labelled with different semantic labels. Finally, by processing and analyzing the annotated point cloud data, precise modelling and digital preservation of traditional cultural IP can be achieved.

3 THEORETICAL BASIS AND RELATED TECHNOLOGIES

Cultural and creative products, also known as cultural and creative products, have the core meaning of re-creating culture. Cultural and creative products are essentially cultural reproductions that contain rich artistic and cultural connotations with high added value. The cultural connotations in cultural and creative products can often awaken people's memories of a certain past, thereby obtaining spiritual comfort. For example, in the past, communication relied on letter records, drawing twists and turns, and the postman delivered the letter to the recipient. This "letter culture" used to be a means of communication, conveying messages between people's hands. Nowadays, with the convenience of mobile communication, the difference is a new way of "transmission." Conveying emotions between people, such as the "Panda Handan" embedded with national treasure panda elements, through various forms of cultural and creative activities such as offline physical stores and online post offices, the emotional bridge between people has been reconstructed. The creativity in cultural and creative products is based on the cultural essence contained in the culture itself, and innovative thinking is processed to transform material and spiritual culture into design elements for recreation, in order to adapt to people's lifestyles and meet their spiritual needs.

The process of constructing a digital media resource library for cultural and creative products is expected to focus on four aspects, including data standardization of the digital media resource library, sharing of massive digital media content, rapid preparation of rendered data, and retrieval and query recommendation of digital media. In terms of data types, it should include images, videos, audio, etc. Their storage and access should be categorized and distinguished. I also want more rendering users to share this resource library, so it is necessary to support massive content storage and sharing. In addition to having a large memory space, there must also be a good data transfer rate. Building such a resource library is our ultimate goal in order to enable more users to use it and back up the resources they need to the buffer in a short time, greatly saving labour costs. Therefore, we need a good retrieval and query mechanism that can meet our requirements.

In the early stages of media library construction, we chose Razuna, an open-source Digital Asset Management 130 system, to manage our media resources. In terms of format conversion, Razuna supports any type of video, image, audio, and document format, and its built-in intelligent conversion engine can convert assets into different formats; In terms of version maintenance, when uploading the latest version of an asset, Razuna will generate a historical version list, making it easy to find the old version; In terms of collaborative work, each folder can be transformed into a public workspace where team members can comment, discuss, and share their resources; In terms of file uploading, users can not only upload resources locally, but also upload them through FTP, email, or other file servers. It is written in Java language and can be used to manage various formats of digital media resources, making it an ideal choice for us to build a media resource library in the early stages. Through the segmentation of design undertakings into various subtasks and their subsequent allocation to distinct agents for handling, MAS facilitates seamless collaboration and design integration. MAS can also use the communication and cooperation mechanism between agents to realize the functions of information sharing, decision support, and conflict resolution in the design process and further improve the innovation of design.

4 COLLABORATIVE FRAMEWORK OF CULTURAL IP INNOVATIVE DESIGN BASED ON GAN AND CAD

As science and technology continue to evolve, the utilization of AI in the design sphere is expanding rapidly. The collaborative framework of cultural IP innovative design based on GAN and CAD proposed in this study aims to achieve the perfect combination of creativity and practicality by deeply integrating the advantages of the two technologies. Creative generation module based on GAN and design optimization module based on CAD. Through data interaction and algorithm collaboration between the two modules, the whole process automation and intelligence of cultural IP design are realized.

The creative generation module uses the powerful image generation ability of GAN and combines specific cultural elements and design requirements to generate creative design drafts. As an auxiliary function of rendering applications, the design and implementation of media resources also have strong practical significance and are not optional. Because in commercial production, rendering every film and design requires a large amount of relevant materials. Moreover, the materials, textures, and 3D models used in different film designs are often overlapping. Therefore, if such a resource library is developed that aggregates the vast majority of shared media resources, it can be a great blessing for future commercial production. This article has carried out relevant functional design and development in such a social context and put it into practical application. This system uses the open-source digital media asset management system Razuna to manage the media asset library, which is crucial as a resource repository in this system. Figure 1 illustrates the residual network model structure tailored for packaging image processing. By leveraging the amalgamation of multiple convolution layers and the ingenious design of residual connections, the model facilitates profound exploration and efficient representation of image features.

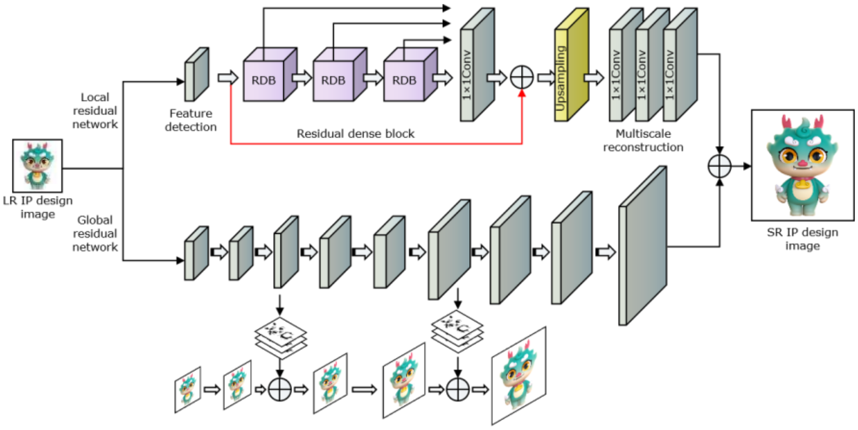


Figure 1: Residual network model.

The generator adopts the design inspired by the U-net network structure and innovatively constructs an hourglass-shaped convolutional neural network. This unique design not only has elegant symmetry, but more importantly, it combines the advantages of layer-hopping connection and effectively promotes the circulation and reuse of information. The network consists of coding and decoding. The coding part is responsible for extracting the features of the input image, while the decoding part is responsible for mapping these features back to the target image space (as shown in Figure 2).

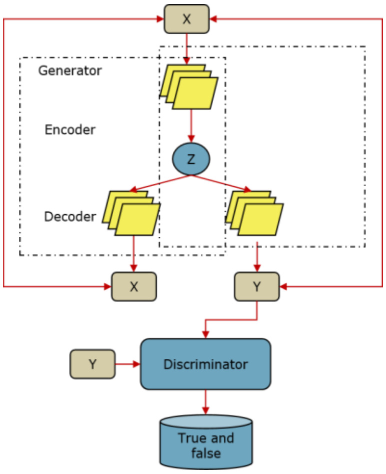


Figure 2: Overall architecture of the model.

Because the encoder and discriminator have identical weights, excluding the final layer, they can be amalgamated, with the common network segment designated as H . Subsequently, the Encoder can be represented by formulas (1) and (2), while the discriminator D is expressed by formula (3).

$$\mu = f_1 \;\; H \;\; X \tag{1}$$

$$\log \sigma^2 = f_2 \;\; H \;\; X \tag{2}$$

$$D = f_3 \ H \ X \tag{3}$$

Here, f signifies various mappings corresponding to the network's final layer.

To mitigate the issue of unclear artistic image synthesis, the inference network assesses image fidelity. The objective of this network is to designate an authentic training sample x_f with a "true" label and assign a "false" label to the generated sample x. Concurrently, the generating network endeavors to create image samples that the inference network identifies as "true." The respective introspective adversarial losses for the inference and generating networks are represented as follows:

$$L_{adv}^{G} = L_{KL} \ z_{a,f} \tag{4}$$

In this context, $z_{a,f}$ denotes the authenticity component of the generated sample.

To train generators and discriminators, standard countermeasures are implemented:

$$\min_G \max_D L_{adv} = E\left[\log D \ \hat{y}^b \ \right] + E\left[\log\left(1 - D\left(G \ V \ E \ p^a \ ,a,b \ ,c \ \right)\right)\right] \tag{5}$$

In this context, E,V,G,D are the encoder, visual angle converter, generator, and discriminator. p^a denotes the original gait energy map input from the a perspective. c signifies the distinct thermal coding while $\hat{y}^b$ corresponds to the authentic gait energy map.

The generic template for each category serves as a pattern for directly matching and subsequently identifying test features. Denote a frame from the test sample and the multipurpose template as x,y, respectively, to ease the computation of similarity, denoted as $s \ x,y$:

$$h_p^{'} \ x,y \ = \begin{cases} 1 & if \ x_p \in y_p \\ 0 & otherwise \end{cases} \tag{6}$$

During the calculation process, if two frames, denoted as x,y, do not align, $s \ x,y$ will not be set to zero but will receive a negative value. Additionally, $h \ x,y$ -5 will serve as a penalty, thereby amplifying the distinction between diverse features.

When GAN generates the creative draft, it is converted into a file format (such as DWG, DXF, etc.) that can be recognized by CAD software and imported into the CAD system for subsequent operation. At the same time, the CAD system can also export the optimized design scheme as an image file for further learning and optimization of the GAN model. This two-way data interaction mechanism not only ensures the consistency of the design process but also enables the two technologies to promote each other.

The conventional approach for image binarization involves manually establishing a specific threshold, denoted as T. Subsequently, the relationship between the grey value of the image at a particular point x,y and the threshold T is examined:

$$g \ x,y \ = \begin{cases} 255 & f \ x,y \ \geq T \\ 0 & f \ x,y \ \leq T \end{cases} \tag{7}$$

Determine the average grey value:

$$\mu_T = \sum_{i=0}^{255} ih \ i \tag{8}$$

The node degree is determined by adding up the components in each row of the similarity matrix. The degree matrix typically represented D is created by utilizing all degree values as its diagonal elements. Definition:

$$D_{ij} = \sum_{j=1}^{n} w \; i,j \tag{9}$$

Examine the pixel value at a point, designated as Examine the pixel value at a point, designated as AA, within the region to ascertain whether it possesses the initially specified value. This determination reveals whether the point has undergone filling within the area. In the affirmative case, adjust its colour or brightness value, and proceed to inspect adjacent points, achieving comprehensive area filling through iterative invocations., within the region to ascertain whether it possesses the initially specified value. This determination reveals whether the point has undergone filling within the area. In the affirmative case, adjust its colour or brightness value, and proceed to inspect adjacent points, achieving comprehensive area filling through iterative invocations.

Following the aforementioned processing, any two feature sequences undergo transformation into a range signal sequence, denoted as $I_1 \; t \; , I_2 \; t$. Upon constructing the feature space $\left[\ell_1, \cdots, \ell_k\right]$, their respective projection trajectories within this space are represented by $P_1 \; t$ and $P_2 \; t$:

$$\begin{aligned} P_1 \; t \; &= \left[\ell_1, \cdots, \ell_k\right]^T I_1 \; t \\ P_2 \; t \; &= \left[\ell_1, \cdots, \ell_k\right]^T I_2 \; t \end{aligned} \tag{10}$$

The measure of similarity between them can then be determined as follows:

$$d^2 - \min_{ab} \sum_{i=1}^{T} \left\| P_1 \; t \; - P_2^{'} \; at + b \; \right\|^2 \tag{11}$$

Herein, $P_2^{'} \; at + b$ represents a vector trajectory that undergoes dynamic adjustments based on time expansion and displacement. The choice of parameter a, b hinges on the disparities in velocity and phase deviations across various sequences.

In order to improve the design efficiency further, we introduce the MAS collaborative algorithm into the framework. The algorithm realizes distributed processing and cooperative work of design tasks by constructing multiple agents. Each agent has specific functions and goals and completes common design tasks through information exchange and task cooperation.

5 RESULT FROM ANALYSIS AND DISCUSSION

5.1 Experimental Data Set and Its Setting

Experiments are conducted on a high-performance GPU-equipped server to guarantee swift and efficient model training. We leverage various renowned deep learning frameworks, including TensorFlow and PyTorch, to construct and train the GAN model. Our dataset comprises an extensive collection of cultural IP-related images and text data, encompassing diverse cultural elements and design styles. This ensures that the GAN model acquires a wealth of creative expressions. Simultaneously, the dataset undergoes preprocessing and labelling to align with the model's training requirements.

During the model training phase, our research utilizes DCGAN as the foundation and makes tailored modifications to suit the study's specific objectives. Tables 1 and 2 present the detailed structures of the encoder and decoder, respectively, outlining the precise parameter configurations for each layer. To bolster the model's discriminatory capabilities, the discriminator employs a structure featuring four convolution layers.

Layers	*Number of convolution kernels*	*Convolution kernel size*	*Step length*	*Activation function*
Conv.1	95	5× 5× [1,1,3]	4	L-ReLU
Conv.2	190	6×6×98	4	L-ReLU
Conv.3	366	6×6×192	4	L-ReLU
Conv.4	765	6×6×382	4	L-ReLU

Table 1: Settings of encoder.

Layers	*Number of convolution kernels*	*Convolution kernel size*	*Step length*	*Activation function*
F-Conv.1	765	6×6×382	1/4	L-ReLU
F-Conv.2	366	6×6×192	1/4	L-ReLU
F-Conv.3	190	6×6×98	1/4	L-ReLU
F-Conv.4	95	6×6×3	1/4	Tanh

Table 2: Settings of decoder.

5.2 Experimental Result

Firstly, the time spent by designers in each design stage and their design efficiency evaluation data recorded in the experiment are visualized, and a design efficiency comparison diagram is generated (as shown in Figure 3). The IP design method based on GAN and CAD technology shows a trend that the design efficiency is obviously higher than the traditional intelligent method.

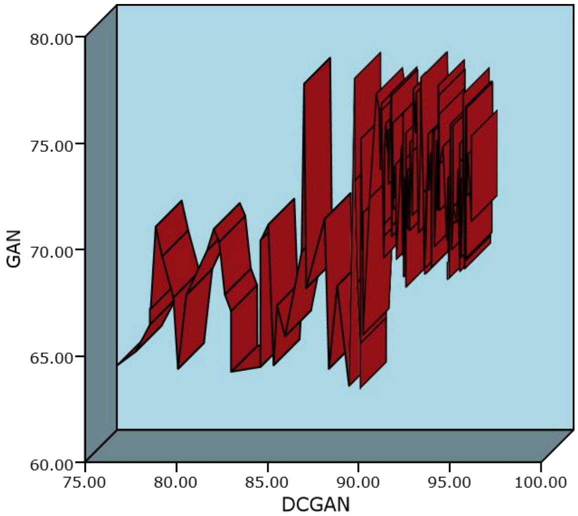


Figure 3: Comparison of design efficiency of different methods.

The time spent by the new method in the creative generation stage is obviously less than that by the traditional method. This shows that the rapid creative generation ability of the GAN model plays an important role at this stage, which enables designers to obtain multiple creative design drafts in a short time, thus improving the efficiency of creative generation. With the advancement of the design process, the new method also maintains high efficiency in the design refinement and optimization stages. This is mainly due to the accurate design ability of CAD technology, which allows designers to refine the creative draft generated by GAN quickly and accurately.

When processing a large image, directly processing the whole image may lead to a huge amount of calculation, thus affecting the processing speed and efficiency. In order to effectively reduce the dimension of the image and keep the key information of the image, a common method is to divide the image into regions and calculate the feature statistics of each region, such as the maximum or average. This method can greatly reduce the number of data points, while retaining the key features in the image, making the subsequent processing and analysis more efficient.

Before any over-fitting, the change chart of recognition accuracy with the training process is obtained through experiments (as shown in Figure 4). The recognition accuracy gradually increases with the training in the initial stage, which indicates that the model is learning from the training data and extracting useful features. With the deepening of training, the accuracy may tend to be stable, because the model is affected by the over-fitting problem. Over-fitting means that the performance of the model on training data is too optimized, which leads to the decline of its generalization ability on unknown data.

Figure 4: Changes in accuracy before adding overfitting measures.

The initialization of weights is a pivotal step in neural network training, as improper weight initialization can cause slow or non-existent convergence. The initial weight has a direct impact on gradient propagation and parameter updates during training. Excessively large or small initial weights can lead to gradient vanishing or explosion, impeding effective learning.

Dropout, a regularization technique, randomly deactivates certain neurons during training. This encourages the network to rely less on specific training features, enhancing the model's generalization. Experimental results (refer to Figure 5) reveal that incorporating Dropout significantly boosts the model's recognition accuracy. In comparison to models without Dropout, the accuracy curve in Figure 5 demonstrates greater stability and consistent improvement. The Dropout technique has proven effective in mitigating overfitting and elevating the model's generalization capabilities.

The algorithm's stability is intricately linked to the dependability and uniformity of design outcomes. A steadfast algorithm offers foreseeable results across diverse design contexts, thereby minimizing risks. Consequently, stability serves as a pivotal metric in assessing IP design algorithm performance. Experimental findings, depicted in Figure 6, reveal that the IP design algorithm, grounded in GAN and CAD technology, exhibits notable stability advantages. Even with substantial datasets, the algorithm sustains a stability level of approximately 90%. This underscores the algorithm's resilience when handling voluminous data, effectively tackling diverse alterations and noise disturbances within the dataset.

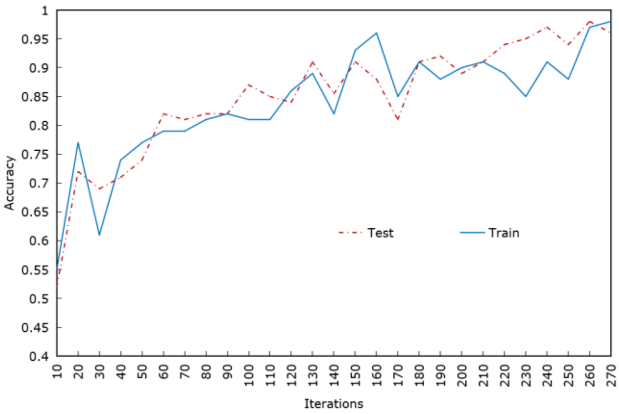
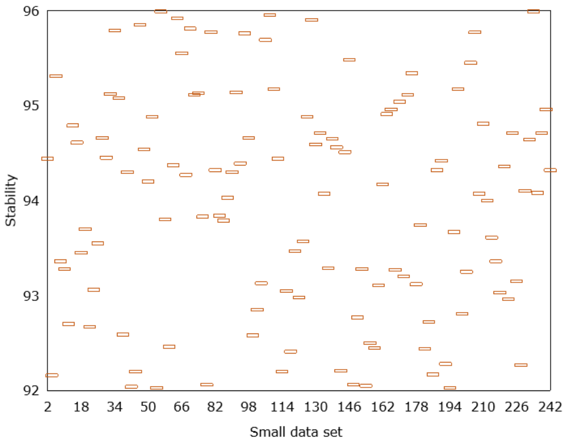
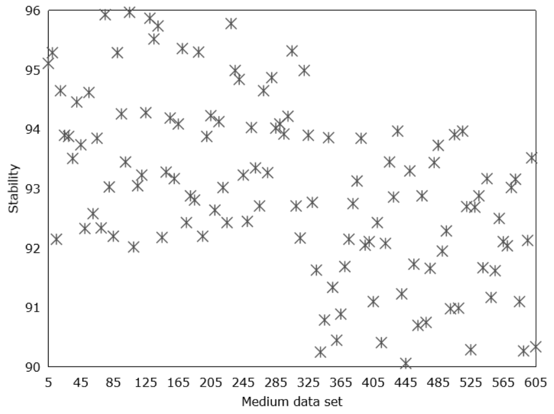


Figure 5: Changes in accuracy after adding over-fitting measures.

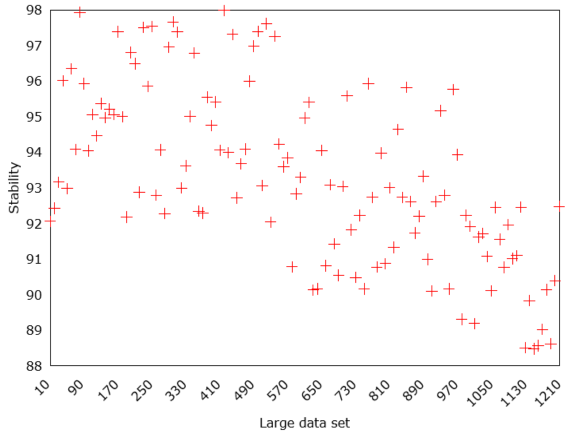
At the same time, the optimization algorithm and stable design flow in CAD software also provide strong support for the algorithm when dealing with large-scale data.
Based on the user satisfaction depicted in Figure 7, it is evident that the IP design approach utilizing GAN and CAD technology considerably outperforms the conventional method in terms of user satisfaction. Most users spoke highly of the IP design method based on GAN and CAD technology. They believe that this method is not only easy to operate, but also can quickly generate high-quality design schemes. The strong generation ability of the GAN model makes the design scheme full of creativity and novelty, while the precise design ability of CAD technology ensures the practicability of the design scheme. When using the IP design method based on GAN and CAD, the user's participation and investment are obviously higher than those using the traditional method. They show higher concentration and enthusiasm in the design process, and their interaction with the design software is smoother and more natural.



(a) Small data set



(b) Medium data set



(c) Large data set

Figure 6: Stability test results of the algorithm.

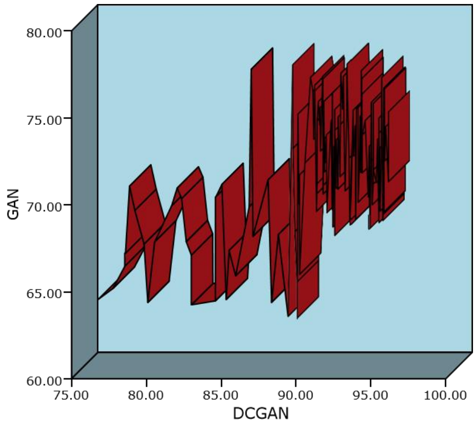


Figure 7: User satisfaction.

6 CONCLUSION

This study delves into the seamless integration of GAN and CAD technologies to forge a cutting-edge design collaboration mechanism. During the creative phase, the GAN model demonstrates impressive generative abilities, rapidly churning out numerous distinctive and inventive design drafts. As we move into the refinement and optimization phase, CAD technology shines, leveraging its precision design capabilities and extensive functional support to guarantee top-notch design quality. The introduction of a collaborative working mechanism further elevates the overall design efficiency. Users overwhelmingly find this approach straightforward, efficient, practical, and transformative, offering a wholly new design experience. These findings not only validate the method's effectiveness and reliability but also pave the way for its widespread adoption in IP design.

In essence, the IP design approach rooted in GAN and CAD technology presents noteworthy strengths in creative design, efficiency enhancement, user satisfaction, and model stability. It revolutionizes methodologies and offers practical insights for propelling the IP design industry forward. Looking ahead, this method promises to unlock the vast potential in diverse design contexts, delivering exceptional value for designers and users alike.

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