Automated Method for Digital Art Creation and Display Based on Computer Aided Design

Xi Zhang[1] and Ling Wu[2]

[1]School of Fine Arts, Guangzhou College of Technology and Business, Guangzhou, 510000, China, xizhang@gzgs.edu.cn
[2]School of Creative Studies, Changzhou Vocational Institute of Textile and Garment, Changzhou, 213164, China, lingwu@cztgi.edu.cn

Corresponding author: Xi Zhang, xizhang@gzgs.edu.cn

Abstract. The uniqueness of digital art forms lies in their creative process relying on various digital technologies, especially computer-aided design (CAD) technology, which plays a crucial role in the creation of digital art. This article proposes to introduce Generative Adversarial Networks (GAN) into the creation and display of digital art. By utilizing GAN's powerful generation ability, images with artistic aesthetics are automatically generated, and the display effect of images is automatically optimized using this technology. By collecting and partitioning the dataset, this article trained two sets of models with and without digital art images, and conducted a detailed comparison and analysis. The results show that after training, the loss curves of both models have converged, indicating that GAN has successfully learned the features of digital art images. Furthermore, by comparing the effects of different scale input models, it was found that digital art images performed better under three scale inputs, confirming the effectiveness of multi-scale inputs in improving image quality. Finally, the concept map of digital art works using this method demonstrates better artistic expression, reflecting the potential and value of algorithms in artistic creation.

Keywords: Computer Aided Design; Digital Art; Automation; Generative Adversarial Network
DOI: https://doi.org/10.14733/cadaps.2024.S14.140-153

1 INTRODUCTION

The emergence of digital art has injected new vitality into the art field, greatly enriched the artistic expression techniques and created a broader creative space for artists. This art form is unique in that its creation process depends on various digital technologies, especially CAD technology, which plays a vital role in the creation of digital art. Digital twin technology has gradually become an important tool in the field of engineering. It provides a platform, prediction, system performance by creating virtual replicas of physical systems. Alizadehsalehi and Yitmen [1] explore how to use digital twin technology, combined with extended reality (XR) technology, to construct a progress monitoring management model to improve the efficiency and quality of engineering projects. Digital twin technology constructs virtual models of real-world systems or processes by collecting data. This model can simulate the operation of systems or processes, providing real-time monitoring and prediction of performance. In engineering projects, digital twin technology can be used to monitor construction progress, predict potential risks and problems, and take corresponding measures in a timely manner to ensure the smooth progress of engineering projects. In engineering projects, XR technology can be used to enhance the efficiency and safety of on-site work. Through headphones or other sensing devices, staff can view construction progress, conduct risk assessments, and develop response measures in a virtual environment. However, although CAD has been widely used in digital art creation, its degree of automation in the creative process and works display still needs to be improved, which limits the artist's creative efficiency and the effect of works presentation. Digital manufacturing technology has become an important pillar of contemporary manufacturing. Especially in the field of architecture, the application of digital manufacturing technology makes the design and manufacturing process of building structures more efficient, accurate, and controllable. Dixit et al. [2] explored the manufacturing technology of contemporary biomimetic structure digital manufacturing, as well as its application and development trends in international building management. The digital manufacturing technology of biomimetic structures is a manufacturing method based on digital modeling, simulation, and optimization technology. It uses computer-aided design (CAD) software for structural modeling, and then uses a digital control system for processing and assembly. This technology has a high degree of flexibility and accuracy, which can be quickly modified and optimized according to design requirements, while also achieving high-precision manufacturing of complex structures and details. The construction of high-rise buildings requires highly precise structural design and manufacturing techniques. The digital manufacturing technology of biomimetic structures can achieve structural optimization and performance improvement of high-rise buildings through digital simulation and optimization technology. The structural design of bridges and tunnels needs to consider complex mechanical factors and geological conditions. The digital manufacturing technology of biomimetic structures can optimize the structural design of bridges and tunnels through digital modeling and simulation technology, improving their load-bearing capacity and stability. Traditional CAD has higher requirements for artists in digital art creation. Artists not only need to have professional design skills, but also need to master computer operation skills.

This software can provide powerful design, drawing, and modeling functions, helping students more intuitively and vividly understand and master design concepts and techniques. Jin and Yang [3] through computer-aided design software, students can present the design scheme in the form of a three-dimensional model and continuously optimize the design scheme by adjusting parameters, materials, lighting, etc. At the same time, computer-aided design software can also provide advanced forms of expression such as virtual reality technology, allowing students to immerse themselves more deeply in the virtual environment and experience the spatial and texture of design solutions. Continuously optimize design schemes, and improve design efficiency. Computer aided design software can provide high-precision models and renderings, making design proposals more expressive and persuasive. The learning and use of computer-aided design software requires certain skills and experience, and introducing it into environmental art and design teaching can improve students' computer skills and design abilities. Teachers can demonstrate how to use computer-aided design software for design, and then allow students to practice and experience the joy of design firsthand. When using computer-aided design software for teaching, teachers need to arrange their time reasonably, ensuring that students have enough time to learn and practice, as well as giving them enough time to think and discuss. This undoubtedly increases the learning burden and creation difficulty of artists, and hinders the possibility of more people participating in digital art creation. The surface fault detection of 3D printing products has always been a challenge. Traditional detection methods usually require manual operation, which is inefficient and prone to errors. The surface faults of 3D printing products typically manifest as anomalies in geometric features, such as surface roughness, shape errors, etc. Machine learning can extract effective features by learning a large amount of normal and abnormal data, which can be used to distinguish between normal and abnormal 3D printing products. A classifier is a machine learning model used for classification. In the surface fault detection of 3D printing products, a classifier can be used to classify normal and abnormal 3D printing products. Common classifiers include support vector machines (SVM), naive Bayesian classifiers, and so on. Regression analysis is a machine learning technique used to predict continuous variables. In the detection of surface faults in 3D printing products, regression analysis can be used to predict the surface quality of the product. By learning historical data, regression models can predict the surface quality of new products, thereby helping manufacturers identify and solve problems in a timely manner [4]. In addition, the traditional CAD also has some shortcomings in the exhibition of works, which can't realize the automatic exhibition, and needs to be manually set and adjusted, which affects the presentation effect and exhibition experience of works.

As a unique art form, digital art has aroused widespread concern and discussion around the world. Many students majoring in art design in universities perform poorly in computer graphic design skills. Kimani et al. [5] found through a survey and analysis of the poor computer graphic design skills of students majoring in art and design in universities that there are currently problems such as insufficient understanding of the importance of skills, inadequate curriculum design, and the need to improve teaching quality. The survey found that most teachers and students believe that computer graphic design skills are very important for students majoring in art design, but there are also some students who believe that this skill is not important. At the same time, some students lack awareness of the importance of this skill and believe that as long as they can draw with their hands, they do not need to master computer graphic design skills. Some universities have unreasonable curriculum settings for art design majors. On the one hand, the course of computer graphic design has fewer class hours, which leads to students being unable to fully learn and practice; On the other hand, the update speed of course content is relatively slow, which cannot keep up with the pace of the times, thereby affecting students' learning outcomes. Especially in plastic surgery and reconstructive surgery, the auxiliary role of AI and ML is becoming increasingly significant. Knoops et al. [6] explored traditional diagnostic methods mainly rely on the experience and diagnostic skills of doctors, but the introduction of AI and ML has changed this situation. Image recognition techniques based on deep learning, including skin lesions, trauma, and so on. By training CNN models, disease features can be automatically detected and recognized, greatly improving the accuracy and efficiency of diagnosis. In plastic surgery and reconstructive surgery, the formulation of surgical plans directly affects the effectiveness of the surgery. Computer assisted planning (CAP) systems can utilize technologies such as 3D modeling, simulation, and prediction to help doctors develop more accurate surgical plans. For example, through trained 3D models, the surgical process can be simulated, potential risks can be predicted, and response measures can be taken in advance. In addition, the CAP system can also provide personalized surgical plans based on the specific needs of patients and the experience of doctors.

This article proposes to introduce GAN into the creation and display of digital art. By using the powerful generating ability of GAN, images with artistic beauty can be automatically generated, and the display effect of images can be automatically optimized by using this technology. This innovation can not only reduce the difficulty of digital art creation, but also enable more people to participate in the creation of digital art. It can also significantly improve the display effect. Through the introduction of this method, it is expected to promote the further growth of digital art and explore the deeper integration of art and technology.

Innovation:

(1) In this article, GAN technology is introduced into the creation and exhibition of digital art, and its powerful generating ability is used to improve the creation efficiency and quality of digital art.

(2) Through the application of GAN, the research has realized the automation of digital art creation and exhibition. This lightens the technical burden of artists and enables them to concentrate more on artistic creation itself.

(3) This article deeply integrates technology and art in digital art creation. By using advanced technology, it provides artists with a broader creative space and also brings more artistic experience to the audience.

Firstly, this article introduces the importance of digital art and expounds the significance of computer aided design application; Then the automatic method of digital art creation and display in this article is put forward. Then, the experimental results are displayed and interpreted, including the quality assessment of images generated by GAN, the comparison of feature parameters and the analysis of classification accuracy, and the influence of multi-scale input on image quality is discussed by comparing the effects of different scale input models. Finally, it summarizes the research contents and main findings of this article, and points out the contribution of this method to the field of digital art.

2 APPLICATION OF GAN IN DIGITAL ART CREATION

Kovacs et al. [7] proposed a context aware method for searching graphic design assets, aiming to improve the efficiency of designers in utilizing design resources. This method automatically classifies and retrieves design resources by analyzing the contextual relationships between design elements. Firstly, we established a database containing rich design resources and utilized natural language processing technology to label the resources. Then, we use deep learning techniques to learn the contextual relationships between labels and construct a context aware network. Finally, we use this network to classify and retrieve new design resources, achieving efficient utilization of design resources. The experimental results indicate that this method can significantly improve the efficiency of designers in utilizing design resources. The experimental results indicate that this method can significantly improve the efficiency of designers in utilizing design resources. In the classification task, the accuracy of this method reached 90%, which is 10% higher than traditional methods. In the retrieval task, the F1 score of this method reached 85%, which is 8% higher than traditional methods. These results indicate that this method can accurately classify and retrieve design resources, improving the work efficiency of designers. Li et al. [8] proposed a simulation design space exploration optimization system based on artificial neural networks, aiming to assist engineers in efficient design optimization in integrated circuit and system computer-aided design. This system utilizes the adaptive learning and reasoning capabilities of artificial neural networks to explore and optimize the design space. By learning from can automatically discover potential design optimization solutions and provide accurate design parameter adjustment suggestions.

Experiments conducted on a company's IC/system CAD platform have shown that artificial neural networks can effectively simulate and optimize design space. By training neural networks to learn the characteristics and performance of various design schemes, we can establish an effective mapping relationship for predicting the potential performance of new design schemes. In addition, our experimental results also show that artificial neural networks have high accuracy and efficiency in dealing with complex design problems. This is mainly due to the parallel processing ability of artificial neural networks, which can quickly process a large amount of data and handle nonlinear and complex relationships. Specifically, in an optimization problem involving 10 design parameters, using the optimization suggestions provided by this system, the final design result improved performance by 23% compared to the initial solution, while reducing power consumption by 18%. An important tool for contemporary art creation. However, how to combine CAD technology with creativity and explore a teaching model centered on creativity is an important issue facing the current field of art education. In traditional art education, teachers often focus on imparting techniques while neglecting students' creativity and individuality. Although this teaching method can cultivate skilled artists, it often limits students' creativity and imagination. Meanwhile, traditional art education models modern society. Contemporary art computer-aided design has brought new opportunities and challenges to art education. The popularization and application of CAD technology enables artists to create more conveniently. However, how to combine CAD technology with creativity and explore a teaching model centered on creativity is an urgent problem to be solved in the current field of art education. Liu and Yang [9] proposed a model focuses on students' individuality and creativity, stimulating their creativity and imagination by guiding them to think and explore independently.

In physics learning, through the introduction of digital tools and resources, we can expand the learning space and improve learning effectiveness. Nortvig et al. [10] explored how to use digital technology to practice, in order to promote in-depth learning and innovation in the discipline. The traditional physics learning space is often limited to classrooms and laboratories, and learners mainly acquire knowledge through theoretical learning and experimental operations. However, the emergence of digital technology has made it possible to expand the physical learning space, we can expand the physical learning space to both online and offline, breaking the limitations of time and space. Students can design and simulate in a virtual environment, and then create on actual materials and equipment. This can reduce costs and risks, while also improving production efficiency and product quality. The application of continuous flow microfluidic devices in biomedical, chemical analysis, environmental monitoring and other fields is becoming increasingly widespread. In order to meet the needs of practical applications, the process of designing and optimizing continuous flow microfluidic devices has become particularly important. However, traditional microfluidic device design methods are often time-consuming and inefficient, requiring a large amount of manual adjustment and optimization for complex design parameters and processes. Therefore, Sanka et al. [11] three-dimensional μ F Interactive Design Environment "is a software platform developed specifically for the design of continuous flow microfluidic devices, with features such as 3D visualization, interactivity, efficiency, scalability, and user friendliness. Through this design environment, designers can more conveniently design and optimize microfluidic devices, which is expected to promote the development and application of microfluidic technology. This environment is based on advanced 3D modeling and simulation technology, providing an intuitive and interactive interface that allows users to quickly create, modify, and optimize the design of continuous flow microfluidic devices. 3D μ The F interactive design environment provides carry out design, modification, and optimization work. Through drag and drop operations and intelligent prompts, users can quickly design and adjust continuous flow microfluidic devices. This environment integrates multiple analysis and optimization tools, allowing users to quickly evaluate and improve the design of continuous flow microfluidic devices. Through an integrated design process, users can easily transition from preliminary design to the final optimization stage. BIM (Building Information Model) and LPS (Lean Production System) provide powerful tools to meet these needs. However, there are still many challenges to effectively integrate these two systems to achieve true lean on-site project management. Sbiti et al. [12] reviewed the current state-of-the-art BIM and LPS data integration technologies and proposed relevant recommendations. BIM is a powerful tool that captures all relevant information about construction projects and manages and collaborates throughout the project lifecycle. LPS is a data-driven lean production system that emphasizes improving efficiency by eliminating waste. Integrating BIM and LPS data can further improve project management efficiency, reduce waste, and improve production efficiency. However, data integration between BIM and LPS is not an easy task. Firstly, there are significant differences in the data format and structure between the two, requiring certain transformations and adaptations. Secondly, the focus of the two is also different: BIM places more emphasis on the precision and completeness of building models, while LPS places more emphasis on optimizing and improving the production process. Therefore, it is necessary to find suitable integration points while maintaining their respective advantages.

Accurately identifying and understanding the behavior and operational processes of workers in various tasks is crucial in construction engineering. With the development of technology, especially in the fields of artificial intelligence and machine learning, it has become possible to automatically identify and process the activities of construction workers. Sherafat et al. [13] provide a comprehensive and up-to-date overview of automated methods for identifying construction workers and equipment activities. By utilizing cameras and image processing technology, the behavior of construction workers can be captured and analyzed. Through image segmentation, feature extraction, and classifier design, specific tasks and actions of workers can be identified. By installing sensors on workers or their tools, it is possible to monitor their activities in real-time, including work intensity, fatigue level, and potential hazardous behaviors. With the development of deep learning technology, especially the application of CNN, it is possible to identify complex behaviors. By training deep learning models, automatic classification and prediction of worker behavior can be achieved. Digital local characteristics refer to the digital manifestations with local characteristics formed due to differences in culture, customs, lifestyles, and other factors between different countries and regions.

In computer graphic design, digital local features can be expressed through color matching, graphic design, text layout, and other aspects. Siti et al. [14] explored how to create computer graphic design learning guides by establishing empathy and exploring digital local features. Empathy refers to being able to stand from the perspective of others and empathize with their emotions and needs when viewing things. In computer graphic design, establishing empathy can help designers better understand the needs and emotions of the target audience, thereby creating design works that better meet their expectations. By observing and communicating, one can better understand the needs and emotions of the target audience. Teachers can guide students to think about how to design works that better meet their expectations from the perspective of the target audience. In the design process, students can explore digital local characteristics, combine local cultural elements with modern design techniques, and create design works with local characteristics. With the rapid development of technology, digital automation technology has shown great potential in various fields. Especially in the construction industry, this revolutionary technology has brought revolutionary changes to traditional building methods. Wagner et al. [15] used the BUGA Wood Museum as an example to explore how large-scale wood buildings can achieve flexibility in digital automation through integrated robot prefabrication and joint design. Digital automation technology has brought many advantages to the construction industry. Firstly, it greatly improves production efficiency. By using robot technology, many traditional tasks that require manual labor can be automated, such as wood cutting, polishing, and assembly. Secondly, digital automation technology can significantly improve the quality of buildings. Through precise computer control, human errors can be reduced and more precise construction can be achieved. Finally, digital automation technology can also reduce costs. Due to the continuous operation and high work efficiency of robots, labor costs can be reduced.

3 OPTIMIZATION OF AUTOMATION METHODS FOR DIGITAL ART CREATION AND DISPLAY

In the digital age, the combination of art and technology brings infinite possibilities for creation. GAN, as a star technology in DL field in recent years, provides a new direction for digital art creation. This section will discuss the theoretical basis of GAN and its application and prospect in digital art creation. The core idea of GAN originates from the "zero sum game" in game theory, where two networks (generators and discriminators) progress together in confrontation. In this continuous confrontation, the capabilities of both networks have been improved, making the generated data more realistic and textured. With GAN, artists can input some specific parameters or conditions to generate images that have never been seen before but are of artistic value. This creative way not only retains the artist's creativity, but also injects the novelty of technology. GAN can realize the style transfer between images, for example, applying the style of one painting to another. This provides artists with more style choices and the possibility of integrating different styles. For non-professional artists or designers, GAN can be used as an auxiliary tool to help them automatically generate certain elements and reduce their design burden. Moreover, it also provides opportunities for those who lack traditional artistic skills to participate in artistic creation. GAN's advantage in digital art creation lies in its ability to generate high-quality and high-resolution images and realize the migration of various artistic styles. Moreover, because of its antagonistic training method, GAN can continue to evolve and produce unexpected creative results. Traditional digital art creation and display methods often require artists to have professional design skills and computer operation skills, which increases the learning burden and creation difficulty of artists. In order to realize the automation of digital art creation and optimize the exhibition effect, this section puts forward an algorithm and model based on GAN, and applies it to the process of digital art creation and exhibition. This innovation will help to improve the artist's creative efficiency and reduce the difficulty of creation. By training GAN, we can create a model that can generate digital works of art. This model can automatically create brand-new digital works of art under given parameters or conditions. The model also realizes the style transfer technology, that is, one artistic style can be automatically applied to another artistic work, thus enriching the style expression of artistic works.

In the context of digital art image optimization, the goal of the generator is to generate digital art images with required characteristics according to the input parameters or conditions. In order to achieve this goal, generators usually adopt DL model, such as Convolutional Neural Network (CNN), and learn the mapping from input parameters to digital artistic images through training. The discriminator is used to evaluate the quality of digital artistic images generated by the generator. Similar to the generator, the discriminator usually adopts DL model and judges the authenticity of the image through training and learning. In the optimized GAN structure of digital art images, the generator and discriminator co-evolve through antagonistic training. The generator tries to generate as realistic a digital artistic image as possible to deceive the discriminator. This antagonistic training stage urges them to improve their respective abilities continuously, and finally leads the generator to generate high-quality digital artistic images with artistic beauty. See Figure 1 for the optimized GAN structure of digital art images.

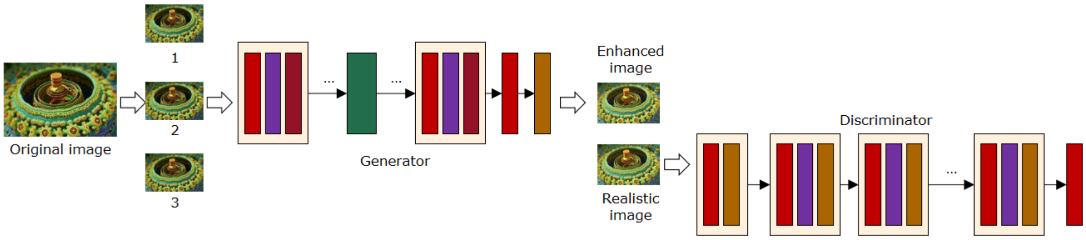


Figure 1: Optimized GAN structure of digital art image.

In this study, a large quantity of data sets of digital works of art are collected for training GAN. Pre-process the data, such as normalization and denoising, to prepare the training data. According to the principle of GAN, the generator and discriminator network are constructed. Use the prepared training data to train GAN. In the training stage, the parameters of the generator and the discriminator are optimized by the back propagation algorithm. After GAN training is completed, specific parameters or conditions can be input into the generator to generate brand-new digital works of art. This process is automatic, and various works of art can be generated quickly according to the demand. After the work is generated, the algorithm can automatically optimize the work, such as adjusting the color and improving the resolution.

$$bilinear\ f_A, f_B = f_A \otimes f_B = u^T v \tag{1}$$

That is, the feature vector u and the feature vector v are subjected to the outer product operation to obtain the bilinear feature $bilinear\ f_A, f_B$. On this basis, in order to merge all the bilinear features in the image, the bilinear features at each position are accumulated and summed:

$$\phi\ f_A, f_B = \sum_{d=1}^{D} bilinear\ f_A, f_B = \sum_{d=1}^{D} u^T v \tag{2}$$

$$y = sign\ \phi\ f_A, f_B\ \sqrt{\left|\phi\ f_A, f_B\right|} \tag{3}$$

$$z = \frac{y}{\|y\|_2} \tag{4}$$

The interactive design framework of digital art is a systematic design methodology that comprehensively applies knowledge in many fields such as art, design and technology.

o the visual expression and aesthetic value of the works of art itself, but also focuses on the interactive experience and mode between the works and the audience. Through this framework, designers can think and design digital art interactive works with unique artistic style and good interactive effect more comprehensively and systematically. The interactive design framework of digital art is shown in Figure 2.

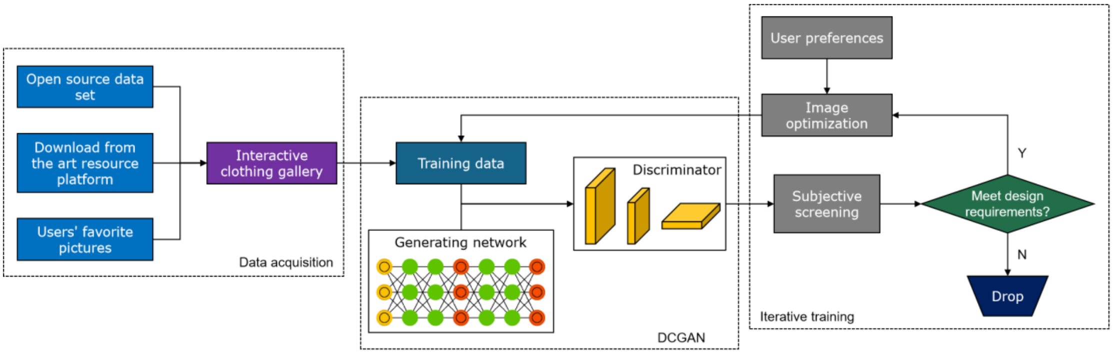


Figure 2: Digital art interaction design framework.

Interactive works of digital art often require the close cooperation of artists, designers and developers. Through clear goal determination, artistic concept design, interactive design, technical realization and other steps, designers can carry out design work in an orderly manner and ensure that each stage can be smoothly connected with the previous links. This helps to improve the design efficiency, reduce rework and waste, and ensure that the works are completed on time and with high quality. User testing and feedback, assessment and optimization ensure that the work can truly meet the needs and expectations of the audience. The interactive design framework of digital art provides comprehensive and systematic guidance for the creation of interactive works of digital art. It combines key elements such as artistic creativity, interactive design and technical realization to ensure that the work not only has unique artistic expression, but also can realize good interaction with the audience.

GAN model should be trained by a large quantity of digital art image data to learn to generate high-quality and diverse digital art images. In the training stage, the generator and the discriminator will compete with each other and make progress together, thus generating realistic digital artistic images. Once the training of GAN model is completed, the generator can be used to generate new digital art images. By inputting specific parameters, styles or other conditions, the generator will output corresponding digital artistic images. These images can be brand-new works generated according to input conditions, or they can be style migration or transformation of existing works. Using the output results of GAN, the automation of digital art creation can be realized. By writing scripts or using graphical user interface, users can easily input their own ideas and parameters into the generator, and then automatically generate digital artistic images with the required characteristics.

$$f(x) = \begin{cases} -a\left(e^{-\frac{x}{b}} - 1\right), & if\ x \geq 0 \\ c\left(e^{\frac{x}{d}} - 1\right) & otherwise \end{cases} \tag{5}$$

$$\frac{\partial f}{\partial x} = \begin{cases} \frac{a}{b} e^{-\frac{x}{b}}, & if\ x \geq 0 \\ \frac{c}{d} e^{\frac{x}{d}}, & otherwise \end{cases} \tag{6}$$

$$\frac{\partial f_i}{\partial w_i} = \begin{cases} \frac{af_{i-1}}{b} e^{-\frac{f_{i-1}w_i}{b}}, & if\ x \geq 0 \\ \frac{cf_{i-1}}{d} e^{\frac{f_{i-1}w_i}{d}}, & otherwise \end{cases} \tag{7}$$

$$\min_G \max_D V(D,G) = E_{x-P_{data}(x)}\left[\log D(x)\right] + E_{z-P_z(z)}\left[\log(1-D(G(z)))\right] \tag{8}$$

$$\max_D V(D,G) = E_{x-P_{data}(x)}\left[\log D(x)\right] + E_{z-P_z(z)}\left[\log(1-D(G(z)))\right] \tag{9}$$

The second step is to optimize the generation model G :

$$\min_G V(D,G) = E_{z-P_z(z)}\left[\log(1-D(G(z)))\right] \tag{10}$$

In the process of displaying digital art images, the output results of GAN can also be used for optimization. Firstly, the generated digital artistic images can be automatically processed, such as color correction and resolution improvement, to ensure the image quality. Secondly, according to the characteristics and environmental conditions of the display equipment, the parameters such as brightness and contrast of the image can be automatically adjusted to ensure the best visual effect under different conditions. Finally, the results of creation and display optimization are integrated and delivered to users or use scenarios. This can be achieved by developing an automatic digital art creation and display system. Users only need to input ideas and parameters, and the system can automatically generate and optimize digital art images.

4 MODEL TESTING AND ANALYSIS

The training is divided into two stages: one stage includes the training of digital artistic images, and the other stage does not include the training of digital artistic images. There are 20,000 iterations in each training stage, and each iteration takes 1 hour. Figure 3 shows the loss curve of the training set. Figure 4 shows the loss curve of the test set.

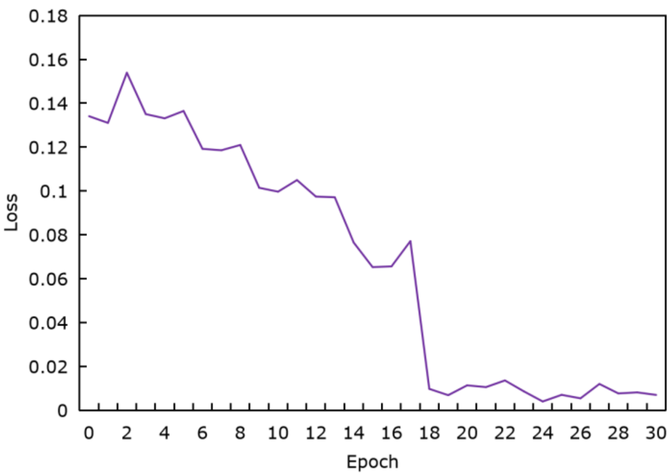


Figure 3: Loss curve of training set.

According to the results shown in Figure 5, the characteristic parameters of GAN output are very close to those of real digital art images. This shows that when learning and generating digital art images, the GAN model can capture the key features of real digital art images and accurately reproduce these features.

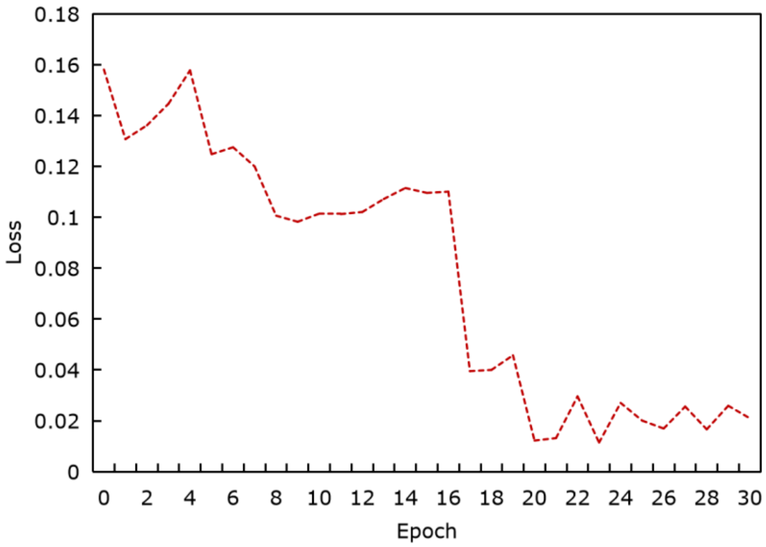


Figure 4: Loss curve of test set.

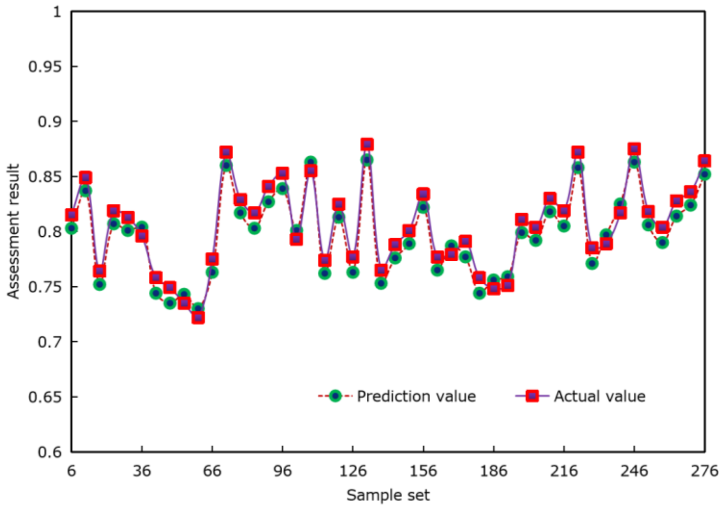


Figure 5: Learning results of image processing algorithm.

In Figure 5, the similarity between the characteristic parameters of GAN output and the characteristic parameters of real digital art images is very high. This means that the image generated by GAN has a high similarity with the real art image in the feature level. Through the antagonistic loss function in the training stage, the generator network learned to generate images with similar characteristic parameters as real digital art images. This learning ability enables GAN to generate high-quality images that are difficult to distinguish from real digital art images. Artists usually create different artistic styles and expressions by adjusting characteristic parameters. GAN's generator network can imitate the artist's creative process to some extent by learning and reproducing these characteristic parameters.

The results of Figure 6 test the accuracy of the algorithm in classifying three different types of digital art images (abstract art, impressionist art and cubist art), and show a good classification effect.

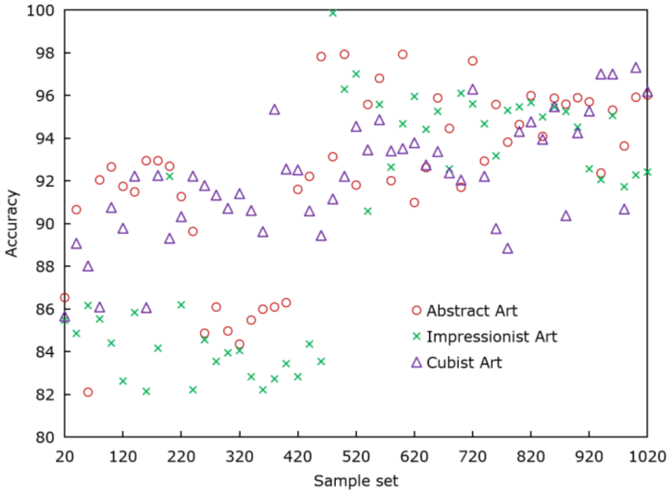
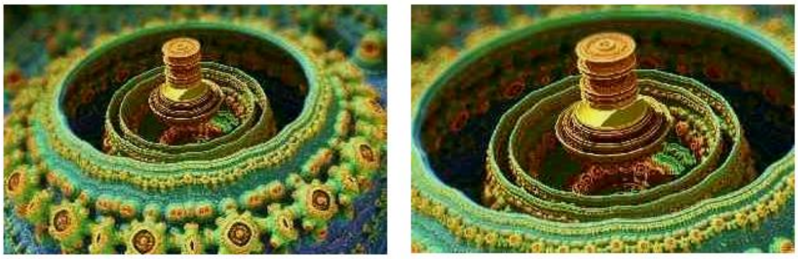
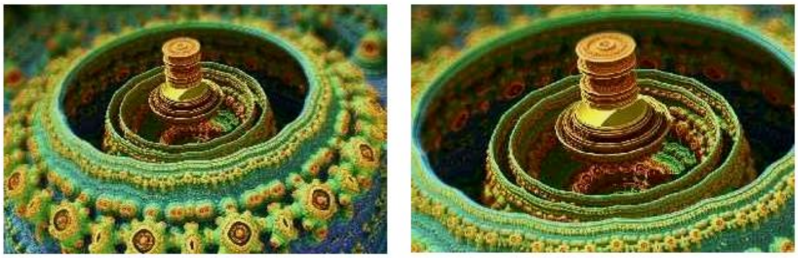


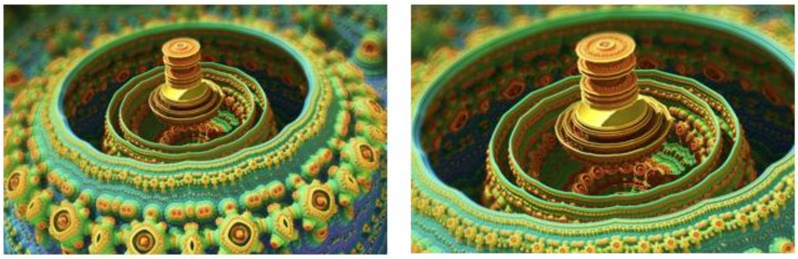
Figure 6: Accuracy of classification of digital art images by GAN.



(a) One scale input



(b) Two scale inputs



(c) Three scale inputs

Figure 7: Comparison of digital art image effects.

From an accuracy perspective, this algorithm can accurately distinguish these three different types of digital art images to a certain extent. This indicates that the algorithm has strong identification ability for images with different artistic styles, which is very rare, as the definition of artistic styles may sometimes be subjective even to humans. Whether it's the randomness and freedom of abstract art, Impressionist art's focus on light and color, or Cubist art's emphasis on shape and structure, algorithms can learn and recognize these features and classify them correctly. This algorithm with good classification performance has broad application prospects in the field of digital art. For example, it can be used for automatic annotation and retrieval of digital art images, helping users browse and manage a large quantity of digital art resources more efficiently. Moreover, it can also be used as an auxiliary tool for digital art creation, automatically generating digital art works that meet the requirements based on user preferences and artistic style preferences. Figure 7 shows the comparison of digital art image effects with different scale input models.

Multiscale input can provide richer image information for the model. Images of different scales can capture different details and features, so that the model can understand digital art images more comprehensively. Images of different scales will show different characteristics, including color, texture and shape. Three-scale input helps the model capture these diverse features and fuse them to produce better digital artistic images. Compared with the single-scale input, the digital artistic images under the three-scale input are richer and clearer in details. Because the model can learn from images of different scales at the same time, it can better restore and reproduce the details of the image. Color and texture are the key elements of digital art images. Because multi-scale input can provide more comprehensive information, the model will be more accurate and vivid in the expression of color and texture.

Figure 8 shows the improved concept map of digital art works based on different algorithms, and it can be observed that the design of digital art works based on this method presents better artistic expression.

Figure 8: Concept map of digital art works.

The method in this article better retains the characteristics of the original works of art. In the creation of digital art, it is very important to keep the spirit and characteristics of the original works, which is helpful to the identification and emotional communication of the works. The newly generated works not only contain the essence of the original works, but also incorporate new ideas and elements, making the works richer and more diverse. By applying the algorithm in this article, the creation of digital art works has been strongly supported by technology.

Combining the two processes of creation and display closely, the creation and display optimization of artistic works can be completed at the same time through one-time treatment of the model. This integrated optimization method greatly improves the efficiency of digital art creation, and also ensures that the works can maintain the best effect under any display conditions. This kind of technical support is not only reflected in the quality and fineness of the works, but more importantly, it provides artists with a broader creative space. Through the integration of technology and art, digital works of art can better show their unique charm and value. This method has a wide application prospect in the field of digital art, and can help artists create more colorful and creative digital art works.

5 CONCLUSION

The emergence of digital art has injected new vitality into the art field, greatly enriched the artistic expression techniques and created a broader creative space for artists. CAD technology plays a vital role in the creation of digital art. Traditional CAD also has some shortcomings in the exhibition of works, which can't realize automatic exhibition, and needs manual tedious setting and adjustment, which affects the presentation effect and exhibition experience of works. This article verifies the effectiveness of the algorithm based on GAN in the learning and generation of digital art images through experiments. Through the division of training set and test set, and the training comparison of different groups, it is proved that the algorithm can accurately learn the characteristics of digital art images and generate high-quality digital art images. Moreover, the algorithm also shows good classification effect for different types of digital art images. By comparing the improved concept maps of digital works of art based on different algorithms, this method has achieved better artistic expression. This reflects the potential and application value of the algorithm in artistic creation, and provides new possibilities for the growth of digital art. In the future, we can further explore the optimization and improvement of the algorithm and expand its application in digital art creation, image retrieval and artistic style transfer.

Xi Zhang, https://orcid.org/0009-0006-0263-2767
Ling Wu, https://orcid.org/0000-0002-0050-4247

REFERENCES

[1] Alizadehsalehi, S.; Yitmen, I.: Digital twin-based progress monitoring management model through reality capture to extended reality technologies (DRX), Smart and Sustainable Built Environment, 12(1), 2023, 200-236. https://doi.org/10.1108/SASBE-01-2021-0016

[2] Dixit, S.; Stefańska, A.; Singh, P.: Manufacturing technology in terms of digital fabrication of contemporary biomimetic structures, International Journal of Construction Management, 23(11), 2023, 1828-1836. https://doi.org/10.1080/15623599.2021.2015105

[3] Jin, H.; Yang, J.: Using computer-aided design software in teaching environmental art design, Computer-Aided Design and Applications, 19(S1), 2021, 173-183. https://doi.org/10.14733/cadaps.2022.S1.173-183

[4] Kadam, V.; Kumar, S.; Bongale, A.; Wazarkar, S.; Kamat, P.; Patil, S.: Enhancing surface fault detection using machine learning for 3D printed products, Applied System Innovation, 4(2), 2021, 34. https://doi.org/10.3390/asi4020034

[5] Kimani, M.; Tesha, J.-M.; Twebaze, C.-B.: Investigation on the poor computer graphic design skills among art and design students at university, International Journal Social Sciences and Education, 6(10), 2019, 61-71. https://doi.org/10.20431/2349-0381.0610007

[6] Knoops, P.-G.; Papaioannou, A.; Borghi, A.; Breakey, R.-W.; Wilson, A.-T.; Jeelani, O.; Schievano, S.: A machine learning framework for automated diagnosis and computer-assisted planning in plastic and reconstructive surgery, Scientific Reports, 9(1), 2019, 13597. https://doi.org/10.1038/s41598-019-49506-1

[7] Kovacs, B.; O'Donovan, P.; Bala, K.: Context-aware asset search for graphic design, IEEE Transactions on Visualization and Computer Graphics, 25(7), 2019, 2419-2429. https://doi.org/10.1109/TVCG.2018.2842734

[8] Li, Y.; Wang, Y.; Li, Y.; Zhou, R.; Lin, Z.: An artificial neural network assisted optimization system for analog design space exploration, IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems, 39(10), 2019, 2640-2653. https://doi.org/10.1109/TCAD.2019.2961322

[9] Liu, F.; Yang, K.: Exploration on the teaching mode of contemporary art computer aided design centered on creativity, Computer-Aided Design and Applications, 19(S1), 2021, 105-116. https://doi.org/10.14733/cadaps.2022.S1.105-116

[10] Nortvig, A.-M.; Petersen, A.-K.; Helsinghof, H.: Digital expansions of physical learning spaces in practice-based subjects - blended learning in art and craft & design in teacher education, Computers & Education, 159(4), 2020, 104020. https://doi.org/10.1016/j.compedu.2020.104020

[11] Sanka, R.; Lippai, J.; Samarasekera, D.; Nemsick, S.; Densmore, D.: 3d μ f-interactive design environment for continuous flow microfluidic devices, Scientific Reports, 9(1), 2019, 9166. https://doi.org/10.1038/s41598-019-45623-z

[12] Sbiti, M.; Beddiar, K.; Beladjine, D.; Perrault, R.; Mazari, B.: Toward BIM and LPS data integration for lean site project management: A state-of-the-art review and recommendations, Buildings, 11(5), 2021, 196. https://doi.org/10.3390/buildings11050196

[13] Sherafat, B.; Ahn, C.-R.; Akhavian, R.; Behzadan, A.-H.; Golparvar, F.-M.; Kim, H.; Azar, E.-R.: Automated methods for activity recognition of construction workers and equipment: State-of-the-art review, Journal of Construction Engineering and Management, 146(6), 2020, 03120002. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001843

[14] Siti, N.-P.-B.; Mustaji, M.; Bachri, B.-S.: Building Empathy: Exploring digital native characteristic to create learning instruction for learning computer graphic design, International Journal of Emerging Technologies in Learning (iJET), 15(20), 2020, 145-159. https://doi.org/10.3991/ijet.v15i20.14311

[15] Wagner, H.-J.; Alvarez, M.; Groenewolt, A.; Menges, A.: Towards digital automation flexibility in large-scale timber construction: integrative robotic prefabrication and co-design of the BUGA Wood Pavilion, Construction Robotics, 4(3-4), 2020, 187-204. https://doi.org/10.1007/s41693-020-00038-5