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Application and Evaluation of Artificial Intelligence in Sustainable Fashion Design

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ABSTRACT

The development of Artificial Intelligence has renewed the direction of art history, making the relationship between technology and art a matter of great interest once again. The application of artificial intelligence in the field of fashion design brings new tools to the designers' way of designing and displaying. This paper researches artificial intelligence technology and analyzes the application of artificial intelligence as an auxiliary means in the field of art and design, and deeply researches the way of applying artificial intelligence in fashion design as well as its advantages. It also researches the intelligent image generation problem under the fashion big data environment, adopts the method of fusing the external features of fashion images and decoupling the internal features, and provides theoretical methods and bases for the controllable generation of fashion images based on the architecture of generative adversarial network. A multiconditional information fusion generative adversarial network architecture (MCF-GAN) is proposed, and the experimental results show that the image generation performance of the model in this paper is excellent, and better performance is obtained compared with other comparative methods. And it is applied to the actual fashion design for evaluation, the designer's evaluation in all dimensions are more than 10 points, indicating that the method in this paper has a better application value in fashion design, and provides an effective path for fashion design optimization.

Keywords: artificial intelligence, generative adversarial network, multiconditional information fusion, MCF-GAN, fashion design

1. Introduction

Artificial Intelligence (AI) technology, as the core driving force for the development of science and technology in the 21st century, is changing every aspect of human society with its unique charm and far-reaching impact [1-2]. This technology originates from the in-depth exploration and simulation of human intelligence, and through a series of cutting-edge technologies such as machine learning, deep

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learning, natural language processing, computer vision, etc., it gives machines the ability to perceive, understand, make decisions and even create [3-4]. In the world of artificial intelligence, algorithm is the soul and data is the sustenance. Together they weave the intelligent future picture. The rise of artificial intelligence technology not only promotes the rapid development of the technology industry, but also brings unprecedented changes to the field of art creation [5-6]. In the field of fashion design, where tradition and innovation coexist, the integration of AI technology undoubtedly provides designers with new creative tools and ways of thinking [7]. Through algorithmic models, AI can analyze massive amounts of fashion elements, trends, and consumer preferences to provide designers with precise sources of inspiration and design suggestions [8-9]. This data-based creation method not only improves the efficiency and quality of design, but also makes the design works full of foresight and innovation [10].

Digital or digital-intelligent products and services intervene in the material and spiritual life of people now and in the future, which has become one of the important trends of national and socio-economic development, and the ability of digital transformation will become an important core kinetic energy for the future development of China's textile and apparel industry and fashion industry [11-12]. Digital intelligence technology is more and more profoundly affecting the development of society and culture, influencing people's way of life, socialization and way of thinking, and then influencing people's understanding and judgment of fashion and popularity, as well as the way of accepting all kinds of fashion information, etc. [13-14]. In short, under the trend of accelerated integration of science and technology and art, Digital Intelligence Fashion is an important direction for creating a lifestyle with Chinese characteristics in the future. At the same time, in the context of the era of socio-economic development and the great abundance of material civilization, the function of fashion is no longer limited to utility, but more emphasis on identity marking, artistic decoration and cultural representation [15-16].

Literature [17] combined real case studies and stakeholder interviews to reveal that AI in fashion design promotes the divergent thinking of designers, while listing the application modes and potential barriers of AI in fashion design. Literature [18] reveals that personalized apparel design empowered by AI technology can provide consumers with authentic perceptions and product quality feedback. Literature [19] reviewed the research related to AI technology in apparel fashion design, involving design thinking shift, communication strategies, fashion work generation forms, and decision-making design methods, and emphasized that AI technology in the field of fashion promotes a paradigm shift in fashion. Literature [20], based on qualitative survey research, corroborates that fashion clothing design forms with generative deep learning models as the core logic can design more creative and practical fashion clothing products. Literature [21] dialectically analyzes the risks and benefits of applying AI technology in the field of fashion architecture, and proposes to adopt critical thinking to view the role and impact of AI technology in the field of fashion architecture. Literature [22] elucidates that AI technology can uncover the emotions and needs of fashion users, facilitates the interaction between fashion designers and customers, and provides effective and reference and support for designers' personalized fashion design.

This paper is oriented to fashion design on the application method of artificial intelligence, the study first combed the definition of artificial intelligence, and analyzed the development of artificial intelligence, explored its application value in the field of art and design. The direction and advantages of the application of artificial intelligence in the field of fashion design were deeply excavated. Based on this, the intelligent image generation of fashion design is studied as a focus, and the generative adversarial network structure (MCF-GAN) based on multi-conditional information fusion is constructed, which contains two steps of sketch generation and rendering generation. Finally, after experimental validation, it is applied to the actual fashion design for evaluation, and the experimental results show that the method of this paper provides an effective intelligent tool for fashion designers.

2. Artificial intelligence technology and the arts

2.1. Artificial Intelligence Technology Definition Sorting

Artificial Intelligence (AI) did not develop overnight, and after two cold winters, AI has triggered a third wave globally. Throughout the sixty-year history of AI development, the definition of AI has been changed several times along with the improvement and evolution of technology. Even though scholars still define AI differently today, there is still a need to conceptualize AI, and on the basis of understanding its conceptual connotation and general scope of research, we can further examine the paths and ways in which AI has intruded into the field of art. How to choose the appropriate concept among the many definitions depends on the context of use and the focus of attention. Researchers' conceptual definitions of AI are mainly characterized by the following views:

1) Defining AI against human intelligence, i.e., AI is the science of getting machines to do those things that humans need intelligence to do. Artificial intelligence studies how to make computers do what humans are good at doing.

2) Focuses on AI learning from experience, generalizing it as a tool for problem solving. That is, AI is a computer system that can learn from experience and make decisions as a result by recognizing patterns in input data. Or the ability of a system to correctly interpret external data, learn from that data, and use that knowledge to achieve specific goals and tasks through flexible adaptation.

3) Categorized according to the functional attributes of artificial intelligence, “artificial intelligence” is defined as the science and engineering of making intelligent machines.

Most of the above conceptual summaries of artificial intelligence take biological intelligence, which is dominated by human intelligence, as the object of labeling, and it is customary to take the intelligence exhibited by human-made machines or intelligent systems as the original meaning of artificial intelligence, whose characteristics can be summarized as. Simulating, extending and expanding human intelligence, possessing functions similar to those of human intelligence. Secondly, it is capable of finding the best decision for the problem to be solved and realizing the prediction and judgment of the “best priority” result by analyzing and integrating rules and procedures in the process of systematic processing of information and knowledge, and learning from experience. Whether AI is regarded as a computer program that imitates human thinking and behavior, or as an advanced technological science capable of self-learning, the way for AI to acquire intelligence cannot be separated from the reasonable actions based on the perception of the environment, and to obtain the maximum benefit on this basis.

2.2. Developments in Artificial Intelligence

Artificial intelligence, as one of the cutting-edge technologies that have attracted much attention, has a key role in promoting the improvement of social and economic benefits. The knowledge of practitioners in various industries about AI-related technologies is also deepening, and the emergence of every important research result in AI technology will attract widespread attention at the social level. Artificial intelligence keyword search index as shown in Figure 1, the search index of artificial intelligence keywords has steadily increased over the past year, and the search index has reached 7900 in 2023, and the development of intelligent technology has received more attention and expectations.

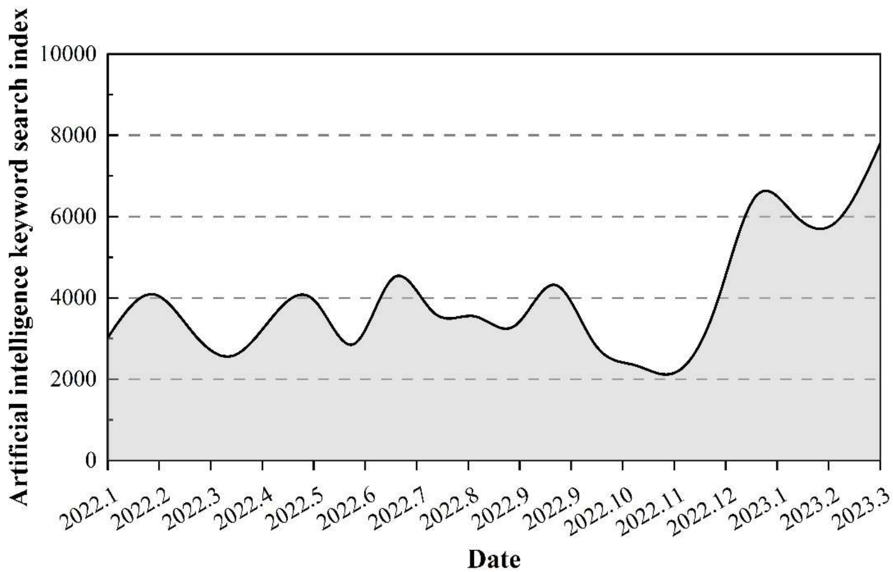

Fig. 1. Artificial intelligence keyword search index

2.3. Artificial Intelligence Technology as an Artistic Aid

Just as paints and brushes are indispensable materials for traditional painters to create art, AI, as an auxiliary tool, plays the role of a necessity for artists pursuing new types of artistic achievements. Algorithm designers formulate logical rules and procedures that provide external conditions for AI to imitate human intelligence, especially in the most intuitive application of visual art, where the involvement of AI brings audiences novel experiences that are different from the usual ones.

The first is in painting. Robotic arm-assisted painting has become the partner of human artists, which not only liberates the hands of artists, but also improves the efficiency of artwork creation. The second is the application of movie and television special effects. "AI face-swapping" and CG roles can solve the reality problem, and computer-generated images such as digital synthesis and digital painting meet the audience's need to consume spectacle scenes. Once again, AI has become increasingly close to human cooperation in music performance, and art has built a bridge for the combination of science and technology and humanities, driving the whole society to a deeper understanding of AI.

The tendency of "humanization" of AI in art practice is increasing, such as flexible mechanical arms, audio-visual special effects hardware facilities to enhance the aesthetic experience, as well as the steel body on stage, these inanimate objects have shown a certain degree of human intelligence in the iteration of technology. The physical form of AI participates in artistic experimentation as an auxiliary tool, "the materialized medium essentially belongs to the externalized form of human intelligence," and the external visualization is a clear evidence of the presence of the art subject. The autonomous learning function of artificial intelligence is certainly powerful, but it must be dependent on the inner human intelligence, and is unable to independently exert its effect on art.

3. Research on the integration of fashion design and artificial intelligence

With the continuous development of big data and artificial intelligence technology, artificial intelligence technology has gradually been applied to different fields and achieved stage-by-stage results. Artificial intelligence technology in the apparel industry is divided into apparel intelligent manufacturing, intelligent apparel, and apparel intelligent design. Clothing intelligent manufacturing is to apply artificial intelligence technology to clothing production and manufacturing links, to realize the automation control of clothing production lines, such as hanging systems, automatic cutting machines and so on. Intelligent Clothing is to apply flexible intelligent fibers or sensors to wearable products such as clothing to realize the function of detecting human body signs, thermal comfort and wet comfort, such as warm clothing based on shape memory materials. Clothing intelligent design is to assist fashion clothing design or realize digital display through artificial intelligence technology.

3.1. Intelligent Design of Fashion Clothing Based on Artificial Intelligence

Fashion clothing intelligent design is the use of artificial intelligence technology to assist designers in realizing the development of clothing products, the application direction of artificial intelligence fashion design is shown in Figure 2, which contains clothing style design, clothing structure design, clothing pattern design and so on based on artificial intelligence technology. Specifically, the first is intelligent style design. Using artificial intelligence technology and digital technology to analyze clothing styles, colors, and materials, and taking into account the user characteristics, consumption habits and consumption preferences of consumers and other factors, systematically establish a prediction model for the fashion trends of clothing styles, colors and clothing materials. Designers can utilize the results of fashion trend prediction based on intelligent technology, combined with the ideas of fashion designers for the development of apparel products, so as to achieve rapid and effective capture of fashion elements and accurate positioning of apparel brands.

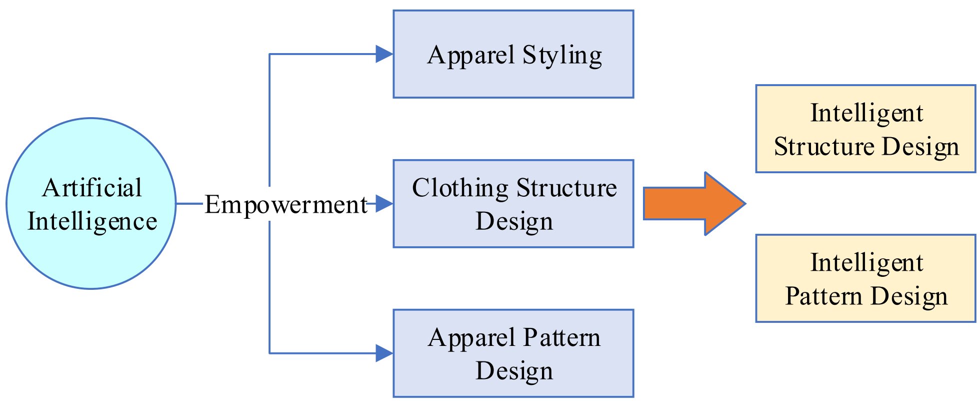

Fig. 2. The application direction of artificial intelligent fashion design

In terms of intelligent structure design. The realization of clothing styles cannot be separated from clothing structure design, and traditional clothing structure design requires rich experience in product development and repeated sample garment production and evaluation. Clothing structure design based on artificial intelligence technology, on the basis of analyzing human body data, can use the basic principles of clothing structure to build parametric clothing structure design models. Through reverse engineering to identify clothing styles, combined with the parameterized clothing structure model, to achieve intelligent clothing structure design. Through the garment surface unfolding technology, compare the garment structure and style, and combine with human-computer interaction design, continuously optimize the garment structure, so as to realize the designer's style design. Intelligent structure design can effectively reduce product development time and save product development costs compared to traditional structure design.

In terms of intelligent pattern design, pattern design based on artificial intelligence technology can utilize image style migration algorithms, which can quickly realize the integration of style and designer's thoughts. For example, intelligent pattern design based on image style, image pattern and image content can effectively show the integration of design content with traditional pattern and modern style, allowing designers to realize high-quality pattern design in a short time.

3.2. Artificial Intelligence Based Fashion Design Presentation

In terms of fashion design display, it is mainly divided into two kinds, one is traditional clothing and virtual display. Traditional costumes are characterized by special patterns and silhouettes, as well as restrictions on dressing scenes. Therefore, there are certain difficulties in restoration and production. By utilizing virtual display technology, the traditional dress pattern and silhouette can be shown realistically. Combined with scene rendering and interactive technology, it can reproduce the historical scene, thus realizing the traditional dress virtual museum and virtual experience hall, and making the traditional dress culture better inheritance. Second, fashion design and virtual display. When fashion is displayed on the stage, the style effect, color effect and pattern effect of clothing can be effectively expressed. However, nowadays people's demand for quality of life is getting higher and higher, and it is difficult to show the functionality and comfort of clothing on the traditional stage. For example, clothing warmth, moisture permeability and air permeability. Through the construction of clothing comfort and functionality model, the use of virtual display technology, to build a more intuitive display platform, can better demonstrate the quality of clothing products.

4. Research on the application of artificial intelligence in fashion design

4.1. Advantages of Artificial Intelligence in Fashion Design

The application of artificial intelligence technology in fashion art design undoubtedly brings unprecedented opportunities and challenges to this industry. Its advantages are mainly reflected in the following three aspects:

1) Artificial intelligence technology injects a strong innovative impetus into digital fashion art design. Through algorithmic modeling, AI is able to mine potential fashion elements and trends, providing designers with a constant source of inspiration. This data-based innovation not only makes the design works more in line with market trends and consumer demand, but also allows designers to break through the traditional thinking framework and create unique works.

2) The introduction of artificial intelligence technology has significantly improved the efficiency of digital fashion art design. In the traditional design process, designers need to spend a lot of time and energy on material collection, sketching, effect preview and other work. The application of artificial intelligence technology makes these tedious steps simple and efficient. Through intelligent design aids, designers can quickly generate design solutions, adjust design details, and even conduct virtual try-on and display, thus shortening the design cycle and improving work efficiency.

3) Industrial intelligence technology provides personalized customization services for digital fashion art design. Under the background of consumption upgrading, consumers' demand for personalization is increasing. By analyzing consumers' behavioral data, preference information and physical characteristics, artificial intelligence technology can generate fashion design solutions that meet consumers' personalized needs. This customized service model not only meets consumers' demand for uniqueness and exclusivity, but also enhances the brand's competitiveness and market influence.

4.2. GAN model based image generation technique

In fashion art design, the application of Generative Adversarial Network (GAN) model pushes the combination of creativity and technology to a new level. The framework of GAN model is shown in Fig. 3.The core of GAN model lies in the framework composed of two neural networks, the generator and the discriminator. The generator's task is to “create” realistic images from random noise, while the discriminator is responsible for distinguishing whether these images are real or “fake” by the generator. This pair of networks is trained to play with each other until the generator produces something that is almost indistinguishable from a real image. In digital fashion design, this mechanism is cleverly used to generate images with novel styles, unique textures, and even unprecedented clothing styles. Designers can easily explore different design styles using GAN models.

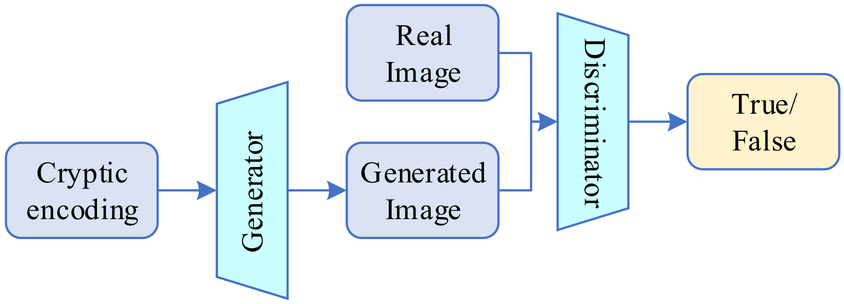

Fig. 3. Gan model framework

4.3. Controlled Generation Algorithm for Fashion Designs Based on GAN Models

4.3.1. Controlled Generation of Fashion Images Based on Multi-Conditional Information Fusion. In recent years, research in the field of fashion has focused on image generation using deep learning models. These generation models can be categorized into two types: unconditional and conditional models. Unconditional models perform image generation based on latent space and achieve impressive generation results, but they are unable to control the attributes and textures of the generated images in a directional manner during the generation process. In contrast, conditional models generate images by given conditions, thus making the generation process more controllable. However, these methods often require the image to be decomposed into multiple classes for training, or require independent training for specific textures, which can lead to degradation of the quality of the generated image. In addition, these methods require a large amount of supervised information during the training process, which can be challenging for inexperienced users. In order to simulate the process of designing finished fashion products in real life, this chapter proposes a generative adversarial network structure based on multiconditional information fusion (MCF-GAN). The method aims to assist designers in automatically generating preliminary sketches and combining them with controllable fashion conditions (e.g., texture and color, etc.) to complete the generation of fashion design images.

The basic structure of the MCF-GAN model is shown in Fig. 4. The proposed generative adversarial network MCF-GAN generative network for multi-conditional information fusion in this chapter contains two steps, i.e., sketch generation and rendering generation. In order to increase the diversity of generation, firstly, a sketch generation is introduced the network learns to generate a variety of diverse drawing sketches seeds from the potential space, and high quality sketch generation is accomplished using adversarial training. Secondly, to solve the problem of fusion of two controllable conditions, texture and sketch, a rendering generation adversarial network is proposed to generate fashion design images.

The proposed MCF-GAN training architecture aims to synthesize the flexibility of the latent codes z and the controllability of the conditions c to achieve diverse generation based on controlled conditions. The model contains two generators $\left(G_s, G_r\right)$ and two discriminators $\left(D_s, D_r\right)$. Generators G_s and G_r are trained using unsupervised and supervised approaches, respectively. A two-step training strategy is employed to optimize generators G_s and G_r. First, generator G_s is optimized to learn the mapping relation from potential space z to data space x_s. Next, generator G_s is utilized to generate diverse results based on potential codes z, and paired conditional data $\left(c_1, c_2\right)$ is used as input to generator G_r to generate $G_r\left(c_1, c_2\right)$.

In the sketch generation phase, the generator G_s generates a sketch $\tilde{I}_s$ using the latent code z. Subsequently, the generator G_r generates an image $\tilde{P}_{s,t}$ (i.e., $G_r\left(c_1, c_2\right)$) utilizing the generated sketch $\tilde{I}_s$ as a condition c_1 and a random texture I_t extracted from a real photograph as a condition c_2. The expected output image $\tilde{P}_{s,t}$ will generate a fashion design image with correct semantic and detail information under the constraints of the sketch $\tilde{I}_s$, utilizing the texture I_t as a condition. This generation process can be represented as:

$$\left\langle \left(z \to \tilde{I}_s\right), I_t \right\rangle \to \tilde{P}_{s,t} \tag{1}$$

However, in practice, it is difficult to collect pairwise data about potential codes z, sketches $\tilde{I}_s$ and their generation results $\tilde{P}_{s,t}$, i.e., there is a lack of pairwise training data consisting of $\left\{\tilde{I}_s, I_t\right\}$. To overcome this challenge, the key idea of MCF-GAN is to decompose the design process into two main modules, i.e., sketch generation adversarial network $\left(H_s\right)$ and texture rendering generation adversarial network $\left(H_r\right)$.

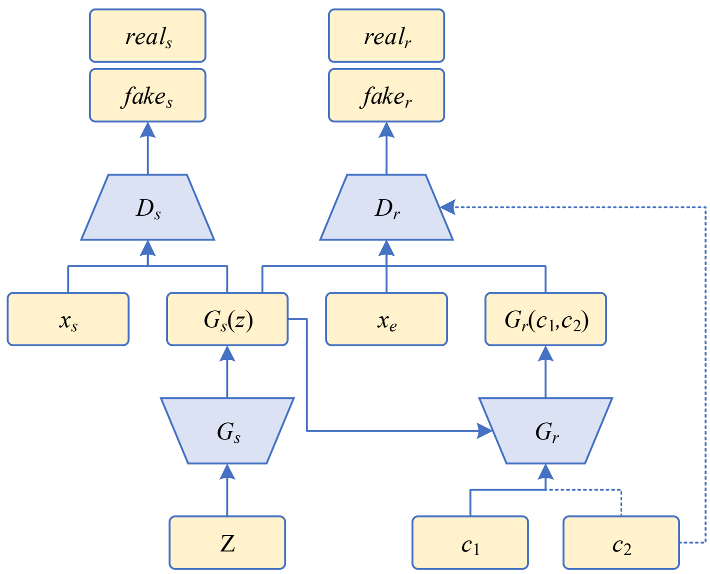

Fig. 4. Basic structure of MCF-GAN model

4.3.2. Sketch Generation Adversarial Networks. Unconditional generative adversarial networks are capable of generating images similar to the true value image by inputting random noise without utilizing any supervisory information. The sketch generation adversarial network H_s in this paper utilizes this feature of unconditional generative networks and employs the unconditional image generation model StyleGAN2 for diverse generation of sketches.

In sketch generation adversarial network H_s, the generator is denoted as $G_s : \square^{z} \to \square^{I_s}$. Where, $P_{data}(z) = N(0,1)$ denotes the standard Gaussian distribution. $I_s \in \square^{1\times H\times W}$ denotes the real sketch data, extracted from the fashion image dataset using nested edge detection (HED). The true-false discriminator is denoted as D_s. The adversarial loss is of the following form:

$$L_{adv_s} = \mathrm{E}_{I_s \sim P_{data}(I_s)}\left[\log D_s\left(I_s\right)\right] + \mathrm{E}_{z \sim P_{data}(z)}\left[\log\left(1 - D_s\left(G_s(z)\right)\right)\right] \tag{2}$$

where $P_{data}\left(\tilde{I}_s\right)$ denotes the size of the sketch image in the generated fake image domain. The path length regularization in StyleGAN2 can be expressed as:

$$L_{reg} = \mathrm{E}_{z_w, G_s(z_w) \sim \mathrm{N}(0,1)}\left(\left\|J_{z_w}^{T} G_s\left(z_w\right)\right\|_2 - a\right)^2 \tag{3}$$

where z_w follows a normal distribution $z_w \sim P_{data(z)}$ and denotes the hidden vector generated through the 8 fully connected layers of G_s. The local scaling of $G_s\left(z_w\right)$ is captured by the Jacobi matrix $J_{z_w} = \partial G_s\left(z_w\right) / \partial z_w$. The objective function of H_s can be defined as:

$$G_s = \arg\min_{G_s}\max_{G_s} L_{adv_s} + L_{reg} \tag{4}$$

It should be noted in particular that sketch generative adversarial networks can also be implemented using other unsupervised generative adversarial networks, such as BigGAN. However, considering the power of StyleGAN2 in image generation, it is more suitable for the sketch generation task in this chapter. Subsequent experiments have demonstrated that using StyleGAN2 as a model for the sketch generation phase enables diverse generation of sketches.

4.3.3. Rendering Generative Adversarial Networks. The proposed Rendering Generative Adversarial Network H_r (Ren-GAN) aims to generate images $\tilde{P}_{s,t}$ in a directed manner using given control conditions, which include textures I_t and sketches generated by G_s. I_s In order to fully utilize the features of the sketches and the textures and to merge their information, a Conditional Feature Interaction (CFI) module is designed in H_r. The goal of this module is to learn a mapping function that facilitates the interaction between sketches and textures, thus helping to generate realistic image rendering the generator representation of the generator network is $G_r : \mathbb{R}^{I_s, I_t} \rightarrow \mathbb{R}^{P_{s,t}}$, and the entire network structure utilizes an encoder-one-decoder architecture. In order to better utilize the information from the sketch and texture, a CFI module is designed in the generator for feature fusion and interaction between the two input conditions. Unlike traditional methods, which allow only one input condition for the control of the generation, the proposed CFI module supports two conditions for directional control of the generation result. Further, the CFI module can be decomposed into two parts, the feature normalization layer (FNL) and the parameter generation layer (PGL). On the one hand, the FNL is used to accurately model the interaction between contour and texture features to eliminate significant differences due to different conditions. On the other hand, the PGL generates scaling and offset parameters by using two convolutional layers. Specifically, sketch I_s and texture I_t are first downsampled through the convolutional layers to obtain the first feature mappings I_s' and I_t', i.e., $I_s' = \varphi_s\left(I_s\right)$, $I_t' = \varphi_t\left(I_t\right)$, where φ_s and φ_t denote the functions of spatial downsampling for I_s and I_t, respectively. In FNL, I_s' is first subtracted from its mean and divided by its variance to obtain the normalized feature $\vec{I}_s$. In PGL, I_t' undergoes a convolution operation to generate two modulation parameters that can be learned, namely, the scale parameter γ_t and the offset parameter β_t. Subsequently, the CFI module consisting of FNL and PGL computes the features of i_s, which can be defined as:

$$I_{s,1}' = \gamma_t \otimes \frac{I_s' - mean\left(I_s'\right)}{std\left(I_s'\right)} \oplus \beta_t \tag{5}$$

where $\oplus$ and $\otimes$ denote the element-level addition and multiplication operations, respectively; and $mean\left(I_s'\right)$ and $std\left(I_s'\right)$ denote the mean and standard deviation of I_s', respectively. In order to further utilize the features of the texture I_t and to facilitate effective communication between the texture and the sketch, the texture features I_t are also fed into the CFI module for computation. The features of I_t' obtained after computation by the CFI module can be expressed as:

$$I_{t,1}' = \gamma_s \otimes \frac{I_t' - mean\left(I_t'\right)}{std\left(I_t'\right)} \oplus \beta_s \tag{6}$$

where I_s undergoes a convolution operation to generate learnable scale parameters γ_s and bias parameters β_s. The proposed feature interaction layer utilizes the computation of mean and variance to better extract the features of the current batch and to reduce the impact of individual sample differences. The parameter generator module, on the other hand, better preserves the semantic information in the input conditions through convolutional operations. In addition, the scaling parameter γ and the bias parameter β are computed in the spatial dimension, which enables the 3D tensor to modulate the input features in the spatial dimension, providing more flexibility in the feature modulation process for single-channel sketches or multi-channel textures. It is worth noting that features $I'_{s,2}$, $I'_{t,2}$, $I'_{s,3}$, $I'_{t,3}$ and $I'_{s,4}$ are also computed in the same way. The CFI module utilizes the semantic information in the feature extraction conditions of the sketches and textures to enable the interaction of texture-specific regions of features with the corresponding pixels of the sketch semantics.

5. Performance evaluation of MCF-GAN models

In order to verify the performance of the model in this paper, Fashion-MNIST and CIFAR datasets will be used for fashion design image generation experiments. Fashion-MNIST is an apparel image dataset containing 10 categories, which contains 70,000 grayscale images of 28×28 pixels and is divided into 60,000 training and 10,000 test set images, and after the normalization the pixel values are distributed in the interval [0,1].CIFAR is an image dataset containing 10 categories of design material containing 60,000 RGB color images of 3×32×32 pixels, of which 50,000 are used for training and 10,000 are used for testing, and the pixel values of the images are distributed in the interval [-1,1] by normalization.

5.1. Analysis of model performance evaluation results

In order to evaluate the ability of clustering of the model, three attribute control evaluation metrics, namely, Clustering Purity (ACC), Normalized Mutual Information (NMI) and Adjusted Rand Index (ARI), are used in this chapter. Two image generation qualities, Inception Score (IS) and Frechet Inception Distance (FID), are used as quality metrics for the generated images.

The experiment compares this paper's model with ClusterGAN, InfoGAN, InfoGAN-CR, GAN with bp, GAN with Disc, and CoDeGAN models, and the results of the performance comparison of different models on the Fashion-MNIST dataset are shown in Table 1.In Fashion-MNIST dataset this paper's The ACC, ARI, MNI, IS and FID of the model are 0.81, 0.67, 0.74, 4.45 and 19.53 respectively. The results that are felt to be optimal compared to other methods have an ACC improvement of 0.13 compared to CoDeGAN and 0.17 compared to InfoGAN-CR.

Table 1. Performance comparison results (Fashion-MNIST)

Model	ACC	ARI	MNI	IS	FID
ClusterGAN	0.64	0.53	0.65	-	-
InfoGAN	0.62	0.45	0.61	-	-
InfoGAN-CR	0.64	0.53	0.67	4.23	30.37
GAN with bp	0.55	0.41	0.54	-	-
GAN with Disc	0.47	0.30	0.40	-	-
CoDeGAN	0.68	0.53	0.67	4.35	17.11
Ours	0.81	0.67	0.74	4.45	15.53

The performance comparison results of different models on the CIFAR dataset are shown in Table 2.On the CIFAR dataset, the performance of this paper's model is further improved with an ACC value of 0.93, and the optimal results are still achieved for each index. Its ACC value is improved by 0.03 compared to CoDeGAN, AIR is improved by 0.11, and FID is reduced by 2.53. It can be seen that the present method significantly outperforms the image generation method in several application scenarios, which verifies the effectiveness of the fashionable design of the image generation model in this paper.

Table 2. Performance comparison results (CIFAR)

Model	ACC	ARI	MNI	IS	FID
ClusterGAN	0.83	0.78	0.87	4.57	48.15
InfoGAN	0.87	0.82	0.91	4.58	64.55
InfoGAN-CR	0.87	0.83	0.91	4.42	69.85
GAN with bp	0.80	0.85	0.93	4.96	48.35
GAN with Disc	0.79	0.81	0.90	4.85	68.15
CoDeGAN	0.90	0.83	0.89	4.75	48.68
Ours	0.93	0.94	0.96	4.97	46.15

5.2. Ablation Pilot Study

In order to explore the effectiveness of the method, this section investigates the effect of model sketch generation network (Hs) with rendering generation (Hr) on the performance of image generation and the results of ablation test are shown in Table 3. It is observed that the performance of the model is significantly improved by adding the sketch generation network (Hs) and rendering generation (Hr), which indicates that the sketch generation network and rendering generation based on this paper can effectively improve the quality of fashion design image generation.

Table 3. Ablation test results

Model module			ACC	ARI	MNI	IS	FID
GAN	Hs	Hr					
√	√	×	0.753	0.642	0.735	4.45	48.843
√	×	√	0.768	0.653	0.733	4.46	48.581
√	√	√	0.931	0.935	0.945	4.952	46.752

6. Evaluation of fashion design effects based on MCF-GAN assistance

In this study, a standardized assessment tool and professionals' opinions were used to review the innovativeness, practicality and aesthetics of fashion design solutions. The assessment dimensions include popular elements, overall shape, detail description, structural proportion, color expression, craft expression, material facing, and use of common, which are noted as S1~S8. This experiment involves four young designers between the ages of 18 and 30 years old, and the experiment is based on an established design, which is scored upon completion. The questionnaire was designed to focus on the participants' evaluation of the results of each phase, aiming to carefully sort out the actual workflow of AI-assisted fashion design.

By collecting and analyzing the designers' satisfaction evaluation of the generating effect of the AI tool in this paper, this study adopts a five-level scale for the data statistics of eight assessment dimensions, aiming to study the effect of the AI tool in this paper in the actual fashion design model, and the rating results of the AI-assisted sketching design are shown in Table 4. The experimental results reveal that this paper's fashion design-oriented intelligent generation tool excels in S5 color performance, S3 detail description and S8 usage scenarios, with total scores higher than 15. It also scored above 10 points in all other dimensions, which is higher than the average value, indicating that the method of this study is meeting the needs of fashion design, and the results of the usage effect evaluation are good, which provides a feasible path for the optimization of fashion design workflow.

Table 4. The results of the ai support sketch design

Evaluation dimension	Evaluation grade	Overall score(20)

	1	2	3	4	5	
S1	0	1	2	1	0	12
S2	0	0	2	2	0	14
S3	0	0	1	2	1	16
S4	0	0	2	2	0	14
S5	0	0	0	3	1	17
S6	0	1	1	2	0	13
S7	0	0	2	1	1	15
S8	0	0	1	2	1	16

7. Conclusion

Artificial intelligence tools provide new possibilities for fashion design, and this paper researches fashion design based on artificial intelligence, and the main research results are as follows:
1) Based on generative adversarial network, this paper proposes a generative adversarial network structure based on multiconditional information fusion, which improves the performance of image generation through sketch generation and rendering generation. In the performance test, the model in this paper achieves optimal results on both Fashion-MNIST dataset and CIFAR dataset. Compared to the CoDeGAN model its ACC value is improved by 0.17 and 0.93 respectively. This for, the ablation experiments reveal that sketch generation and rendering generation have a significant effect on the model performance enhancement. The comprehensive experimental results prove the performance effect of the model in this paper.
2) In the actual fashion design application, it is found through the evaluation results of designers that this paper's method is outstanding in color performance, detail description and use scene, with the total score higher than 15 points. And the total score in other dimensions is in the range of 12~15, which further indicates that the method in this paper realizes artificial intelligence-assisted fashion design, can meet the actual needs of fashion design, and the evaluation results of the use effect are excellent.

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