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Computer-Aided Design AND APPLICATIONS

# Interactive Clothing Design System Based on Fractal Patterns

Mingyan Zhang[1], Shubin Li[2] and Haixiang Zhu[3]

[1]Suzhou Vocational University, Suzhou, Jiangsu 215104, China, zmy@jssvc.edu.cn
[2]Suzhou Vocational University, Suzhou, Jiangsu 215104, China, lishubin@jssvc.edu.cn
[3]Suzhou Vocational University, Suzhou, Jiangsu 215104, China, zhuhaixiang@jssvc.edu.cn

Corresponding author: Mingyan Zhang, zmy@jssvc.edu.cn

**Abstract.** As one of the three elements of clothing design, style is an important factor affecting the overall aesthetics of clothing. With the increase of people's personalized demand, clothing style customization, as a new service mode, has attracted people's attention. Interactive fashion design teaching system usually has a certain scale database, including styles, fabrics, colors and other components, so it is difficult for non-professionals to achieve independent collocation. In this article, the realization of clothing graphic feature recognition algorithm in computer-aided clothing design (CAGD) system is explored, and the interactive clothing pattern design method is innovated. The deep learning algorithm is applied to the automatic generation of clothing style drawings, which provides a certain technical reference for the construction of interactive clothing design and computer-aided learning (CAI) system. The test results show that the recall of Deep Convolution Generation Countermeasure Network (DCGAN) has been greatly improved compared with the conventional GAN model, and the error has also been greatly reduced. The improved method improves the convergence of network parameters, thus improving the classification accuracy of the model. When the quantity of pixels of feature information is larger, the processing time will be longer. The artistic features of fractal patterns are transferred to fashion design, and finally the combination of fractal pattern art and fashion design will open up new materials for fashion design and open up new ways for fashion design teaching.

**Keywords:** Fractal Pattern; Computer-Aided Design; Interactive Fashion Design; Deep Learning; Teaching System
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## 1 INTRODUCTION

Due to the rapid growth of computer technology, people rely more and more on computers and the Internet for food, clothing, housing and transportation, and the clothing industry has also entered the digital information age. The garment industry, which has always been called labor-intensive, is facing great changes. The digital replica of men's tight underwear is an emerging field in textile research. Cheng et al. [1] used 3D scanning equipment to obtain detailed surface shapes and

structures of male bodies, and converted the data into a 3D digital model. These models can accurately display the contours and lines of the body, providing an accurate basis for the design of tight underwear. By wearing a 3D digital model on consumers, the wearing effect of tight underwear can be simulated. This virtual fitting technology can help designers better understand consumer needs and market trends, thereby optimizing product design. Research materials and structures suitable for making men's tight underwear, including fabrics, elastic fabrics, and fitting techniques. At the same time, factors such as breathability, comfort, and durability of the fabric need to be considered. The digital reproduction of men's tight underwear is an emerging field in textile research, involving multiple aspects of technology and research. Through research in this field, it is possible to better understand consumer demand and market trends, improve product quality and performance, and reduce production costs, providing new impetus for the development of the textile industry. People in the industry can use digital technology to make the design, production and sales of clothing more efficient. The garment design system based on interactive multimedia technology needs to design and develop mathematical models and optimize the design process. The core of system design is the design of digital logic, which can give designers more complex design ideas. As an information technology, multimedia technology has the key characteristics of integration, interactivity, nonlinearity, real-time, diversity, convenience and dynamics. The research on virtual display of weft knitted seamless knee pads based on free deformation models can help designers and consumers better understand and experience the appearance and performance of knee pads. Cong et al. [2] analyzed the virtual display of weft knitted seamless knee pads based on a free deformation model. It uses a 3D scanner to obtain the surface shape and structure of the knee pads, and imports the data into a virtual display platform. On the virtual display platform, use a free deformation model to virtually shape and adjust the knee pads to meet the needs of designers and consumers. The free deformation model can provide flexible editing tools, allowing designers to freely adjust the shape, size, curvature, and other parameters of the knee pads. By wearing a virtual knee protector model on consumers, they can feel the wearing effect and comfort of the knee protector. This can better understand consumer needs and market trends, thereby optimizing product design. On the virtual display platform, simulation tools can be used to simulate and showcase the performance of knee pads. For example, it is possible to simulate the deformation and stress situation of knee pads under different motion states, so that designers can better understand the performance and characteristics of knee pads. Display virtual knee pads on the internet or mobile devices for consumers to browse and interact online. Virtual display can provide more diverse and vivid display methods, while also improving product sales and brand awareness. This technology, in which users can interact with computers in real time through various senses, has greatly changed people's traditional methods of obtaining information, and plays a very important role in improving the effect of human-computer interaction, improving the efficiency of information exchange and promoting cooperation. Gan et al. [3] analyzed the complex themes of computer-aided design and computer graphics. It involves precise analysis of human body analytical models, edge contours, and pose features. Firstly, edge contour refers to the shape of an object's contour line, which is commonly used in image processing and computer vision to recognize and classify objects. In human body analysis, edge contours can be used to identify and distinguish various parts of the body, such as the head, shoulders, arms, legs, etc. Posture features refer to the position and direction of the human body in space. These features can be used to recognize and classify human actions and postures. For example, standing, sitting, walking, etc. The goal is to create a model that accurately recognizes and classifies various parts of the human body, as well as their movements and postures, by using these features. This model needs to handle complex calculations and analysis, such as image processing, machine learning, 3D reconstruction, etc. In the fields of computer-aided design and computer graphics, this model can be used to create more realistic and vivid character models, such as in games, movies, or virtual reality. At the same time, it can also be used for analyzing and researching human movements and postures in fields such as health science and sports science.

Indrie et al. [4] conducted computer-aided design and virtual clothing simulation of knitted and woven fabrics. Knitted and woven fabrics are two common textile manufacturing methods, each with its unique characteristics and uses. The application of computer-aided design and virtual clothing simulation technology in the textile field makes it easier for designers and consumers to design and preview clothing effects. Knitted fabric is a type of textile manufactured using a knitting machine, characterized by the intertwining of fabric coils, which has good elasticity and elongation. The design of knitted fabrics can be carried out through computer-aided design software, such as using specialized knitting CAD software, which can design knitted fabrics of various shapes and textures, and simulate the appearance and texture of the fabric. The design of woven fabrics can also be carried out through computer-aided design software. Under the effect of digital technology, the competition in the clothing market is becoming more and more fierce, which puts forward higher requirements for the clothing design education and talent training direction in universities in China. Combined with the characteristics of clothing specialty, the teaching method is innovated by using CAD method, and the teaching content and form of combining styles and styles in clothing teaching are reconstructed through reasonable interactive design. On the same day when the integrated teaching of styles and styles is realized, not only can the learning-centered learning style be effectively promoted, but also all links and elements in the teaching process can be better handled and coordinated, and the optimization of teaching course can be realized. Fractal pattern art is a new art form of digital design with the progress of computer technology, and its digital process is closely related to mathematics. Complex graphics are generated by combining the simple calculation method of fractal geometry with computer graphics. This article explores the realization of clothing graphic feature recognition algorithm in CAGD system, innovates the interactive clothing pattern design method, and studies the construction strategy of interactive clothing design teaching system based on fractal pattern and CAD.

Seamless weft knitted fabric is a special type of knitted fabric, characterized by the absence of coil connections in the warp direction, and the formation of the desired shape and structure through a series of bends and twists in the weft direction. The advantage of this type of knitted fabric is that it can achieve 360-degree seam free, has better elasticity and breathability, and is suitable for manufacturing various clothing and textiles. Ji et al. [5] analyzed the structural characteristics of seamless weft knitted fabrics. This includes the direction of the yarn, the structure and variation pattern of the coil, and the elasticity and breathability of the fabric. By studying the structure, we can better understand the performance and characteristics of fabrics, thus providing a foundation for subsequent simulation research. It establishes a simulation model for seamless weft knitted fabrics, predicting the performance and performance of the fabric by simulating its structure and motion. For example, mathematical models can be established to simulate the bending and twisting of yarns, calculate the density and elasticity of coils, and predict the elasticity and breathability of fabrics. Verify the accuracy and reliability of the simulation model through experiments, compare the differences between simulation results and actual results, and revise and improve the simulation model. For example, the structure and performance of fabrics can be tested by making samples, and the test results can be compared and analyzed with simulation results. Clothing pattern design is mainly for the decoration design of clothing, accessories related to clothing and its affiliated objects. Its main feature is that as an accessory, it plays the role of decoration and expression of an aesthetic relationship. Computers can not only store a large amount of information, but also have a faster calculation and processing speed, which makes the efficiency of clothing design and production continuously improve. Because fractal theory is related to recursion, iteration and other algorithms, the generated fractal pattern is a fine-structured self-similar pattern with infinite subdivision, showing a colorful and extremely high-resolution art form. In a specific sense, there is a difference between clothing patterns and clothing design. The former focuses on the decoration and beautification of clothing and requires subordination to established clothing. Although the latter is inseparable from aesthetics, it faces people and focuses on the overall planning of clothing around the center of "human body". This article introduces the theoretical basis of fractal pattern and analyzes the characteristics of fractal pattern, and analyzes the application mode of fractal pattern in fashion design teaching system.

Compared with the research of traditional fashion design teaching system, this article has made the following innovations:

The prediction and classification of fabric drape for 3D clothing virtualization is an important research field in clothing science and technology. The drape of a fabric refers to its bending and shape when stationary or in motion, which is influenced by various factors such as the texture, structure, weight, and elasticity of the fabric. Predicting and classifying the drape of fabrics is of great significance for the design and simulation of 3D virtual clothing. Kim et al. [6] measured the drape of fabrics through practical experiments, such as using specialized experimental equipment to measure the curvature, tensile properties, and other indicators of the fabric. This method can obtain accurate data, but it requires a long time and manpower. It has established a physics based mathematical model to simulate the drape process of fabrics and predict their morphology. For example, a spring particle model can be used to simulate the bending and stretching of fabrics, thereby predicting the drape of the fabric. By training a large number of 3D clothing models and corresponding fabric data, machine learning algorithms are used to establish a prediction and classification model for fabric drape. For example, deep learning algorithms can be used to predict the drape shape of fabrics by using image or texture features of the fabric as input. In summary, fabric drape prediction and classification for 3D clothing virtualization is an important research field in clothing science and technology. In this article, the design method of fractal pattern in fashion design teaching system is explored by combining the operation of fractal pattern generation, and the pattern is formed by changing the design method through software generation or morphological law, from which the pattern composition law of extracting and transforming fractal pattern art is analyzed and summarized.

(2) In this article, an interactive garment style drawing generation system based on fractal pattern CAD is realized with DCGAN algorithm as the core, and the deep learning algorithm is applied to the automatic generation of garment style drawings, which provides a certain technical reference for interactive garment design and the construction of CAI system.

This article introduces the application of fractal pattern in CAGD, and puts forward the feature extraction and feature fusion algorithm of clothing graphics based on DCGAN. The feasibility of the algorithm in interactive fashion design teaching system is verified by testing on real database. Finally, the contribution and achievements of the research are summarized.

## 2 RELATED WORK

Based on the analysis of English listening barriers in computer-aided teaching, Li and Ji [7] explored the possible English listening barriers that students may face in a computer-assisted teaching environment, including technical issues, language skill issues, and learning strategy issues. In computer-aided teaching, various software such as players and recording software are often used. There may be issues such as software incompatibility, low version, and inability to play, resulting in the inability to practice listening. Network fluctuations or disconnection may result in inability to load listening resources or forced interruptions during online listening tests. Hardware devices such as headphones or speakers may malfunction, or device drivers may not be installed properly, affecting the effectiveness of listening practice. Teachers can introduce students to their English cultural background and teach effective listening strategies to help them improve their listening skills. Teachers can provide suitable listening materials based on students' English proficiency, ensuring that students can engage in effective listening training within their own abilities. Through the above methods, teachers can help students overcome English listening barriers that may be encountered in computer-aided teaching environments, improve listening skills and overall English proficiency. The research on fabric modeling and simulation in virtual fitting is a very complex and multi-dimensional field, involving multiple disciplines such as textile engineering, physics, computer graphics, and artificial intelligence. The goal of Li et al. [8] is to create a model that can simulate the visual and physical effects of real clothing worn by the human body, so that consumers can obtain a more realistic and accurate preview experience when

purchasing clothing. Fabric modeling is an important part of virtual fitting systems, which mainly focuses on how to describe and simulate the dynamic behavior and appearance of fabrics through mathematical models. Divide the fabric into a series of small units, conduct independent physical analysis on each unit, and then simulate the overall behavior of the fabric through the interaction between the units. This method can handle complex shapes and dynamic behaviors, but its computational complexity is relatively high. The research on fabric modeling and simulation in virtual fitting is a challenging and promising field that combines knowledge from multiple disciplines such as textile engineering, physics, computer graphics, and artificial intelligence. Intended to provide consumers with a more authentic and convenient shopping experience, while also providing enterprises with more accurate market analysis and product design tools. The computer-aided design (CAD) of weft knitted double-sided jacquard fabrics can help designers create and modify fabric patterns on computers, thereby improving design efficiency and accuracy. In CAD software, designers can use various tools and libraries to create and modify fabric patterns. For example, you can use a color library to select different colors and textures, and use different yarn types and specifications to create different fabrics and effects. Through simulation tools, designers can preview the appearance and performance of fabrics on a computer. For example, it is possible to simulate the color and texture of fabrics under different light and angles, as well as the deformation and elasticity of fabrics under different stretching and bending conditions. Through optimization tools, designers can optimize fabric design and improve fabric performance. For example, the density and elasticity of yarn can be adjusted to optimize the structure and pattern of the fabric, thereby improving the quality and yield of the fabric. Through CAM software, Liang et al. [9] transformed the design into actual fabric samples. For example, design data can be input into a loom to produce double-sided jacquard fabric samples. In summary, computer-aided design of weft knitted double-sided jacquard fabrics can help designers better understand and create fabrics, thereby improving design efficiency and accuracy, and also providing more possibilities for producing high-quality fabrics. With the continuous development of technology, computer-aided design has been widely applied in various fields. In contemporary art teaching, the use of CAD tools not only improves the efficiency of design, but also provides more innovative opportunities for artists and designers. This article will explore how to construct a contemporary art computer-aided design teaching model centered on innovation, aiming to improve students' innovation ability, practical ability, and comprehensive quality. Liu and Yang [10] explored the teaching mode of contemporary art computer-aided design with innovation as the core. Achieve more realistic artistic effects through 3D modeling and rendering techniques. CAD software provides rich drawing tools and parameter adjustment functions, which can help students break traditional painting methods and thinking patterns, and explore innovative ideas. By analyzing classic art works and designer cases, guide students to understand and master innovative thinking and methods. Provide an open practical environment where students can freely try out various innovative design solutions, and encourage interdisciplinary communication and cooperation. Provide timely feedback and guidance to students, help them adjust design plans, improve innovation ability and practical skills. Warp knitted tubular bandages are a special type of textile, similar in shape to circular tubes, commonly used in medical, protective, and industrial applications. To simulate the geometry of this textile, a mesh model can be used to establish its geometric structure. The shape of a warp knitted tubular bandage can be approximated as a cylinder, so the geometric shape of the cylinder can be used to establish its model. You can use 3D modeling software such as SolidWorks, AutoCAD, etc. to establish a geometric model of a cylinder. Liu et al. [11] divided the surface of the cylinder into a series of small grids to more accurately simulate the shape and structure of warp knitted tubular bandages. Finite element analysis software (such as ANSYS, ABAQUS, etc.) can be used to divide the mesh. Define material properties for the grid model, including elastic modulus, Poisson's ratio, density, etc. These properties can be set based on the actual material of the warp knitted tubular bandage. Simulate the mesh model using finite element analysis software to predict the mechanical properties and deformation behavior of warp knitted tubular bandages. For example, mechanical tests such as tension, compression, and bending can be conducted to evaluate the strength and stability of warp

knitted tubular bandages. 3D warp knitted tubular fabric is a special textile structure with a hollow tubular structure, commonly used for manufacturing various pipes and protective equipment. The grid modeling and simulation of it can help to better understand its structural characteristics and provide guidance for design and production. Liu et al. [12] analyzed the mesh modeling and simulation of three-dimensional warp knitted tubular fabrics. Firstly, it is necessary to obtain structural data of three-dimensional warp knitted tubular fabrics, including the geometric shape of the fabric, yarn direction, fabric density, etc. This information can be obtained through 3D scanning equipment or analyzed through photography and image processing techniques. After obtaining fabric structure data, an appropriate mesh generation algorithm can be used to establish a mesh model of the fabric. This model can represent the geometric shape and internal structure of fabrics, including the direction and density of yarns. By simulating and analyzing the fabric mesh model, various properties of the fabric can be understood, such as breathability, warmth retention, durability, etc. These properties are related to the structure and materials of the fabric, and simulation can predict the performance differences of different design schemes, thereby optimizing product design. Meng et al. [13] conducted automatic identification of structural parameters of woven fabrics. The automatic recognition of structural parameters of woven fabrics is an important research field, with the aim of utilizing artificial intelligence and computer vision technology to automatically recognize and understand the structural parameters of fabrics. This includes the texture, density, color, material and other characteristics of the fabric, as well as defects and anomalies in the fabric. This automatic recognition technology is of great significance for textile manufacturing, quality control, classification, and recognition. The automatic recognition of structural parameters of woven fabrics mainly focuses on how to use computer vision and artificial intelligence technology to automatically recognize and understand the structural parameters of fabrics. This includes identifying the texture, density, color, material and other features of the fabric, as well as detecting defects and anomalies in the fabric. The automatic recognition of structural parameters of woven fabrics mainly adopts machine learning and computer vision technology. This includes methods such as image processing, deep learning, and convolutional neural networks. Blended learning is a method that combines online learning with traditional face-to-face teaching. Through blended learning, students can access information online, engage in self-learning, and interact with teachers and other students in the classroom to solve questions and deepen understanding. Reusable learning objects refer to digital or non-digital learning resources that can be used multiple times and reused across courses. These resources can include videos, audio, interactive tutorials, online discussions, etc. to meet the needs of different learners. In computer-aided design teaching, reusable learning objects can include tutorials for various CAD software, explanations of design principles, and analysis of design cases. By providing these learning objects to students in a blended learning manner, it can help them better master CAD skills and also improve teaching efficiency. Onofrei and Ferry [14] discussed how to create these reusable learning objects, how to integrate them into a blended learning environment, and how to evaluate the effectiveness of this teaching method. In addition, the paper may also discuss how to address potential issues that may arise in this teaching method, such as student engagement, technical issues, and the effectiveness of teaching methods. Pelliccia et al. [15] analyzed the applicability of 3D factory simulation software in computer-aided participatory design of industrial workplaces and processes. The applicability of 3D factory simulation software in industrial workplaces and process computer-aided participatory design involves topics related to computer simulation and industrial design. This software can play an important role in designing and optimizing industrial processes, especially in situations involving complex environments and multiple factors. 3D factory simulation software can provide a realistic environment for designers or engineers to simulate and test their designs in a virtual environment. This environment includes various elements, from equipment to personnel, to materials. Through simulation, people can predict and evaluate their performance in the real world, as well as potential problems that may arise. In terms of participatory design, 3D factory simulation software provides a platform for all participants to understand and experience the design. This not only helps to improve the accuracy and efficiency of design, but also promotes collaboration and

communication between teams. Through simulation, engineers can predict and optimize the performance of the design before actual construction. This includes evaluating the effectiveness of different design options and identifying the best design solution. Simulation software can be used to train new engineers and operators. By training in a virtual environment, people can quickly master skills and be prepared to operate in real environments. Špelic [16] analyzed the current application status of 3D scanning and CAD/CAM in textile research. The application of 3D scanning and CAD/CAM (computer-aided design and manufacturing) in textile research is constantly developing and popularizing. These technologies provide textile designers and manufacturers with more creativity and precision, while also improving production efficiency and quality. 3D scanning is a technology that can quickly and accurately obtain the shape and structure of an object's surface. In textile research, 3D scanning can be used to obtain the surface morphology and fiber morphology of fabrics, thereby helping designers better understand the structure and characteristics of fabrics. For example, 3D scanning can obtain parameters such as thickness, density, and porosity of fabrics, which have a significant impact on their performance and appearance. CAD/CAM technology is the process of designing and manufacturing objects on a computer. Yuan and Niu [17] explored how to optimize the computer-aided industrial design system for passenger aircraft cabins. By analyzing the existing design system and proposing improvement plans, we aim to improve the efficiency and accuracy of the design. Specifically, we studied various factors in the design process, including human-computer interaction, computational efficiency, and design aesthetics, and proposed optimization strategies for these factors. Finally, the effectiveness of the optimization strategy was verified through experiments, proving that the improved computer-aided industrial design system can better meet design requirements. Circular knitted transfer jacquard fabric is a complex textile fabric that needs to be designed through visual simulation modeling. Before starting production, the designer needs to design a pattern for transferring the jacquard pattern. This can be achieved by using CAD software. Designers can choose different colors, shapes, and sizes to create unique patterns. Before starting weaving, it is necessary to set and adjust the loom. This includes selecting suitable knitting needles, setting the density and number of needles of the loom, and so on. Zheng and Jiang [18] input the designed pattern into the loom and start weaving. In this process, the loom will weave according to the pre designed pattern to form a transfer jacquard fabric. During the weaving process, specific software can be used to visually simulate and model the fabric. This can help designers better understand the structure and appearance of fabrics, as well as predict their performance and effect. Based on the results of visual simulation modeling, further analysis and optimization of the fabric can be carried out. This can help improve the quality and performance of fabrics, while also reducing waste and costs in the production process.

## 3 METHODOLOGY

### 3.1 Application of Fractal Pattern in CAGD

Under the effect of digital technology, the competition in the clothing market is becoming more and more fierce, which puts forward higher requirements for the clothing design education and talent training direction in universities in China. Traditional pattern design is composed by designers, and then the pattern is expressed through drawings or other media. Fractal patterns meet the requirements of consumers for novelty, beauty and change in clothing design. Fractal theory is a new concept. Although it has not yet formed a complete logical system, it has not affected its rapid and extensive application in various disciplines. Due to the rapid growth of computer and digital technology since the new century, fractal pattern design based on fractal theory has the characteristics of convenient generation, various types and complex structure, which promotes its application in clothing printing pattern designs. In the symmetrical structure design of the pattern, the traditional pattern design only has simple axial symmetry and central symmetry, while the fractal pattern is more complex symmetry between the part and the whole, which makes the whole pattern more exquisite and delicate in structure. On the color level of

pattern, fractal pattern can effectively break through the color registration limitation of traditional pattern design based on its special generation method, and create a powerful visual impact with richer color layering.

Applying fractal theory to CAGD can provide a brand-new idea and design concept for designers, and can also stimulate and release designers' creative inspiration, create more clothing patterns and improve the level of clothing design. The former focuses on the decoration and beautification of clothing and requires subordination to established clothing. Although the latter is inseparable from aesthetics, it faces people and focuses on the overall planning of clothing around the center of "human body". This article introduces the theoretical basis of fractal pattern and analyzes the characteristics of fractal pattern, and analyzes the application mode of fractal pattern in fashion design teaching system. In the design of clothing printing pattern, the most basic organizational form is individual pattern, that is, the pattern itself exists independently, and there is no connection or continuous relationship with other forms around it. Because there is no restriction on the appearance of individual patterns, they can be used as decorative patterns alone or combined with other patterns to form more complex patterns. Using CAD can save the time of revision, improve the speed of design and development, so as to make the newly designed clothing put into the market faster and enhance the market competitiveness of clothing design enterprises.

### 3.2 Feature Extraction of Clothing Graphics Based on DCGAN

Clothing 3D parametric design system template style selection front clothing design side clothing design style generation processing template style selection color addition pattern addition generation picture parameterization generation transfer picture parameter transfer processing generation clothing database style selection online template addition independent design style extension interface template style selection color addition pattern addition undo redo generation picture. An important feature of fractal pattern is that it can be infinitely fine, and clothing fabric, as the carrier of pattern printing and dyeing, cannot present the whole picture of fractal pattern as perfectly and finely as paper, so the choice of fractal pattern details can highlight the key points and have more formal aesthetic feeling. Designers can also use CAD to design clothing patterns. In the actual processing and production of clothing, designers can use CAD to select suitable panels, let models try them on first, and check the actual wearing effect. If there are inappropriate places, designers can adjust and modify them on the computer to achieve ideal results.

GAN is a deep learning model that relies on the game between generator and discriminator to output high-quality results. In this article, an interactive design system of clothing style drawing based on DCGAN algorithm is constructed, which includes three modules: data acquisition, DCGAN image generation and iterative training, as shown in Figure 1.

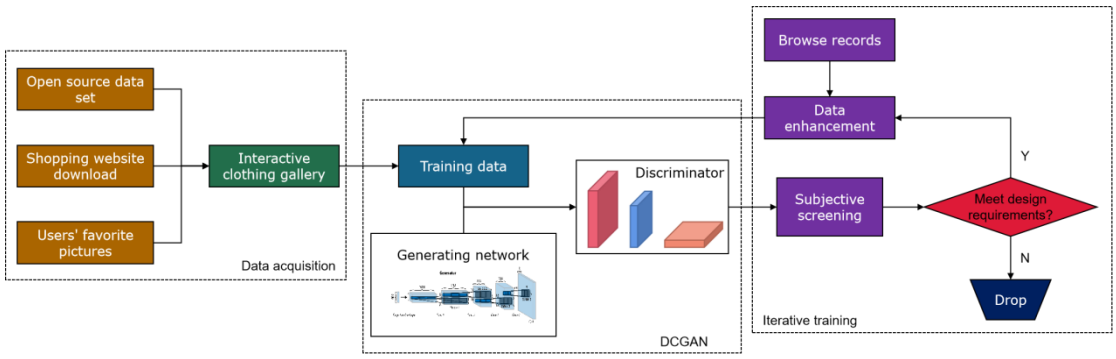


**Figure 1**: Interactive design framework for clothing style diagrams.

The data acquisition module relies on image collection and data enhancement to build an interactive clothing database, which is used to store the training pictures of DCGAN model. DCGAN image generation module is the core part of the system, which aims to generate a large quantity of interactive clothing style drawings with better parameters; Iterative training module is an interactive module based on the user's choice, which adds the clothing style map that the user likes to the training data, so that the clothing style map that meets the individual needs of the user can be obtained after several rounds of iterative training. DCGAN function is defined as:

$$x_j^l = f\left(\sum_{i \in M_j} x_i^{l-1} \times k_{ij}^l + b_j^l\right) \tag{1}$$

Where $x_i$ represents the input characteristic map, $k$ represents the convolution kernel, $b$ represents the deviation term, and the convolution output is the characteristic map $x_j$. If the output feature map is represented in a layer, then:

$$F_j^{(n)} = \sum_i w_{ij}^{(n)} * F_i^{(n-1)} + b_j^{(n)} \tag{2}$$

Where: * is a 2D convolution; $w_{ij}^{(n)}$ and $b_j^{(n)}$ are convolution filters and deviations, respectively; $F_j^{(n)}$ is the $j$ output characteristic map at the $n$ layer. The formula of active layer after convolution is as follows:

$$F_j^{(n+1)} = f\left(F_j^n\right) \tag{3}$$

Where: $f$ is a point-by-point activation function. Convert each data item $x_i$ in the small batch $B = \{x_1, x_2, x_3, \ldots, x_m\}$ with size $m$ to $y_i$:

$$y_i = \gamma \hat{x}_i + \beta \tag{4}$$

$$\hat{x}_i = \frac{x_i - E_M(x_i)}{\sqrt{Var_M(x_i) + \varepsilon}} \tag{5}$$

Where: $E_M(x_i)$ and $Var_M(x_i)$ are the mean and variance, respectively.

After the online design and production of clothing is completed, it is necessary to save the finished product and transmit the production parameters and other information to the production department for processing and production operations. Designers can use CAD to find the mannequin they need from the computer's human body dynamic library, so as to carry out the design work quickly. In the program, brushes can be designed according to the design needs, and the customized brushes can show unique artistic effects and certain personality styles. The network structure of this algorithm is shown in Figure 2.

Clothing geometric modeling method is intuitive and fast, and it can directly model clothing modeling without setting the sewing information of clothing, but its main defect is that the clothing generated by this method has no real drooping feeling of substantive materials. Therefore, people usually adopt the method of physical simulation, and the virtual sewing process can present the reality of clothing fitting in the mannequin. The risk function of interactive clothing feature recognition model is:

$$\theta^* = \arg\min_{\theta} \frac{1}{N} \sum_{i=1}^{N} L\left(y_i, f\left(x_i; \theta\right)\right) + \lambda \Phi(\theta) \tag{6}$$

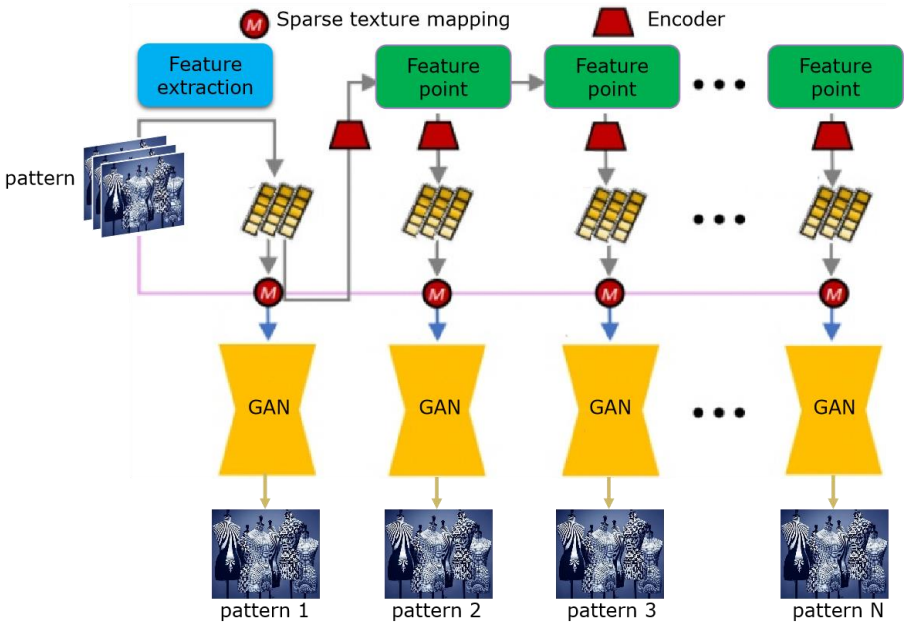


**Figure 2**: Network structure of the algorithm in this article.

Among them, the $L$ function represents the loss function; $x_i$ and $y_i$ represent the predicted value and the true value respectively; the $f$ function is the function of the model, and the $\Phi$ is the regularization term. The calculation formula of the logarithmic loss function is as follows:

$$L\left(Y,P\left(Y|X\right)\right)=-\log P\left(Y|X\right)=-\frac{1}{N}\sum_{i=1}^{N}\sum_{j=1}^{M}y_{ij}\log\left(p_{ij}\right) \tag{7}$$

Among them, $Y$ is the output variable of the function, $X$ is the input variable of the function, $N$ is the total quantity of input samples, $L$ is the loss function, and $M$ is the quantity of possible categories. Obtaining the optimized area of clothing texture image by the method of gray difference:

$$I_{Truth}=\begin{cases}1 & if\ I_D\geq s\\ 0 & otherwise\end{cases} \tag{8}$$

Among them, $I_D$ is the absolute difference of the gray value of each pixel of the optimized image and the original image.

### 3.3 Clothing Graphic Feature Fusion

Any type of pattern, as long as it is used on the attached object, must consider the feasibility of the application of the pattern in materials and technological means. For example, early clothes were woven with different colors in the warp and weft directions to form colorful fabrics with plane patterns, which were cut and processed into clothes, thus realizing the application of patterns in clothing. There are many kinds of patterns, such as embroidery, printing and dyeing, which can be selected flexibly according to the decorative effect. Fractal pattern is complex and irregular, it is an infinite level of a figure nested in a figure, and it is the self-similarity of local components similar to

the overall modeling form. This "self-similarity" is a stochastic and statistical process, which actually presents dynamics, infinity and interaction. Self-similarity is the similarity between the whole and parts, parts and parts, and so on. It is a stage of constant reproduction and expansion with certain randomness. The dynamic fusion method of clothing image features based on DCGAN is shown in Figure 3.

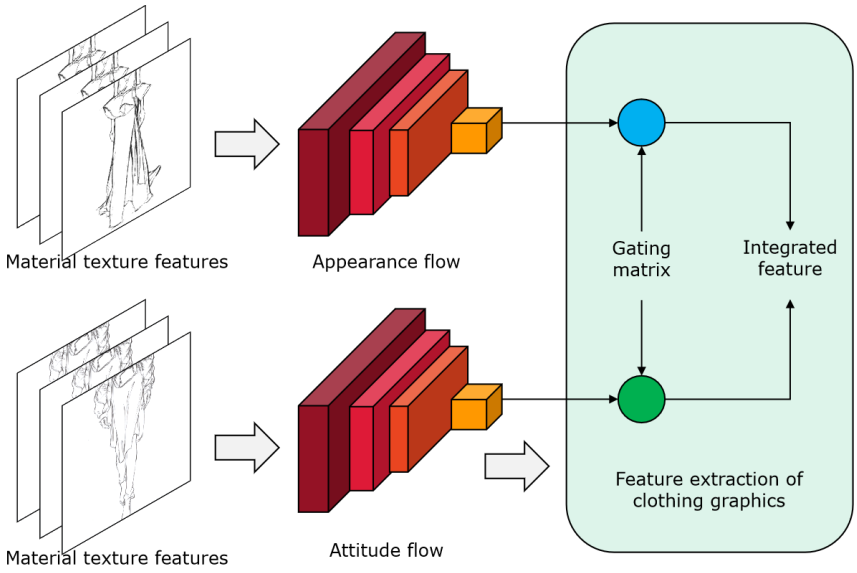


**Figure 3**: Dynamic fusion of clothing image features.

Generally, it has been designed by composition, color and modeling, and belongs to a complete pattern, which can be directly decorated on clothing as a pattern to fully express the characteristics of fractal patterns. In the stage of clothing revision, only the basic code needs to be modified on the version that has been pushed, and the related version will also change automatically.

Input the output of DCGAN into the final classification layer, and calculate the conditional probability distribution of any word generated at the current $t$ moment by using softmax function:

$$p\left(y_t \middle| y_{1:t-1}\right) = soft\max\left(W_p h_t^2 + b_p\right) \tag{9}$$

$W$ is the model parameter to be learned, $b_p$ is the bias term, and $y_t$ is the word generated at time $t$.

Image gating scalar $\beta_t$ and semantic gating scalar $\gamma_t$ are multiplied by image context vector $context_{img}$ and semantic context vector $context_{sem}$ according to elements, respectively, to obtain the final image context vector $context_{img}^{'}$ and semantic context vector $context_{sem}^{'}$.

After adding gating scalar, the image context vector and semantic context vector are respectively:

$$context_{img}^{'} = \beta_t context_{img} \tag{10}$$

$$context_{sem}^{'} = \gamma_t context_{sem} \tag{11}$$

The overall loss function is defined as:

$$L(W)=\sum_{i=1}^{|I|}\left(\sum_{k=1}^{K}\left(X_i^{(k)};W\right)+\left(X_i^{fuse};W\right)\right) \tag{12}$$

Where $X_i^{(k)}$ is the activation value of convolution stage $k$, $X_i^{fuse}$ is the activation value of fusion layer, $|I|$ represents the quantity of pixels of image $I$, and $K$ represents the quantity of convolution stages.

## 4 RESULT ANALYSIS AND DISCUSSION

Using CAD technology, the sensory information and experience are quantified and systematized as accurately as possible, so as to obtain clear characteristics and laws and improve the accuracy and efficiency of clothing graphic feature extraction. After each round of iterative training, on the basis of fully considering the interactive clothing style, some distorted, incomplete, twisted and fuzzy style drawings were eliminated, and finally 300 style drawings were obtained. In order to facilitate the screening of experimental objects, 300 style drawings were divided into 10 groups, 30 were randomly selected as a group, and displayed on the same page. In order to meet the needs of users' clothing styles, training data needs to be updated according to users' preferences.

The training environment of DCGAN model in this article is win11+cuda9.2+TensorFlow. Through subjective evaluation, the interactive clothing style drawings that users are interested in are screened out, and the personal browsing records of users on clothing websites are collected. The pictures are passed through the data enhancement module as new training data to replace part of the original data and continue to use the above-mentioned DCGAN model, and a personal training model is constructed by updating the training data set. After several rounds of alternating training of generator and discriminator, the learning rate is set to 0.0002, the training period is set to 500epoch, and the ratio of training times of generator and discriminator is set to 2 : 1, that is, the generated network is trained twice every time the discriminant network is trained.

The performance of clothing graphic feature extraction of DCGAN is tested, and the results show that the results of clothing graphic feature extraction by this algorithm are in good agreement with the actual situation, as shown in Figure 4.

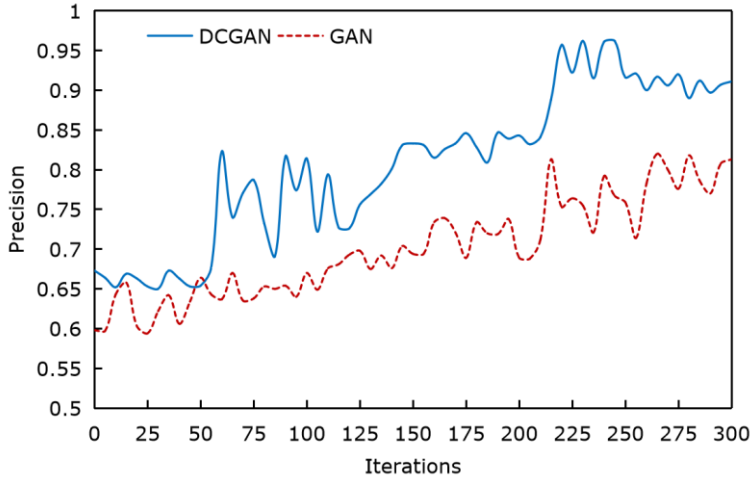


**Figure 4**: Image recognition accuracy of different algorithms in image recognition.

Compared with high-level statistical features, the classification model of clothing pattern features is established by using low-level features, which has higher classification accuracy. Through comparison and analysis, the time spent by the testing method in the stage of clothing graphic feature extraction is shown in Figure 5.

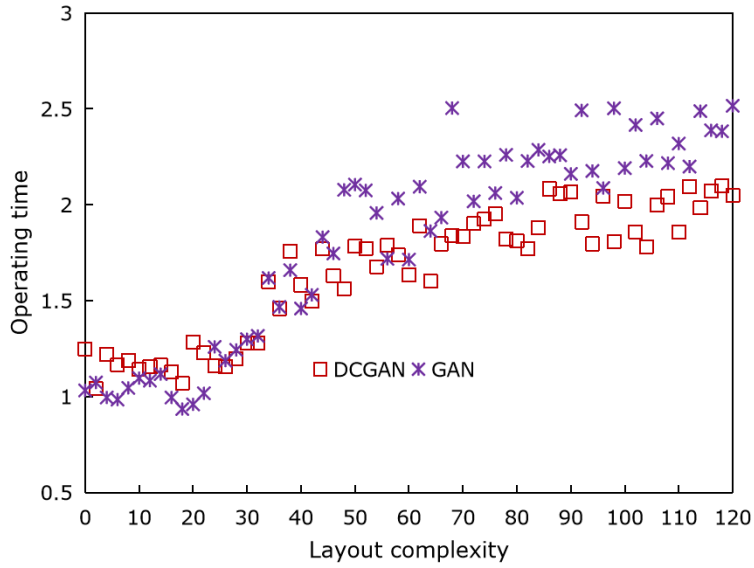


**Figure 5**: Time-consuming clothing graphic feature extraction by different methods.

When the quantity of pixels of feature information is larger, the processing time will be longer. Although the computing time of DCGAN in clothing image feature extraction is also increasing, it has obvious advantages compared with traditional GAN. The characteristics of order and randomness in the stage of fractal pattern generation complicate the non-static dynamic growth stage of graphics, and the continuous growth and change of fractal generation creates one of the factors that the random growth of fractal pattern art cannot define the specific shape of graphics, just like the natural form that cannot be described in the growth state of nature.

Using DCGAN model to extract the features of interactive clothing can keep the detailed information in complex images to the maximum extent and provide reference for the optimal design of interactive clothing. Comparing the clothing graphic feature extraction model based on DCGAN with the traditional GAN model, the test results of recall and recognition error are shown in Figure 6 and Figure 7 respectively.

As can be seen from Figures 6 and 7, after several evolutions, the recall of DCGAN is greatly improved compared with that of the conventional GAN model, and the error is also greatly reduced. The improved method improves the convergence of network parameters, thus improving the classification accuracy of the model. This algorithm can not only get better clothing pattern feature recognition effect, but also has higher recognition accuracy compared with other image processing algorithms. The system has the functions of template style selection, front garment design, side garment design, etc. By studying garment curved surface modeling and parametric design technology, applying dynamic parameters to garment design teaching can improve design efficiency and innovate teaching methods. On the basis of GAN, the graphic feature recognition of CAD clothing can accurately and efficiently extract the group features of clothing, which is very important for realizing the intelligence of clothing design and implementing the digital development concept in clothing design teaching.

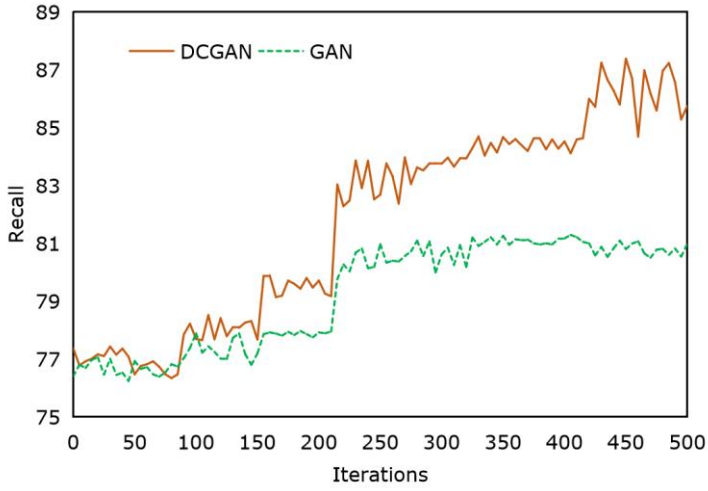


**Figure 6**: Recall test.

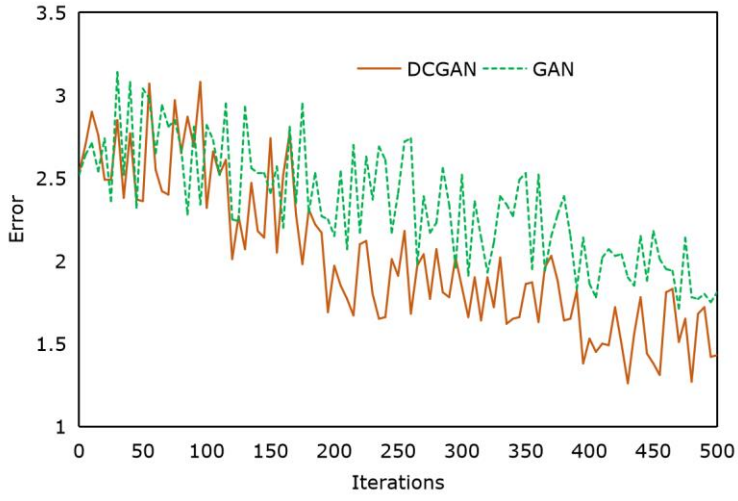


**Figure 7**: Identification error test.

## 5 CONCLUSIONS

Fractal patterns have unique artistic features of self-similarity similar to the whole. No matter how large they are, every local element can reflect the whole shape, creating vivid richness of the picture and inspiring the infinite imagination of the creator. Fractal pattern art provides a new way for the innovation of fashion design, which has a strong visual feeling, conforms to the aesthetic way of modern people and is unique. This article explores the realization of clothing graphic feature recognition algorithm in CAGD system, innovates the interactive clothing pattern design method, and studies the construction strategy of interactive clothing design teaching system based on fractal pattern and CAD. The system has the functions of template style selection, front garment design, side garment design, etc. By studying garment curved surface modeling and parametric design technology, applying dynamic parameters to garment design teaching can improve design efficiency and innovate teaching methods. Teachers of fashion design course can

easily build their own personalized network-assisted teaching environment, carry out personalized network-assisted teaching activities, expand teaching exchange platform, strengthen the construction of characteristic teaching of fashion design course, enhance the development and interaction of teaching activities combining teachers and students with enterprises and the world.

## 6 ACKNOWLEDGEMENT

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*Mingyan Zhang*, https://orcid.org/0000-0002-7680-6911
*Shubin Li*, https://orcid.org/0009-0008-2355-1290
*Haixiang Zhu*, https://orcid.org/0009-0004-3528-360X

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