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Computer-Aided Design and Applications

Dynamic Style Generation of Clothing Based on Reinforcement Learning

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Abstract. This article aims to establish and validate a dynamic model for clothing style generation in order to enhance rapid style innovation and personalized customization in the clothing design sector. This study utilizes a clothing model grounded in CAD (Computer Aided Design) technology, paired with an RL (Reinforcement Learning) algorithm for style generation. By compiling and analyzing a comprehensive dataset of clothing CAD information and style reference samples, a simulation environment is created for model training and evaluation. The findings reveal that, in comparison to conventional CAD design techniques and rule-based style generation methods, the dynamic clothing style generation model presented in this study exhibits superior style consistency, originality, and aesthetic appeal. This model is capable of producing tailored clothing designs based on specified design elements and style references, demonstrating high levels of flexibility and adaptability. In conclusion, this research introduces an innovative design tool and model for the clothing industry, poised to streamline design processes, minimize costs, and foster sustainable industry growth.

Keywords: Computer-Aided Design; Reinforcement Learning; Clothing Design; Dynamic Style Generation of Clothing
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1 INTRODUCTION

As science and technology advance, along with the evolving fashion industry, clothing design is increasingly merging with technology, seeking out fresh design approaches and innovative methods. CAD technology, a pivotal tool in modern design, has found widespread application in clothing design. The dynamic style of clothing refers to the unique beauty and dynamic effects exhibited by clothing during movements such as walking, turning, and dancing. It is an important component of many cultural heritage, documenting the evolution of history, culture, aesthetics, and social customs. However, traditional recording methods often struggle to capture the dynamic beauty of clothing fully. With the development of CAD technology and reinforcement learning 3D technology, we have more means to record, reproduce, and innovate this valuable cultural heritage. Balletti and Ballarin [1] explored innovative traditional clothing dynamic styles and brought new inspiration to modern clothing design. CAD technology provides a digital platform for fashion designers. In the study of dynamic clothing styles, CAD technology can be used to accurately capture and record every detail of clothing, including cutting, lines, proportions, and colours. Designers can use CAD software to simulate the performance of clothing under different movements, thereby gaining a deeper understanding of its dynamic beauty. It uses CAD technology to accurately capture and record traditional clothing dynamic styles and then uses reinforcement learning 3D technology to simulate and predict the application effects of these styles in modern clothing design. By combining computer-aided design (CAD) technology, designers can create 3D-printed fashion clothing prototypes with multi-colour textures. Chan et al. [2] explored CAD-based methods for creating 3D-printed fashion clothing prototypes with multi-colour textures and analyzed their potential applications in the fashion industry. 3D printing technology has brought unprecedented innovation to the fashion industry with its unique manufacturing methods. Through 3D printing technology, designers can create complex clothing structures and unique texture effects more quickly and flexibly. Computer-aided design (CAD) technology provides strong support for this process, allowing designers to accurately simulate and adjust designs in virtual environments. CAD technology provides a powerful tool for the design of 3D-printed fashion clothing prototypes. Designers can use CAD software to create 3D models that accurately simulate the shape, structure, and texture of clothing. Nonetheless, conventional CAD designs still require significant input from designers and lack true automation and intelligence. In recent years, RL, a novel machine learning technique, has garnered notable success across diverse domains due to its autonomous learning and decision-making capabilities. In this research, we aim to integrate CAD technology with RL to pioneer a new approach for generating dynamic clothing styles.

In the field of clothing design, CAD has been widely used in pattern design, pattern making and virtual fitting. Many scholars and enterprises are constantly exploring the combination of CAD technology and artificial intelligence in order to realize more intelligent clothing design. Knitted clothing has unique characteristics in the design and production process, such as the texture and stretchability of fabrics. Chang [3] successfully created a 3D model of knitted clothing through parameterized design and delved into the impact of various parameters in the design process on the final design results. It analyzed the advantages of parametric design in knitted clothing modelling and explored its challenges and prospects in practical applications. Knitted clothing holds an important position in the fashion industry due to its unique weaving characteristics and diverse style designs. The traditional design and manufacturing process of knitted clothing often relies on manual sampling and physical fitting, which is not only inefficient but also costly. Enabling designers to create 3D models with knitted characteristics more efficiently. In practical applications, parametric design is widely used in the creation of 3D models of knitted clothing. Clothing colour imagery and visual aesthetics are indispensable elements in clothing design, which directly affect consumer purchasing decisions and aesthetic experiences. Deng et al. [4] explored how to combine these two technologies, guided by clothing colour imagery and visual aesthetics. In clothing design, the selection and matching of colours are crucial. Appropriate colours not only highlight the style of clothing but also convey specific emotions and imagery. CAD technology provides designers with a digital platform that enables them to accurately simulate and adjust the colours and patterns of clothing. Through CAD software, designers can easily try different colour combinations. Observe their performance under different fabrics and lighting conditions in order to select the colour scheme that best fits the clothing's colour imagery and visual aesthetics.

The introduction of computer-aided design (CAD) technology provides a brand-new design platform for fashion designers. However, traditional CAD systems still have certain limitations in clothing styling design, such as cumbersome design processes and difficult modifications. Hu [5] demonstrated the potential of parametric design in knitted clothing design and provided designers with a new design tool and method. By adjusting parameters, designers can easily explore different design solutions and find the most suitable design for user needs. Meanwhile, this method can also help designers better understand the structure and characteristics of knitted clothing, thereby improving the accuracy and quality of design. The system achieves rapid generation and modification of clothing shapes through component-based design, improving design efficiency and accuracy. The system uses C++ as the development language and combines OpenGL graphics library to achieve rendering and display of 3D shapes. Meanwhile, rule-based intelligent optimization algorithms are used to optimize the shape. The component library is stored in XML format, with each component corresponding to an XML file that contains geometric information, material information, texture information, and more. The system provides the import and export function of components, making it convenient for designers to create and edit components. This article begins by elucidating the research background, its significance, current research status, developmental trends, research content, and innovations, as well as the structural outline of the paper. Subsequently, it presents relevant theories and technical foundations, the principles and advancements of RL, style generation, and transfer learning. Thereafter, a comprehensive discussion on the establishment and methodology of the clothing dynamic style generation model ensues. This section introduces the design and execution of simulation experiments, accompanied by an analysis and deliberation of experimental outcomes. Additionally, the article delves into the prospective applications and potential value of dynamic style generation in clothing. In conclusion, the study summarizes its primary contributions and limitations, offering a glimpse into future research directions. For a concise overview, Table 1 outlines the essential aspects covered in this study.

Research contents	*Describe*
Application Status of CAD Technology in Clothing Design	This article analyzes the application, advantages, and disadvantages of CAD technology in clothing design.
Application of RL in Style Generation	This article studies how RL is applied to generate and optimize clothing styles automatically.
Style generation model combining CAD and RL	Build a new model to improve design efficiency and style diversity.
Simulation experiment verification	Improved the standardization and effectiveness of the experimental model.

Table 1: Research contents.

The novelty of this article is predominantly manifested in the following ways:

(1) Combining CAD technology with RL, a brand-new method for generating dynamic style of clothing is proposed.

(2) By constructing an adaptive RL model, the automatic generation and migration of clothing styles are realized.

2 RELATED THEORY AND TECHNICAL BASIS

As an important component of cultural heritage, ethnic clothing patterns have always been loved for their unique design elements and aesthetic value. However, traditional design methods are often limited by the creativity and experience of designers. To overcome this limitation, Hu et al. [6] proposed a national clothing pattern design method that combines CAD technology, reinforcement learning, shape syntax, and artificial neural networks. This method aims to achieve innovative and automated design of ethnic clothing patterns through intelligent algorithms and computer-aided design tools. As an important carrier of traditional culture, the design of ethnic clothing patterns not only reflects ethnic characteristics but also contains rich cultural connotations. With the advancement of technology, combining modern technology with traditional pattern design to achieve innovative and automated patterns has become an urgent problem that needs to be solved. Therefore, this article proposes a national clothing pattern design method based on CAD technology, reinforcement learning, shape syntax, and artificial neural networks. The application of these technologies improves the production, it also enables designers to more intuitively predict and evaluate the final effect of the design. The application of these technologies is particularly significant for knitted and woven fabrics.

Indrie et al. [7] Fabrics typically have complex patterns and textures. The CAD system provides rich drawing tools and pattern libraries, making it convenient for designers to design and modify patterns. Through advanced algorithms and texture mapping techniques, CAD systems can simulate the texture, gloss, and feel of knitted fabrics. This allows designers to predict the texture of the finished product in the early stages of design in order to make adjustments and optimizations. Designers can adjust parameters in real time, observe simulation results, and find the most satisfactory design solution. In addition, CAD can also help designers predict the physical properties of knitted fabrics, such as stretchability, wear resistance, etc., providing a reference for subsequent clothing design and production. For woven fabrics, CAD technology can also greatly improve design efficiency.

CAD is an important extension of traditional design tools. Designers can use CAD software to create precise virtual models, simulate the behaviour of fabrics in three-dimensional space, and predict the fit and comfort of clothing. Jankoska [8] analyzed the application of reinforcement learning in three-dimensional clothing design. Reinforcement learning is a machine learning technique that allows algorithms to learn and improve through interaction with the environment. For example, algorithms can learn how to adjust design parameters based on user feedback and preferences in order to create clothing that better meets user needs. Combining CAD and reinforcement learning can further promote the development of 3D clothing design. Designers can use CAD to create precise virtual models and use reinforcement learning algorithms for fitting and optimization. This combination enables designers to quickly iterate design solutions and make real-time adjustments based on user feedback, thereby creating clothing that is more in line with user needs and more innovative. In the fashion industry, designers have always been pursuing innovation and unique designs. The clothing dynamic style design search based on CAD and reinforcement learning perception provides designers with more intelligent and efficient design tools. Kovacs et al. [9] analyzed the dynamic style design of clothing under the perception of reinforcement learning. Through CAD software, designers can precisely control every detail of clothing, including fabric, style, size, etc. In addition, CAD can also simulate the performance of clothing on different body types, helping designers predict the fit and comfort of clothing. In dynamic style design, the application of CAD is even more indispensable. Designers can create multiple different design schemes through CAD software, and select the most suitable design scheme through simulation and comparison.

Liu et al. [10] explored how to integrate elements of Yue opera into modern fashion clothing design and, through virtual simulation technology, achieve a perfect combination of Yue opera clothing and fashionable textiles, thereby promoting the inheritance and innovation of traditional culture. Yue Opera costumes are known for their gorgeous patterns, rich colours, and exquisite craftsmanship. Designers can extract representative elements from Yue Opera costumes, such as embroidery patterns, colour matching, and clothing styling, and then transform them into modern clothing design elements. Utilizing modern design techniques and techniques it can help designers quickly and accurately present design effects, reducing the cost and time of physical production. Through virtual simulation technology, designers can try on, adjust, and optimize Yue Opera costumes in a virtual environment, thereby achieving a perfect presentation of the design. Sharma et al. [11] proposed a data-driven system based on computer-aided design (CAD) technology and reinforcement learning, aiming to recommend personalized clothing design solutions. This system provides users with precise and efficient personalized clothing design services, combined with the precise simulation ability of CAD technology and the intelligent decision-making ability of reinforcement learning. In order to achieve personalized clothing design solution recommendations, it proposes a data-driven system based on CAD technology and reinforcement learning. The system first collects and analyzes a large amount of clothing design data, user behaviour data, and feedback data. Then, utilizing the precise simulation capability of CAD technology, multiple possible design solutions are generated. Reinforcement learning is a machine learning method that learns how to make the best decisions through trial and error.

In clothing design, colour selection is crucial. However, designers often face difficulties and challenges when choosing colours, as they need to consider multiple factors such as colour matching, brand style, and market demand. In clothing design, colour selection is a crucial step. Appropriate colour combinations can make clothing more attractive, enhance brand image, and meet market demand. In clothing colour combination, reinforcement learning can intelligently adjust colour combination schemes based on user feedback and aesthetic standards of colour matching. Through extensive trial and error and learning, reinforcement learning can gradually learn colour combination rules that match user preferences, providing designers with more accurate and practical colour suggestions. To address this issue, Xu et al. [12] proposed a clothing colour network model based on CAD technology and reinforcement learning, which can convert colour images from clothing images and provide designers with auxiliary colour combination suggestions. Computer perception image systems are playing an increasingly important role in the evaluation of creative design in clothing culture. Xu and Zheng [13] introduced the basic principles of computer perception image systems and their applications in clothing design. Then, it explored how to use these systems for creative design evaluation and analyzed their advantages and limitations. Finally, the future development prospects of computer perception image systems in the field of clothing design were discussed. Making it difficult to accurately and objectively evaluate the quality of a design. A computer perception image system is a system that utilizes computer vision and image processing techniques to perceive and analyze image information. It can achieve objective description and evaluation of image content through feature extraction, recognition, and analysis of images.

Chinese painting elements contain rich cultural connotations and aesthetic values, and their unique brushwork and composition provide endless inspiration for creative clothing products. With the advancement of technology, computer-aided design (CAD) technology and reinforcement learning have been widely applied in this field. Yan [14] explored how to combine CAD technology with reinforcement learning, effectively integrating Chinese painting elements and bringing new design ideas and practical methods to clothing and cultural creative products. Incorporating Chinese painting elements into the design of clothing and cultural and creative products can not only enrich the cultural connotations of the products but also enhance their artistic value and market competitiveness. CAD technology provides a digital platform for fashion designers to accurately draw and modify design patterns. In the design of clothing and cultural creative products, CAD technology can be used to draw and simulate patterns and textures of Chinese painting elements, such as mountains and rivers, flowers and birds, characters, etc. Designers can use CAD software to adjust and optimize the details and proportions of patterns, making them more in line with modern aesthetics and dressing needs. New Year prints, as a traditional art form, contain strong cultural connotations and a festive atmosphere. Zhang and Romainoor [15] explored how to use artificial intelligence to generate artistic images in the style of New Year prints. And apply these images to clothing and cultural creative products, thereby injecting new creativity and vitality into traditional culture. Applying artificial intelligence generated New Year printmaking style artistic images to clothing cultural creative products connotations and modern fashion sense. These images not only retain the charm of traditional printmaking but also incorporate the creativity of modern art, providing rich design materials for clothing culture creative products. For example, designers can print these images on clothing or use them as patterns for clothing accessories, thereby endowing clothing with unique artistic charm. In addition, these images can also be used for designing clothing packaging, promotional posters, etc., to enhance the overall quality and market competitiveness of the product.

3 CONSTRUCTION OF CLOTHING DYNAMIC STYLE GENERATION MODEL

3.1 Establishment of a Clothing Model Based on CAD Technology

CAD technology, a computer-aided design tool, is extensively employed in the design realm, aiding designers in their work through a combination of computer software and hardware. In clothing design specifically, CAD finds application in pattern creation, pattern development, and virtual fitting. By leveraging CAD software, designers can efficiently sketch and refine patterns, ensuring precise production and swift pattern adjustments. Furthermore, with the help of virtual fitting technology, designers can simulate the wearing effect of clothing on the computer so as to display the design results more intuitively and optimize the design scheme. RL is a machine learning method to learn the optimal decision strategy through the interaction between agents and the environment. It guides the behaviour choice of agents based on reward signals and gradually approaches the optimal strategy through trial and error and learning. The development of RL has experienced the transformation from traditional tabular method to modern deep RL, especially the combination of deep neural network and RL algorithm makes RL achieve remarkable results in dealing with high-dimensional complex problems.

Style generation refers to the process of automatically generating artistic works or design patterns with specific styles through computer algorithms, which can realize knowledge transfer and sharing, thus improving learning efficiency and application scope. In the field of style generation, transfer learning is widely used in the task of style transfer; that is, by transferring the characteristics of one style to another content, artistic works or design patterns with new styles are generated. This study will use the ideas and methods of transfer learning for reference to realize the automatic generation and transfer of clothing styles. In clothing design, the generation and change of style is a complex and subjective process involving the combination and adjustment of multiple design elements. In this study, the generation of clothing dynamic style is defined as under the given design elements and style reference, the clothing design scheme that meets the specific style requirements is automatically generated through the algorithm. In order to achieve this goal, a model framework combining CAD technology and RL is proposed. The framework mainly includes three parts: the establishment of a clothing model based on CAD, the formulation of RL style generation strategy and the training and optimization of the model. Firstly, the basic model of clothing is established by using CAD technology, including design elements such as patterns and patterns. Then, the strategy of style generation is learned by the RL algorithm so that the model can automatically generate the corresponding clothing design scheme according to the given style reference. Finally, by training and optimizing the model, the accuracy and efficiency of style generation are improved.

In this article, a skin model is constructed for each sample posture, and the position of the clothing vertex in the corresponding posture is calculated. Furthermore, using the skinning scheme described in Formula (1), the positions of clothing vertices in other postures similar to these sample postures are further calculated:

$$y^j = \sum_{b=1}^{N_B} w_b^j \;\; R_b^{j,in} y^j + T_b^{j,in} \;\; + R_b^{j,in} \tau_b^j T_b^{j,in} \tag{1}$$

Where $R_b^{j,in}$ and $T_b^{j,in}$ represent the relative rotation and translation angles of bone b from $\mathrm{P_j}$ to $\mathrm{P_{in}}$. w_b^j And τ_b^j define the weight of skeleton rotation and translation of clothing vertices, respectively. w_b^j Stands for the skeleton rotation weight selected based on the clothing deformation effect, which is usually regarded as a common method to select the standard weight in the skeleton deformation space.

For each input posture p , the clothing deformation algorithm based on posture will calculate the corresponding clothing deformation shape. By using Formula (2), the model can deduce the garment deformation in all approximate postures so as to predict the garment deformation effect of input postures accurately:

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$$y^{in} = \sum_{J=1}^{N_J} w^{j}\ \ p^{in}\ \ y^{j} \tag{2}$$

$$y\ \ p^{in}\ \ - y^{j} \cong \sum_{m=1}^{3N_{\Gamma}} S_{m}^{j} \Delta\Theta_{m} \tag{3}$$

Where: p^{in} is an arbitrary gesture. $\Delta\Theta_m$ Is the $\Theta\ \ p^{j}, p$ joint rotation angle of this posture m?

Feature fusion plays a pivotal role in garment image processing as it effectively integrates feature information derived from various sources or levels. This encompasses low-level features like colour, texture, shape, and style alongside high-level semantic features obtained through deep learning and other advanced technologies. Dynamic fusion underscores the flexibility in adjusting fusion methods and weights based on different scenarios or tasks. This adaptability allows for real-time adjustments based on input image attributes, user requirements, or real-time feedback. In a clothing image retrieval system, dynamic feature fusion dynamically adjusts the weights of features such as colour, texture, and style based on the user's search patterns and preferences. This ensures more relevant search results tailored to the user's needs. Figure 1 in this article illustrates the dynamic fusion of clothing image features.

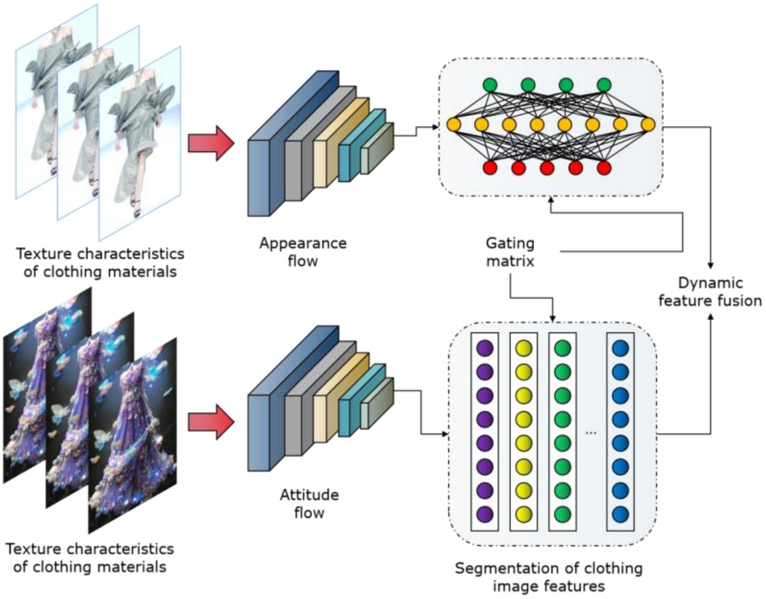

Figure 1: Dynamic fusion of clothing image features.

In the generation model of clothing dynamic style, CAD technology is the key to constructing the basic clothing model. This article collects and sorts out the CAD data of various clothing patterns and patterns, and establishes a rich clothing model library. Which includes design elements such as version size, pattern shape and color. In this way, we can flexibly generate various clothing design schemes by adjusting these parameters. In this article, the risk function of virtual modelling of the clothing dynamic style generation model is as follows:

$$\theta^{*} = \arg\min_{\theta} \frac{1}{N} \sum_{i=1}^{N} L\ \ y_i, f\ \ x_i; \theta\ \ + \lambda\Phi\ \ \theta \tag{4}$$

$$L\ \ Y, P\ \ Y \middle| X\ \ = -\log P\ \ Y \middle| X \tag{5}$$

$$L\left(Y,P\left(Y\middle|X\right)\right)=-\frac{1}{N}\sum_{i=1}^{N}\sum_{j=1}^{M}y_{ij}\log\left(p_{ij}\right) \tag{6}$$

In this context, Y it represents the output variable of the given function, X denotes the input variable, N signifies the total count of input samples, L stands for the loss function, and M indicates the number of potential categories. The 3D characteristics of clothing images are acquired through a gray difference approach.

$$I_{Truth}=\begin{cases}1 & if\ I_D\geq s\\ 0 & otherwise\end{cases} \tag{7}$$

In this context, I_D it represents the absolute disparity in gray values for each pixel when comparing the optimized image to the original one.

In addition, in order to meet the requirements of the RL algorithm for input data, this article also preprocesses the CAD model and extracts its features. By extracting key information such as pattern size and pattern characteristics, the clothing model is transformed into a data format that can be processed by the algorithm, which provides a basis for subsequent style generation.

3.2 Application Strategy of RL in Style Generation

The application strategy of RL in clothing dynamic style generation mainly includes three parts: state space definition, action space design and reward function setting.

State space includes information such as design elements and style characteristics of current clothing. In this article, each design element of clothing (such as pattern size, pattern, etc.) is regarded as a part of the state space, and the current design state of clothing is expressed in the form of a state vector. Action space refers to the way and scope of adjusting design elements. This article defines a series of actions, such as changing the size of the version, replacing the pattern, etc., and each action corresponds to an adjustment method of the design elements. The model changes the current design state by performing these actions, thus generating a new clothing design scheme. The reward function is an index used to evaluate whether the design scheme generated by the model meets the requirements of a given style. In this article, the reward function is designed according to the similarity between style reference and generation scheme, and the higher the similarity, the greater the reward. Furthermore, in order to encourage the model to explore new design styles, exploratory factors are added to the reward function to balance the use of known styles and the exploration of new styles.

3.3 Model Training and Optimization Method

In order to train and optimize the clothing dynamic style generation model, this article adopts the depth RL algorithm. Firstly, the training data set is constructed by using the collected clothing CAD data and style reference samples. Then, the deep neural network is used to approximate the state value and action value functions, to learn the strategy of style generation. In the training process, experience playback and fixed Q target network are used to stabilize the learning process and improve the convergence speed of the model. The loss function of model training is weighted cross-entropy L_{Mask}, and the Formula is as follows:

$$L_{\mathrm{Mask}}=-\frac{1}{C}\sum_{i=0}^{C-1}\left[\alpha\cdot y_i\ln\left(y_i'\right)+\beta\cdot\left(1-y_i\right)\ln\left(1-y_i'\right)\right] \tag{8}$$

The convergence speed of the model is shown in Figure 2.

In the aspect of model optimization, we mainly focus on improving the accuracy and efficiency of style generation. By adjusting the architecture and parameters of the neural network, optimizing the design of the reward function and introducing an advanced RL algorithm, the performance of the model is continuously improved. Furthermore, this article also considers how to combine domain knowledge and feedback from human experts to further improve the quality of model generation and innovation ability.

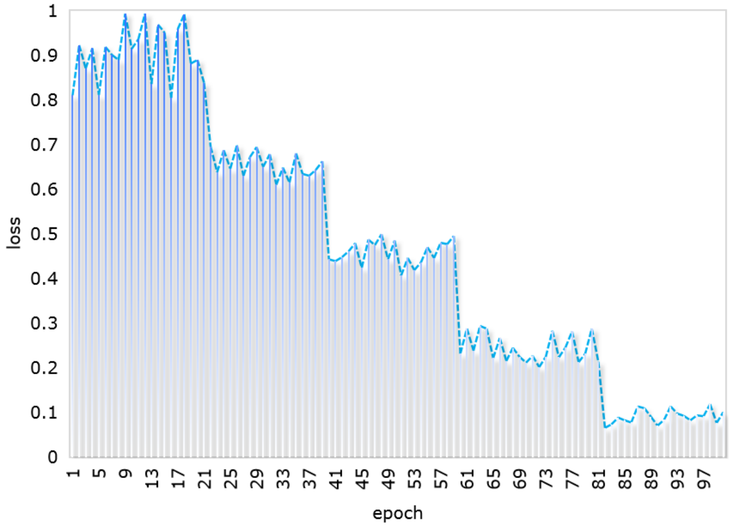

Figure 2: Convergence rate of the model.

4 SIMULATION EXPERIMENT DESIGN AND IMPLEMENTATION

4.1 Simulation Experiment Environment and Results Display

In this section, a simulation environment is designed to verify the effectiveness of the clothing dynamic style generation model. The environment is built on a high-performance computing platform, and a professional graphics processing unit is configured to support the efficient training of the deep RL algorithm. Furthermore, a wealth of clothing CAD data sets and style reference samples are integrated, which provides diverse learning materials for the model. We also collected a large number of style reference samples from fashion magazines, design websites and other channels, covering a variety of popular and classic clothing styles. These samples are labeled and classified by professional designers and used to guide the style generation process of the model. In the design of the experimental scheme, the method of comparative experiment is adopted to compare the dynamic style generation model of clothing with the traditional CAD design method and rule-based style generation method. The specific experimental steps are as follows:

Model training: First, the preprocessed CAD data set and style reference samples are used to train the clothing dynamic style generation model. By adjusting the parameters and learning strategies of the model, it can gradually master the law of style generation.

Style generation: after the training, a new set of style reference samples is selected as input, and the model is required to generate a corresponding clothing design scheme according to these samples. Furthermore, the traditional CAD design method and rule-based style generation method are also used to generate the comparison scheme, as shown in Figures 3-5.

Scheme assessment: In order to objectively evaluate the advantages and disadvantages of each scheme, a group of professional designers and fashion critics were invited to grade and comment on the generated clothing design scheme. The assessment process strictly follows industry standards and professional aesthetics. The assessment index covers three aspects: style consistency, innovation, and design aesthetics, with the aim of comprehensively reflecting the comprehensive performance of the design scheme. The assessment results are shown in Figures 6-8.

Figure 3: Traditional CAD design method.

Figure 4: Style generation method based on rules.

Figure 5: Dynamic style generation method in this article.

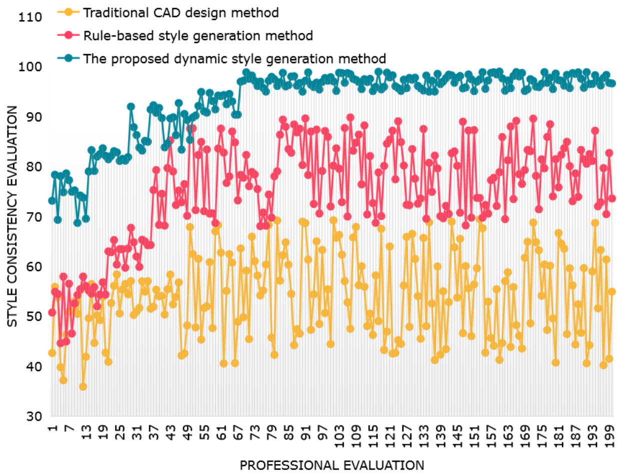

Figure 6: Style consistency assessment.

Style consistency is an important index to evaluate whether the clothing design scheme meets the specific style requirements. According to the results shown in Figure 6, professional designers and fashion critics have scored about 9.5 points on the style consistency of the generated design scheme. This shows that the generated design scheme can accurately grasp and reflect the given style characteristics. This high consistency not only proves the sensitivity and accuracy of the generated model to style features but also provides a solid foundation for subsequent style innovation and individualized customization.

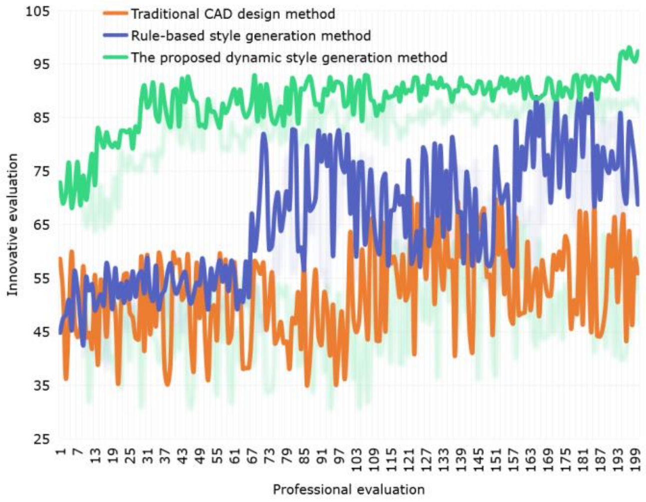

Figure 7: Innovative assessment.

Innovation is the key index to measure whether the clothing design scheme is novel and unique. According to the assessment results in Figure 7, the generated design scheme also got a high score of more than 9.2 points in terms of innovation. This means that the generated model can not only copy the existing style but also incorporate new elements and ideas into the design, resulting in a refreshing design scheme. This innovation is not only reflected in the recombination and interpretation of traditional elements but also includes the keen insight and flexible application of emerging trends and aesthetic trends.

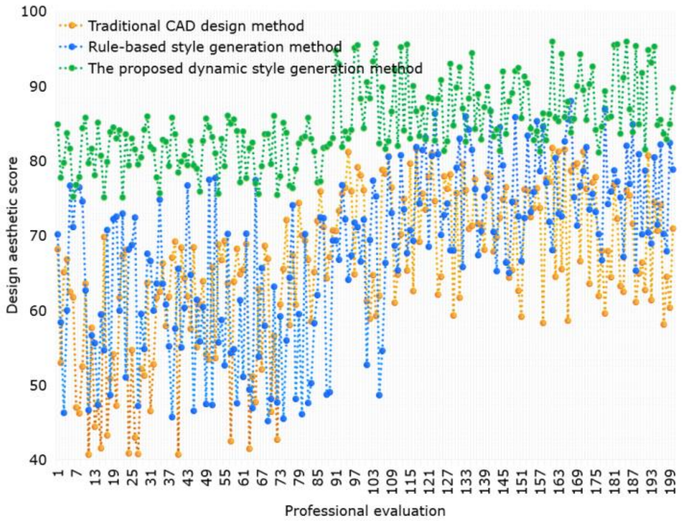

Figure 8: Design aesthetic score.

The aesthetic feeling of design is the core index to evaluate whether the clothing design scheme has aesthetic value and attraction. According to the assessment results in Figure 8, professional designers and fashion critics also scored more than 9 points on the design aesthetics of the generated design scheme. This shows that the generated design scheme not only meets professional aesthetic standards but also has wide market appeal and consumer acceptance. This aesthetic feeling is not only reflected in the clever use of basic design elements such as colours, lines and shapes but also in the accurate grasp of the overall style and atmosphere. This high aesthetic feeling not only enhances the added value and brand image of clothing but also brings consumers a more pleasant and satisfying shopping experience.

4.2 Discussion on Experimental Results

After a series of experimental operations and data statistics, this section has obtained rich experimental results. From the aspect of style consistency, the clothing design scheme generated by the clothing dynamic style generation model is highly consistent with the given reference sample in style characteristics. In terms of innovation, the model can combine various design elements for flexible combination and innovative design. In terms of design aesthetics, professional designers and fashion critics give a high assessment of the scheme generated by the model. Compared with the traditional CAD design method and rule-based style generation method, the dynamic style generation model of clothing shows better performance in style consistency, innovation and design aesthetics. This is mainly due to the self-learning and decision-making ability of the RL algorithm, which enables the model to be flexibly adjusted and optimized according to the design environment and style requirements.

Despite the experimental results demonstrating the efficacy of the clothing dynamic style generation model, there is room for enhancement. One potential approach is to incorporate a broader range of clothing CAD data and style reference samples during model training. This strategy is likely to enhance the model's generalization capabilities and adaptability. Additionally, in terms of evaluating various schemes, we may explore the use of more objective evaluation metrics and quantitative analysis techniques. This would enable a more comprehensive assessment of the strengths and weaknesses associated with each scheme.

5 EXPLORATION OF THE APPLICATION OF CLOTHING DYNAMIC STYLE GENERATION

(1) Application potential in the clothing design industry

As the fashion industry continues to evolve swiftly, the variety and pace of clothing styles are constantly growing, thereby demanding greater innovation and efficiency from designers. Clothing dynamic style generation technology, emerging as a novel design tool, holds promising potential for widespread application within the clothing design industry. This technology can assist designers in promptly creating market-driven clothing designs, thereby enhancing both design efficiency and innovation. Through collaborative efforts with fashion brands, designers, and supply chains, this technology is anticipated to breathe new life into the clothing design industry, fostering its sustainable growth and development.

(2) Innovative mode of individualized customization service

In today's consumer market, consumers' demand for individualized products is growing. The technology of clothing dynamic style generation provides consumers with the opportunity to participate in the design process and realize individualized customization by adjusting design elements and style characteristics. This innovative model not only satisfies consumers' pursuit of uniqueness and individuality but also enhances the interaction and stickiness between brands and consumers. In the future, with the continuous maturity of technology and the further differentiation of consumer demand, individualized, customized service will become an important development direction of the fashion industry.

(3) The influence and change on the clothing design process.

The traditional clothing design process usually includes market research, design conception, drawing sketches, making sample clothes and other links, which is time-consuming and costly. The technology of clothing dynamic style generation can automatically generate multiple design schemes for selection and optimization in a short time, which greatly simplifies the design process. See Table 2 for details.

Process link	*Traditional costume design*	*Dynamic Style Generation Technology of Clothing*
Market research	It is needed to conduct complicated market research to collect and analyze information such as consumer demand and fashion trends.	Automatically analyze market trends and consumer preferences through big data and machine learning algorithms.
Design concept	Designers make preliminary design ideas according to the research results and personal creativity.	According to the input conditions and requirements, the system automatically generates multiple design ideas for selection.
Skeletonizing	It takes a long time for designers to draw sketches by hand or using design software.	The system automatically generates design sketches, which can quickly present multiple design schemes.
Make sample clothes	It is needed to make physical sample clothes for fitting and assessment, and the cost is high.	Through virtual fitting technology, the effect of sample clothes can be simulated on the computer, saving costs.
Feedback and adjustment	According to the try-on effect and assessment feedback, make several revisions and adjustments.	The system can automatically adjust the design scheme according to real-time feedback to improve the flexibility and response speed of the design.

Design cost	It is time-consuming and costly and requires a lot of human and material resources.	The design cost is greatly reduced, and the work efficiency of designers is improved.
Sustainable development	Traditional design process produces a lot of waste, which is not conducive to environmental protection.	It is helpful to realize the green and sustainable development of the fashion industry and reduce the waste of resources and environmental pollution.

Table 2: Comparison of clothing design processes.

While the prospects for clothing dynamic style generation technology are vast, it encounters several practical challenges. One such challenge is ensuring that the designs produced align with consumer aesthetic preferences and functional needs. Another consideration is striking a balance between technological advancements and traditional craftsmanship. Additionally, safeguarding the intellectual property rights of the designs remains a pressing concern. However, as technology continues to evolve and industry standards are gradually established, there is optimism that these issues will be addressed. Moreover, the integration of clothing dynamic style generation technology with cutting-edge technologies holds promise for delivering an even more immersive and interactive shopping experience for consumers.

6 CONCLUSIONS AND PROSPECT

6.1 Summary and Main Contributions of Research Work

In this study, by constructing the dynamic style generation model of clothing, the corresponding clothing design scheme is automatically generated according to the given design elements and style references. The validity of the model is verified by simulation experiments, and the application potential of this technology in the clothing design industry, the innovative mode of individualized customization service, and the influence and reform on the clothing design process are discussed. The research results show that the clothing dynamic style generation technology has high practical value and broad market prospects, which is expected to bring new development opportunities to the fashion industry.

6.2 Research Deficiency and Future Research Prospect

Although some achievements have been made in this study, there are still some shortcomings and limitations. First of all, in the aspect of model construction, the multi-dimensional characteristics and complex constraints of clothing design have not been fully considered, which leads to the generated design scheme not being precise enough in some details or meeting the actual needs. Secondly, in the aspect of experimental design and assessment, due to the limitation of time and resources, more comprehensive comparative experiments and user tests have not been carried out to fully verify the superiority and applicability of the model. Finally, in application exploration, although some potential application scenarios and innovative models have been put forward, in-depth market research and business model analysis have not been carried out to further verify its feasibility and commercial value.

In view of the above shortcomings and limitations, this article puts forward the following suggestions for future research: First, further, improve the construction method of the clothing dynamic style generation model and introduce more design features and constraints to improve the fineness and practicability of the generated design scheme. Secondly, strengthen the experimental design and assessment and carry out more comprehensive comparative experiments and user tests to fully verify the performance and superiority of the model. Finally, the application mode and business model innovation path of clothing dynamic style generation technology in the fashion industry are deeply explored to make greater contributions to promoting the sustainable development of the fashion industry.

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