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Innovation of Clothing Design Element Extraction and CAD System Based on Computer Vision and Multimedia Analysis Technology

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Abstract. In this article, we introduce a method of using CNN (Convolutional Neural Network) to identify and extract clothing design elements. This method is seamlessly integrated into CAD (computer-aided design) systems, achieving automation and intelligence in the design process. Our approach emphasizes the importance of data preprocessing and feature engineering. We enhance the data and carefully select features to improve the accuracy and reliability of the model. In addition, we have also improved the structure of CNN to achieve optimal performance. In the experimental section, we conduct functional, performance, and user experience testing. We compared our innovative CAD system with other algorithms to evaluate its performance comprehensively. The results indicate that accuracy, recall, and F1 score are all very high. In addition, ROC curve analysis enhances its excellent performance. This system can not only accurately identify and extract design elements from images, but also automatically adjust and optimize design schemes. It provides intuitive and efficient interaction and supports collaboration with other design tools. Our research represents significant progress in the fashion design industry, paving the way for innovation and industry upgrading.

Keywords: Computer Vision; Multimedia Analysis Technology; Fashion Design; Element Extraction; Computerized Design System; Convolutional Neural Network
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1 INTRODUCTION

Clothing design elements are the basic units of clothing, including lines, colours, fabrics, styles and other aspects. In today's era of digitization and informatization, information and communication technology (ICT) has penetrated deeply into various industries, including the field of clothing design. Abdurahimovna [1] explores how to use information and CAD communication technology tools to cultivate fashion design talents in professional discipline organizations. Information and CAD communication technology tools provide powerful technical support for clothing design. Through CAD software, designers can efficiently carry out two-dimensional and three-dimensional clothing design, achieving precise measurement, rapid modelling, and real-time modification. Meanwhile, using communication technology tools, designers can conveniently communicate and collaborate remotely with team members, customers, and suppliers, achieving real-time sharing and updating of design information. These elements can create colourful clothing styles and styles through different combinations and expressions. In fashion design, designers need to choose appropriate elements to match and innovate according to fashion trends and consumer demand. Cheng et al. [2] explored the production process of digital replicas of men's tight-fitting underwear based on these technologies and analyzed their application in textile research. Through digital replication, it is possible to conduct in-depth research on the design, fabric performance, and wearing experience of men's tight underwear, providing new ideas and methods for the development of the textile industry. As an important component of modern clothing, the design and fabric selection of men's tight-fitting underwear have a significant impact on the comfort and appearance of the wearer. Traditional textile research methods often rely on manual measurement and physical testing, which is time-consuming, labour-intensive, and difficult to obtain accurate data. Digital replicas based on computer vision and multimedia analysis technology can achieve rapid and accurate measurement and analysis of men's tight underwear, providing new technological means for textile research.

Therefore, it is of great significance to accurately identify and extract clothing design elements for improving design efficiency and quality. At present, fashion design is gradually merging with science and technology, showing an unprecedented innovation trend. Cong et al. [3] studied the virtual display technology of weft-knitted seamless knee pads based on the free deformation model, aiming to improve the design efficiency and display effect of knee pads. By constructing a free deformation model, flexible adjustment and optimization of the shape of the knee pads were achieved, and the wearing effect and performance characteristics of the knee pads were vividly presented through virtual display technology. The virtual display of seamless weft knitted knee pads based on the free deformation model can vividly present the wearing effect and performance characteristics of the knee pads. Through virtual display technology, it can simulate the wearing effect of knee pads under different body types and sports states, demonstrating the adaptability and comfort of knee pads. At the same time, we can also use virtual display technology to flexibly adjust the material, colour, texture and other properties of knee pads to meet the personalized needs of different consumers. As a product of the information age, computer vision and multimedia analysis technologies have played a pivotal role in digitizing and intellectualizing fashion design. Horiba et al. [4] proposed a hybrid method based on clothing CAD and finite element analysis software. It is used to estimate the clothing pressure of tight-fitting clothing made of elastic materials. Clothing CAD (computer-aided design) software has a wide range of applications in clothing design and production. It can help designers quickly and accurately draw clothing style diagrams and generate accurate size and pattern data. In tight-fitting clothing design, CAD software can assist designers in optimizing clothing structure and improving wearing comfort based on ergonomic principles. By establishing a three-dimensional model of clothing and the human body and setting appropriate material properties and boundary conditions, finite element analysis software can simulate the deformation process of tight-fitting clothing during wearing.

With the steady advancement of AI and the broadening of its application scope, these technologies are poised to have a more profound and widespread impact on fashion design. Hu [5] explores the design and implementation of a component-based intelligent clothing modelling CAD system. The component-based intelligent clothing modelling CAD system is a comprehensive software platform that integrates multiple functions. It utilizes advanced computer graphics, artificial intelligence, and database technology to achieve the integration of clothing design, plate making, sampling, simulation, and other functions through modular and component-based design concepts. This system can help designers quickly and accurately complete clothing design and provide real-time feedback and optimization suggestions, greatly improving design efficiency and quality. The component-based intelligent clothing modelling CAD system adopts the concept of component-based design, dividing the system into multiple independent components, each with specific functions and interfaces. In terms of technical implementation, the system adopts advanced computer graphics algorithms and artificial intelligence technology to achieve automation and intelligent processing of the clothing design process. Indrie et al. [6] explored the computer-aided design process for knitted and woven fabrics, as well as the application of virtual clothing simulation technology. Knitted and woven fabrics, as the main types of textiles, have always received widespread attention in the industry in their design and production processes. Traditional design methods often rely on manual drawing and physical sample production, which is not only inefficient but also costly. The introduction of computer-aided design and virtual clothing simulation technology has brought revolutionary changes to the design of knitted and woven fabrics. Designers can directly draw the desired patterns and structures on the computer through CAD software, avoiding the complexity and errors of traditional manual drawing. At the same time, CAD software also provides rich texture, colour, and material options, allowing designers to express their creativity more flexibly.

This study aims to explore methods for extracting fashion design elements using these cutting-edge technologies and integrating them into CAD systems. Our goal is to enhance design efficiency, diversify design approaches, and catalyze innovation in the fashion industry. The focal points of this research are threefold: (1) developing a CNN-based model for recognizing and extracting key features of fashion design elements, (2) designing and conducting simulation experiments to assess the model's efficacy, and (3) exploring methods and scenarios for integrating the extracted design elements into CAD systems. In terms of significance, leveraging computer vision to automate the identification and extraction of design elements promises to significantly reduce designers' workloads and streamline the design process. Additionally, multimedia analysis can unlock insights into fashion design trends and patterns, serving as a source of inspiration and creative fodder for designers. Lastly, the integration of extracted design elements into CAD systems holds the potential to digitize and parameterize fashion design, facilitating easier design iteration and optimization while enhancing collaboration across the industry's value chain.

The novelty of this article is primarily showcased in several key areas. Firstly, a revamped CNN model is presented for the automated recognition and extraction of fashion design elements. This model, a fusion of CNN technology and image processing techniques, boasts enhanced accuracy and resilience. Secondly, this research breaks new ground by amalgamating computer vision and multimedia analysis technology in fashion design. This holistic approach redefines the process, streamlining it from design element extraction straight through to CAD system integration. Lastly, the study introduces an optimized CAD system tailored to the extracted fashion elements, elevating the system's intelligence and usability.

The article commences with an overview of the research's background, importance, content, and innovations. Subsequently, it delves into computer vision, multimedia analysis, the application of CNN in image recognition, and the fundamentals of fashion design elements and CAD systems. It then details the creation of the feature recognition and extraction model, outlines the simulation experiment's design and execution, and showcases the innovative CAD system integration. In conclusion, the article reflects on the study's major accomplishments, identifies potential shortcomings, and outlines future research directions and potential applications.

2 THEORETICAL BASIS AND RELATED TECHNOLOGIES

CAD technology provides powerful technical support for 3D clothing design through precise data processing and powerful graphic processing capabilities. Designers can quickly construct three-dimensional models of clothing through CAD software and observe and modify them from multiple angles and all directions. In addition, CAD software can also provide a rich material and colour library, allowing designers to choose flexibly during the creative process, thereby creating more personalized and creative clothing works. CAD technology can greatly shorten the design cycle and reduce the time cost for designers in drawing and modifying. Jankoska [7] only needs to input relevant parameters in the software to quickly generate a 3D model and make real-time modifications. CAD technology is based on precise data processing, ensuring that the 3D model of clothing is highly consistent with the actual finished product in terms of size, proportion, and details.

This helps to reduce errors in the design process and improve design quality. Ji et al. [8] established a three-dimensional simulation model of seamless weft knitted fabric using simulation software. This model can accurately reproduce the coil structure, yarn direction, and texture effects of knitted fabrics and can simulate the deformation and wearing process of knitted fabrics in a virtual environment. By establishing a simulation model, it is possible to predict and optimize the performance of seamless weft-knitted fabrics. Adjust the size and density of the coil to change the material and colour of the yarn to achieve different performance and appearance effects. Meanwhile, simulation models can also be used to evaluate the feasibility and superiority of different design schemes, providing strong support for the design of knitted fabrics.

With the rapid development of 3D clothing virtualization technology, accurate prediction and classification of fabric drapes become particularly important in clothing design and production. Kim et al. [9] explored a fabric drape prediction method for 3D clothing virtualization and introduced new advances in clothing science and technology based on fabric performance classification. 3D clothing virtualization technology, as an important means of modern clothing design and production, can achieve precise modelling and virtual display of clothing. However, accurately simulating the drape of fabrics in virtual environments remains a technical challenge. The drape of fabrics not only affects their appearance but also directly affects the comfort and functionality of wearing. Therefore, researching and developing fabric drape prediction and classification techniques for 3D clothing virtualization is of great significance. The intelligent clothing styling CAD system, as an important technology in the field of clothing design, can significantly improve the work efficiency of designers, reduce design costs, and promote innovative development in the clothing industry. Lee et al. [10] explored the design and implementation of a component-based intelligent clothing modelling CAD system. The component-based intelligent clothing modelling CAD system is a comprehensive software platform that integrates multiple functions. This system can help designers quickly and accurately complete clothing design and provide real-time feedback and optimization suggestions, greatly improving design efficiency and quality. The system has established a comprehensive database for storing and managing clothing design-related data. In the field of clothing pattern production, the introduction of these technologies has brought unprecedented convenience and innovative space to designers. Linet et al. [11] explored a clothing pattern-making method based on computer vision and multimedia analysis technology, as well as its application value in clothing design and production. Computer vision technology refers to the simulation of biological vision using computers and related devices, which can process and analyze the obtained image or video information. Computer vision technology plays an important role in clothing pattern production. Computer vision technology can achieve automated image processing and recognition. Designers can use this technology to convert traditional hand-drawn patterns into digital formats and edit, adjust, and optimize them. This not only improves the efficiency of pattern-making but also makes the patterns more precise and delicate.

In emotion-driven computer-aided technology, designers can use software tools to transform their emotions into specific design parameters and graphic elements. Further refinement through technical means enables the work to accurately convey the designer's emotions and intentions. This fusion not only enhances the artistic quality of design but also makes clothing design more in line with people's aesthetic and emotional needs. The application of computer-aided technology driven by emotions in clothing design not only provides designers with a broader design space but also provides new perspectives and methods for clothing design research. Through in-depth research on the design process driven by emotions, Liu [12] has better understood the creative thinking and emotional expression mechanisms of designers, providing more scientific guidance for future clothing design. In the performance of Yue opera, clothing is not only a symbol of character identity and personality but also an important carrier of opera emotions and cultural connotations. With the advancement of technology, virtual simulation technology has provided new possibilities for the design of Yue Opera costumes. Liu et al. [13] explored the virtual simulation and clothing design of Yueju costumes based on Yueju elements. Yue opera costumes have strong ethnic characteristics and artistic styles. Its design inspiration mostly comes from ancient clothing, emphasizing the smoothness of lines and the harmony of colours. Virtual simulation technology provides a new design platform for Yue Opera costume design. Designers can use 3D modelling software to construct realistic virtual clothing models based on the characteristics and elements of Yue Opera costumes. These models can be displayed and modified from multiple angles and angles on a computer, allowing designers to more intuitively experience the visual and wearing effects of clothing.

With the rapid development of the textile and fashion industries, the extraction and utilization of elements in clothing design and production processes have become increasingly important. In order to improve design efficiency and optimize production processes, Moniruzzaman and Oishe [14] introduced a method of using CAD systems to design clothing element extraction solutions, aiming to provide useful references for practitioners in the textile and fashion technology fields. Import clothing images into a CAD system and perform preprocessing operations such as denoising and enhancing contrast to improve image quality and provide a solid foundation for subsequent element extraction. It utilizes the image recognition function of CAD systems to automatically recognize elements such as patterns, colours, and textures in clothing images. These elements can be feature-extracted and classified through algorithms for subsequent design and application. Zhang [15] explored the application of CAD computer vision design in the extraction of elements in vocational clothing design. As an important field for cultivating professional talents, vocational clothing design has always been committed to exploring new design methods and means. CAD computer vision design, as an advanced design technology, has the advantages of efficiency, accuracy, and visualization and has been widely applied in the field of clothing design. Through CAD computer vision design, designers can more conveniently extract clothing elements to achieve design innovation and personalized customization. Designers can modify the dimensions, proportions, colours, etc., of elements as needed to better meet design requirements. In addition, CAD systems can also achieve automatic splicing and combination of elements, providing designers with more creative space. Panneerselvam and Prakash [16] studied the application algorithm of floating control fabric for computer-aided jacquard design of different pattern fabrics, aiming to improve the accuracy and efficiency of jacquard design and provide strong support for the development of the textile industry. Jacquard design is an important part of fabric design, and its quality and efficiency directly affect the appearance and performance of the fabric. Traditional jacquard design methods mostly use manual drawing, which is not only time-consuming and labor-intensive but also difficult to ensure the accuracy and consistency of the design. Therefore, studying computer-aided jacquard pattern design algorithms has important practical significance and application value. Different pattern fabrics have their own unique characteristics and needs. Therefore, in the process of jacquard pattern design, it is necessary to choose appropriate algorithms and parameters based on the characteristics of different pattern fabrics to achieve the best design effect.

The design of gesture-controlled lighting textiles based on computer vision mainly relies on the combination of computer vision technology and intelligent textiles. The design of gesture-controlled lighting textiles based on computer vision has led to a revolution. Tan et al. [17] delved into the principles, applications, and future development trends of this technology. Computer vision technology can capture and analyze real-time hand gesture information, while smart textiles can convert this information into control commands for lighting equipment. Specifically, smart textiles are equipped with sensors and microprocessors that can receive signals from computer vision systems. When users make specific gestures, the computer vision system recognizes and parses these gestures and then sends instructions to smart textiles through wireless transmission technology. After receiving instructions, smart textiles will trigger corresponding lighting devices to respond to gestures. The virtual clothing fitting system provides consumers with a brand-new shopping experience through digital technology. However, due to the diversity of human body shapes and clothing styles, virtual fitting systems often face many challenges in practical applications. Among them, accurate evaluation of fit is particularly crucial. Therefore, Won and Lee [18] chose pants, a common type of clothing, as their research object to evaluate the performance of virtual fitting systems by comparing the fit similarity between actual and virtual pants contours. It collected a series of samples of pants in different styles and sizes and invited multiple volunteers to try them on. Measure and record the silhouette data of each volunteer's pants after trying them on. Next, use a virtual clothing fitting system to perform a virtual fitting on the same batch of pants and extract the contour data of the pants after the virtual fitting.

Despite its utility, the current CAD system still faces challenges in terms of intelligence and usability, struggling to cater to designers' varying needs. Our study aims to bridge this gap by integrating extracted clothing design elements with the CAD system, paving the way for a smarter, more streamlined design workflow.

3 FEATURE RECOGNITION AND EXTRACTION MODEL DESIGN OF FASHION DESIGN ELEMENTS

When constructing the feature recognition model of clothing design elements, the first task is to clarify the design ideas and objectives. The purpose of this study is to develop a model that can automatically identify and extract key design elements from clothing images to support the subsequent CAD system innovation and design application. The design idea revolves around the following core points: using computer vision technology to process clothing image data; Learning and extracting the features of design elements in the image through the CNN algorithm; The extracted features are used for the classification and recognition of design elements. Specific objectives include:

(1) Develop an efficient and accurate feature recognition and extraction model, which can handle different types, styles, and quality of clothing image data.

(2) Ensure that the model can identify and extract the key elements that have an important influence on clothing design, such as patterns, colours, fabric textures, etc.

(3) Design reasonable training and optimization strategies for the model to improve its performance and generalization ability.

(4) Formulate scientific model evaluation indexes and methods to evaluate the performance and practicability of the model objectively.

A CAD system is a tool that utilizes computer technology for various design applications. When it comes to model design, data preprocessing emerges as a crucial step. This involves cleaning, transforming, and enhancing the original data to elevate its quality and subsequently improve the model's performance. In the context of feature recognition and extraction of clothing design elements, data preprocessing entails operations like image scaling, cropping, and rotation. These adjustments ensure that the model can accommodate input images of varying sizes and angles. Additionally, to bolster the model's generalization capabilities, adjustments to image brightness and the introduction of noise become necessary. The formula for data standardization is as follows:

$$x' = \frac{x - x_{\min}}{x_{\max} - x_{\min}} \tag{1}$$

Where x represents the original value, while $x_{\min}$ and $x_{\max}$ denote the minimum and maximum values present within the given data set. The formula for z-score standardization is as stated below:

$$z = \frac{x - \overline{x}}{s} \tag{2}$$

Where z is the normalized value, $\overline{s}$ is the average value and s is the standard deviation.

Feature engineering is the process of extracting and constructing useful features from original data. In clothing image recognition, the key features include colour histogram, texture feature, shape feature and so on. These features can be automatically extracted by an image processing algorithm and CNN technology. In addition, in order to improve the performance of the model, a feature selection operation can be carried out to remove redundant and irrelevant features.

CNN is one of the important branches of deep learning, especially suitable for the field of image processing. In the model of feature recognition and extraction of clothing design elements, the CNN model is used to automatically learn and extract the features of design elements in images. The model construction includes the steps of determining the network structure, selecting the appropriate activation function and optimizing the algorithm. The CNN model structure constructed in this article is shown in Figure 1.

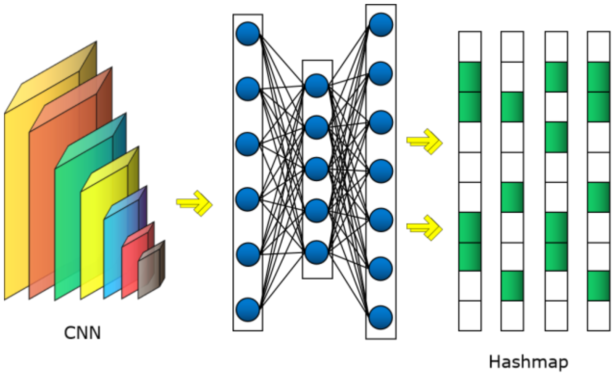

Figure 1: CNN model structure.

In CNN, the convolution operation is as follows:

$$Z_i^{'} = \sigma\left(\sum_{v_j \in N \ v_i} \tilde{\Delta}_{sym}\left[i,j\right] \ WZ_j\right) \tag{3}$$

It can be regarded as $\tilde{\Delta}_{sym}Z \quad N \ v_i$ representing the neighbour nodes of the node v_i and $Z_i^{'}$ represents the updated feature vector Z_j. Assume that the characteristic direction is:

$$h_i \ \ i = 1,2,\cdots,m \tag{4}$$

Integrating the information of k feature vectors to get the vector h^*, the reasonable method is a weighted average, that is:

$$h^* = \sum_{i=1}^{k} a_i h_i \tag{5}$$

Among them a_i is the weight, and the attention mechanism is to get a reasonable a_i.

Based on the distinct traits and recognition demands of clothing images, this article constructs multi-layer architectures, including convolution layers, pooling layers, and fully connected layers. These structures aim to comprehensively capture both local and global features present in the images. However, due to the typically large parameter count and computational intensity of the fully connected layer in CNN algorithms, we often employ Dropout technology to mitigate these challenges and enhance the model's generalization capabilities. Dropout involves randomly dropping some neurons, effectively reducing the model's parameter count and computational complexity. This, in turn, helps prevent overfitting. This operation can be expressed by Formula (6). By applying Dropout, the CNN model can be trained and optimized more effectively while maintaining its good performance on unknown data.

$$h_{w,b} \ x \ = f \ W^T x + b \tag{6}$$

In this context, $h_{w,b} \ x$ denotes output data, x signifies input data, $W^T x$ stands for connection weight, b is the offset, and a represents the activation function. The invariance of scale exhibited by the CNN can be visualized in Figure 2.

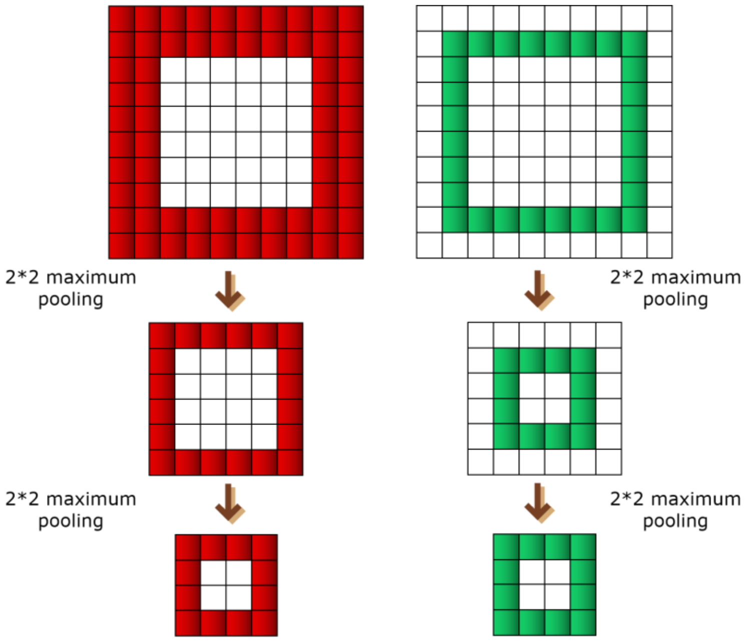

Figure 2: Scale invariance.

The random pool training formula adopted in this article is as follows:

$$p_i = \frac{a_i}{\sum_{k \in R_j} a_k} \tag{7}$$

Once the probability p of each element in R_j has been computed, multiple distributed sampling procedures are carried out by p. Furthermore, to enhance the model's performance, this article incorporates regularization and batch normalization techniques for model optimization. Regularization is usually achieved by adding a weighted penalty term to the loss function, such as L2 regularization:

$$L_{reg} = \lambda \sum_{i,j} W_{ij}^2 \tag{8}$$

Where L_{reg} is the regularization term and λ is the regularization coefficient.

Model training is a process of training a model by using marked data and adjusting its parameters to minimize prediction errors. In this model, the Cross-Entropy loss function is used for training, and the cost function is defined as:

$$loss = -\frac{1}{8} \sum_{i=1}^{8} t_i \ln \hat{y}_i \tag{9}$$

Among them, t_i the target class is 1, and t_i of other classes are 0. In addition to the basic training strategy, this article also considers the transfer learning technology to use the knowledge in the pre-training model to accelerate the training process and improve performance. Transfer learning allows us to transfer the model parameters trained on a large data set to the task as initial parameters for fine-tuning.

4 SIMULATION EXPERIMENT

4.1 Design and Implementation of Simulation Experiment

Before the simulation experiment, the first task is to prepare the appropriate data set. Aiming at the task of feature recognition and extraction of clothing design elements, this study collected and sorted out a large number of clothing image data containing different design elements. The selection of data sets follows the principles of diversity, representativeness and accessibility to ensure that the model can effectively identify design elements in various scenarios. The preprocessing of the data set includes image cleaning, labelling and enhancement. Low-quality, repetitive and task-independent images are removed in the cleaning process to ensure the purity of the data set. Labelling invited professionals in the fashion field to accurately label the design elements in the image, providing reliable label information for model training. Furthermore, to bolster the model's generalization capabilities, this article incorporates image enhancement techniques such as rotation, scaling, cropping, and brightness adjustments within the data set. Subsequently, the refined data set is partitioned into three distinct components: the training set for educating the model, the validation set for fine-tuning parameters, and the test set for evaluating model performance.

The empirical workflow outlined in this segment follows these sequential steps:

(1) Initialization Phase: Commence by initializing the model parameters based on the CNN architecture devised previously and load any pre-trained weights if available.

(2) Data Acquisition: Procure the training, validation, and testing data subsets from the prepared data set and carry out any prerequisite preprocessing tasks.

(3) Training Iteration: Train the model using the designated training data while updating the model parameters iteratively through the backpropagation algorithm and an optimizer. During training, intermittently validate the model's progress using the validation data subset to assess its current state and efficacy.

(4) Performance Evaluation: Upon the completion of the training cycle, appraise the model's proficiency by evaluating it against the testing data subset and computing relevant performance metrics.

(5) Result Interpretation: Delve into the experimental findings to discern the strengths and weaknesses of the model. Juxtapose its outcomes with those of baseline models to underscore the study's advancements and efficacy. Moreover, deliberate on any potential issues or shortcomings within the results, providing a basis for future iterations and enhancements.

Through simulation experiments, this section obtains the performance of the feature recognition and extraction model of clothing design elements on the test set. The specific results include classification performance indicators such as accuracy, recall, and F1 score and more detailed analysis results such as the ROC curve.

In the experimental section, we conduct functional, performance, and user experience testing. We compared our CNN algorithm with other algorithms to comprehensively evaluate its performance. Among them, the accuracy is shown in Figure 3.

On the test dataset, the accuracy of the CNN-based method reached 95.15%, while the accuracy of GA and RNN algorithms were 78.6% and 82.8%, respectively. The results indicate that CNN-based methods have high accuracy in identifying design elements and classifying design schemes. The recall rate is shown in Figure 4.

The recall curve of this method is also better than GA and RNN algorithms. Specifically, the recall rate of this method is 97.8%, while the recall rates of GA and RNN algorithms are 69.8% and 86.5%, respectively. This means that the method in this article can identify the relevant design elements more comprehensively and reduce the possibility of missing inspections. The F1 score is shown in Figure 5.

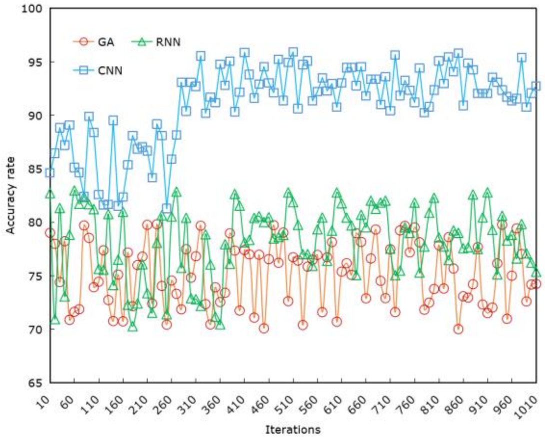

Figure 3: Accuracy.

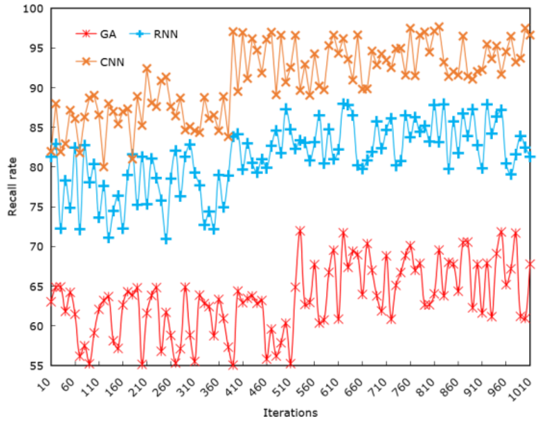

Figure 4: Recall rate.

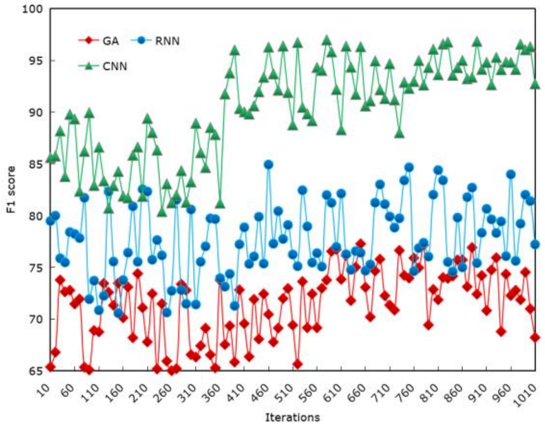

Figure 5: F1 score.

The F1 score curve of this method is higher than that of GA and RNN algorithms. Specifically, the F1 score of this method is 96.3%, while the F1 scores of GA and RNN algorithms are 75.4% and 82.1%, respectively. This result further confirms the superiority of this method in accuracy and completeness.

The ROC curve, which plots the true sample rate on the vertical axis against the false positive sample rate on the horizontal axis, serves as a tool for assessing model performance across varying thresholds. Illustrated in Figure 6 is a comparative analysis of the ROC curves obtained from this method versus those of the GA and RNN algorithms.

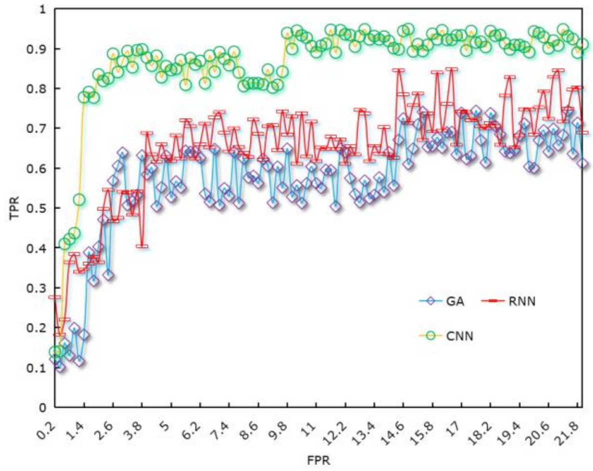

Figure 6: ROC curve.

The figure reveals that the ROC curve of this method is situated nearer to the upper left corner, indicating a higher TPR and a lower FPR. This signifies that the method described in this article exhibits consistent performance across various thresholds, demonstrating robustness and strong generalization capabilities.

The experimental results aforementioned clearly demonstrate that this method outperforms the GA and RNN algorithms in terms of accuracy, recall, F1 score, and the ROC curve. These findings unequivocally emphasize the notable benefits of the innovative CAD system in enhancing design efficiency and quality. Specifically, this approach offers more precise identification of design elements, more comprehensive coverage of related design schemes, and consistent performance across different thresholds. These strengths equip designers with more effective and dependable design support tools, thereby fostering innovation and progress within the fashion design industry.

4.2 Analysis of Simulation Experiment Results

After conducting the simulation experiment and thoroughly analyzing the results, this section arrives at the following conclusions:

Firstly, the clothing design element recognition and extraction model introduced in this research has demonstrated excellent performance in the simulation, exhibiting high accuracy and dependability. This validates the model's efficacy and real-world applicability.

Secondly, the preparation and handling of datasets play a pivotal role in determining the model's overall performance. Future studies could focus on refining dataset collection, labelling, and enhancement techniques to enhance the model's generalization capabilities and overall performance.

Lastly, while this study has made significant progress, there are still areas for improvement and potential challenges to address. For instance, exploring more intricate network architectures and optimization algorithms could further boost the model's performance. Additionally, to better identify specific design elements, incorporating attention mechanisms or similar approaches could be beneficial. Moreover, extending the application of this methodology to other fashion-related tasks would be a worthwhile pursuit to assess its broader applicability and practicality.

5 INNOVATION AND INTEGRATED APPLICATION OF CAD SYSTEM

5.1 Functional Analysis of Existing CAD System

Before discussing the innovation and integrated application of the CAD system, the functions of the existing CAD system are analyzed in depth. Traditional CAD systems mainly serve designers and engineers. In the field of clothing design, they usually provide basic drawing, editing and measuring tools for creating and modifying clothing patterns. These systems often also support material library management, colour filling and simple 3D simulation functions. However, the existing CAD system has limitations in dealing with complex design elements and automatic design processes. They often can't directly identify and analyze the design elements in the image and can't automatically adjust and optimize the design scheme according to the designer's intention. In addition, the existing system usually lacks intuitive and efficient interaction with designers, which makes the design process still rely on a lot of manual operation and empirical judgment.

5.2 Innovative CAD System Design Concept and Function Planning

Aiming at the deficiency of existing CAD systems, this section puts forward an innovative CAD system design concept. This concept emphasizes user-centred and realizes the automation and intelligence of the design process by introducing AI and ML technologies. Specifically, the innovative CAD system should have the following functions:

(1) Intelligent design element identification and extraction: It can automatically identify and extract design elements from images or videos, such as colours, patterns, fabric textures, etc., and provide designers with rich design materials.

(2) Automatic design optimization and suggestion: Based on the extracted design elements and the input of designers, the system can automatically adjust and optimize the design scheme, such as automatic colour matching and automatic layout, so as to improve design efficiency.

(3) Intuitive and efficient interaction: By introducing natural language processing, gesture recognition and other technologies, a more natural and efficient interaction with designers can be realized, and the operation difficulty and learning cost can be reduced.

(4) Cross-platform collaboration and sharing: support seamless docking with other design tools, production management systems and other platforms, realize the sharing and collaborative work of design data, and improve the coordination of the whole design and production process.

5.3 Integration Method of Clothing Design Element Extraction and CAD System

To achieve the functional planning of an innovative CAD system, the integration of clothing design element extraction technology with the CAD system is imperative. This article adopts the following methods:

(1)API interface integration: by calling the API interface provided by the CAD system, the design element extraction function is embedded into the CAD system, and the seamless connection between the two is realized.

(2) Plug-in or extension module development: A plug-in or extension module is developed for a specific CAD system, and the design element extraction function is provided to users as an additional function of the CAD system.

(3) Cloud service platform integration: build a cloud service platform, deploy the design element extraction function in the cloud, and provide design element extraction service for CAD system through cloud service to realize cross-platform and cross-terminal integrated applications.

After determining the design concept and function planning of an innovative CAD system, this article begins to develop and realize the prototype system. The process includes system architecture design, functional module division, algorithm implementation and debugging, interface design and development. In the development process, pay attention to the expansibility, maintainability and user experience of the system to ensure that the system can meet the actual needs of designers and have a good user experience.

5.4 System Testing and Application Case Presentation

To assess the efficacy of the innovative CAD system, this section has undergone comprehensive testing. This included functional, performance, and user experience evaluations. The results indicated that the system could precisely identify and extract design elements from images, adapt and enhance design plans automatically, offer an intuitive and effective interactive approach, and facilitate seamless collaboration with other design tools, as summarized in Table 1.

Test category	*Test content*	*Test result*
Functional test	Identification and extraction of design elements	The system can accurately identify and extract design elements from images.
	Automatic adjustment and optimization of design schemes	The system can automatically adjust and optimize the design scheme based on the extracted design elements
	Collaborate with other design tools.	The system supports seamless integration and collaborative work with other design tools.
Performance test	Response time	The system has a fast response speed and meets real-time design requirements.
	Processing capacity	The system is capable of processing large-scale datasets while maintaining efficient performance.
	Stability	The system runs stably without any obvious crashes or malfunctions.
User experience test	Interaction mode	The system provides an intuitive and efficient way of interaction, reducing operational difficulty and learning costs.
	Interface design	The system interface is friendly and in line with user habits.
	Usability	Users can quickly get started and proficiently operate the system to complete design tasks.

Table 1: Summary of test results of innovative CAD system.

In addition, this section shows several typical application cases, such as intelligent colour scheme generation and automatic pattern layout adjustment (as shown in Figure 7).

Determining the colour scheme in conventional design processes typically relies on the designer's individual expertise and artistic sensibilities, a method that is both time-intensive and prone to subjectivity. However, by innovating the intelligent colour-matching function of the CAD system, the system can analyze the colour-matching law of design elements based on the CNN algorithm and automatically generate a harmonious and creative colour-matching scheme for users. This function has been proved in experiments that it can significantly reduce the decision-making time of designers in colour matching. Furthermore, it provides more diverse and innovative TINT for designers to choose from.

Figure 7: Typical application case.

Furthermore, pattern layout is an important link in clothing design, which directly affects the overall visual effect of clothing. In the traditional CAD system, the layout adjustment of patterns needs to be done manually by designers, which is inefficient and error-prone. In the innovative CAD system, by integrating advanced image recognition and processing technology, the system can automatically identify pattern elements and automatically adjust their layout according to preset rules or user preferences. In the experiment, the system showed excellent automatic adjustment ability, which not only greatly improved the accuracy and efficiency of layout adjustment but also made a more beautiful and more in line with the design principles through algorithm optimization.

The above cases show the advantages of innovative CAD systems in improving design efficiency and quality, which have been recognized and praised by designers.

6 CONCLUSIONS

This research aims to create a cutting-edge CAD system capable of automatically recognizing and extracting crucial fashion design elements, providing designers with intelligent support. By delving into the intricacies of the CNN algorithm, we have successfully established a robust model for recognizing and extracting fashion design features. Its exceptional performance in simulation tests attests to its precision and dependability.

During the model's development, we emphasized the significance of data preprocessing and feature engineering. We enhanced the model's generalizability and performance through meticulous data augmentation and strategic feature selection. Additionally, we refined the CNN structure, incorporating advanced network layers and training techniques to boost recognition accuracy and efficiency further.

Regarding CAD system innovation and integration, we analyzed the functional limitations of existing systems and proposed a novel design philosophy centred on user-friendliness, intelligence, and automation. By integrating our garment design element extraction technology with the CAD system, we achieved a significant leap in design automation and intelligence, elevating both efficiency and quality.

Looking ahead, our methodology has the potential to revolutionize other fashion-adjacent fields like textile and accessory design, demonstrating its broad applicability and practicality. We also foresee exploring hybrid approaches that combine NN algorithms with other ML techniques to enhance model performance and stability. Moreover, we are excited about the prospects of integrating emerging technologies like augmented reality and virtual reality into fashion design, exploring their synergies with our innovative CAD system.

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