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Computer-Aided Design AND APPLICATIONS

Application of Artistic Design CAD System Integrating Neural Network and Computer Vision Algorithm

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Abstract. The core problem of this study is how to effectively integrate Neural Networks (NN) and computer vision algorithms to design a more intelligent and efficient CAD system for art. In this article, by deeply exploring the application of existing NN and computer vision algorithms in artistic design, a CAD system model of artistic design integrating NN and computer vision algorithm is designed and implemented. Finally, the feasibility of the system is verified by simulation experiments, and the potential and value of the system in practical application are discussed. The results show that this method has achieved remarkable results in various artistic design tasks. The automatic generation system can generate high-quality artistic design schemes according to users' needs, and designers can easily switch between different styles through style transfer technology. In addition, the artistic design evaluation module can provide accurate evaluation results and suggestions for improvement and help designers improve the quality of their work. Compared with traditional methods and other generation models, this method has obvious advantages in automatic generation and optimization of artistic design. It provides new ideas and methods for research in related fields and promotes the technological innovation and application development of artistic design CAD systems.

Keywords: Neural Network; Computer Vision; Artistic Design; CAD System
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1 INTRODUCTION

With the advent of the digital age, image information has become an indispensable part of our lives. For designers and artists, how to effectively retrieve the artworks they need from massive image resources is a challenging problem. For this purpose, Asadi et al. [1] proposed a novel content-based visual art design image retrieval system that integrates colour and texture features. Traditional image retrieval methods often rely on keywords or metadata, which often appear inadequate when dealing with art and design images with complex content and rich details. Content-based image retrieval (CBIR), on the other hand, extracts image features such as colour, texture, shape, etc., to describe and compare images, thus achieving accurate image retrieval. In our system, we first extract features from the input art and design images to obtain their colour histograms and texture features. Then, we compare these features with the image features in the database to find the most similar image. In order to improve retrieval efficiency, we also adopted a similarity calculation method based on K-nearest neighbours (K-NN). Artificial Neural Networks (ANN), particularly Deep Neural Networks (DNN), have garnered remarkable achievements within the domain of computer vision. As an illustration, Convolutional Neural Network (CNN) excels in efficiently extracting features from images, whereas Recurrent Neural Networks (RNN) and Long Short-Term Memory (LSTM) networks are widely employed for processing video sequence data. Virtual reality (VR) technology provides new possibilities for artistic creation. Traditional art creation is limited by physical space and material limitations, while virtual reality technology breaks these limitations and allows artists to create and display in virtual environments. However, artistic creation in virtual environments still poses certain challenges, such as how to generate artistic and creative works and how to interact with users. Cabero et al. [2] presented a case study exploring the application of virtual reality technology that integrates neural networks and computer vision algorithms in the field of art generation. We have developed an innovative virtual reality art generation system by combining the generation ability of neural networks with the image processing ability of computer vision algorithms. The system can generate artwork in real-time in a virtual environment based on user input and preferences. This article provides a detailed introduction to the implementation process, technical challenges, and solutions of the system and verifies its feasibility and effectiveness through experiments. In order to process image information in virtual environments, we adopted computer vision algorithms. Specifically, we used image processing techniques to extract features of the image, such as colour, texture, and shape. These features will be used to guide the generation process of neural networks to ensure that the generated works are consistent with user inputs and preferences. In addition, Generative Adversarial Network (GAN) has also shown great capabilities in image generation and style transfer. In recent years, with the development of deep learning technology, CNN-based methods have made significant progress in art video image stitching. However, these methods suffer from low computational efficiency when dealing with large-scale data. Traditional image stitching methods are usually based on manual design and feature extraction, but these methods have poor performance when dealing with complex art videos. Therefore, Cao [3] proposed a method that combines image registration algorithms with CNN models for art video image stitching. This method first uses image registration algorithms to align images in art videos, then uses CNN models to extract and classify features from the images, and finally performs image stitching based on the classification results. The experimental results show that this method has high accuracy and efficiency in art video image stitching. Art video image stitching is the process of stitching multiple art video images into a complete video according to certain rules and order. In art video production, image stitching is an important technique that can be used to create special effects, enhance visual effects, and so on. With the rapid development of digital technology, the digital storage and transmission of artistic images have become increasingly common. However, this also brings about issues of copyright protection and data security. One effective method to protect the copyright of artistic images and prevent data tampering is to embed watermarks in the images. Traditional watermark embedding methods are usually based on pixel strength or frequency domain transformation, but these methods have poor performance in processing artistic images. In recent years, the development of deep learning technology has provided new ideas for watermark embedding. Dhaya [4] proposed a secure and robust artistic image watermarking scheme based on lightweight CNN. Digital watermarking is a technique that embeds identification information into digital media. By embedding watermarks in digital media, copyright protection and data tracking can be achieved. It adopts a watermark embedding method based on LSB (Least Significant Bit) to embed the watermark information into the least significant bit of the artistic image. This embedding method has high robustness and has little impact on image quality.

With the rapid development of technology, technologies such as artificial intelligence, computer vision, and virtual reality are increasingly integrated into art creation and design teaching in universities. Feng [5] explored how to integrate neural networks and computer vision algorithms to build an intelligent virtual reality environment in order to promote innovation and development in art creation and design teaching in universities. In today's era of informatization and digitization, art creation and design teaching in universities are also undergoing a technological revolution. Traditional teaching methods can no longer meet the needs of modern creative industries for talent cultivation. Emerging technologies such as neural networks, computer vision, and virtual reality provide unlimited possibilities for art creation and design teaching in universities. Through deep learning methods, we can train neural networks to recognize and understand different art styles, such as abstraction, realism, Impressionism, etc. Meanwhile, computer vision algorithms can assist in extracting and analyzing visual elements of artwork, such as colour, lines, shape, and texture. This integration enables machines to not only understand and analyze art but also generate new works of art. Hammad et al. [7] proposed an art and design texture feature steganography classification algorithm based on a unique visual algorithm. This algorithm deeply analyzes the texture features of art and design and uses unique visual algorithms for steganography processing, thereby achieving accurate classification and recognition of steganographic data. Art and design texture features are a unique visual representation of an image, such as colour, shape, structure, etc. By conducting an in-depth analysis of these features, key information in the image can be extracted, providing a basis for subsequent steganography processing. It proposes an art and design texture feature steganalysis classification algorithm based on a unique visual algorithm. This algorithm first preprocesses the input image to extract artistic and design texture features. Then, unique visual algorithms are used to perform steganography on the features and generate steganographic data. Finally, the steganographic data is classified and recognized using a classifier. To verify the effectiveness of the algorithm proposed in this article, we conducted a series of experiments. The experimental results show that the algorithm proposed in this paper has high accuracy and efficiency in the steganalysis and classification of texture features in art and design. Compared with traditional steganalysis algorithms, our algorithm has better performance in handling complex artistic design texture features. Virtual reality (VR) technology has gradually penetrated into various fields, including art education. The art of virtual reality technology that integrates neural networks and computer vision algorithms has brought revolutionary changes to painting teaching. Hui et al. [8] delved into the practical application of this technology in order to bring new insights to art education. A neural network is a computational model that simulates the connectivity of human brain neurons, optimizing its performance by learning a large amount of data. Computer vision algorithms are algorithms that analyze, recognize, and process images, enabling the recognition and extraction of various elements in the image. By combining these two, automatic recognition and transformation of artistic elements can be achieved, providing strong technical support for virtual reality painting. In the practice of art virtual reality painting, firstly, a large number of artworks are learned through neural networks to extract the characteristics and patterns of various art elements. Then, using computer vision algorithms, the input image is analyzed to identify artistic elements such as lines, colours, shapes, etc. Finally, convert these elements into virtual models and present them through virtual reality technology. Through image processing and computer vision, designers can quickly perform colour adjustment, filter processing, style transfer and other operations on images. Some complex computer vision algorithms, such as structured light scanning and 3D reconstruction algorithms, are also used to create digital models from real objects, which greatly enriches the content and form of artistic design.

At present, there are some artistic design CAD systems in the market, and most of them provide basic drawing and design tools, which can help designers complete some routine design tasks. However, these systems also have some obvious limitations. There are still some limitations in creativity, aesthetic feeling and design efficiency. Therefore, how to combine the latest NN and computer vision technology to provide a more intelligent and efficient CAD system for artistic design has become a hot issue in current research. Furthermore, when considering the industrial perspective, artistic design holds profound significance within industries such as advertising, media, and game production. The implementation of a robust artistic design CAD system not only enhances the productivity of designers but also yields substantial economic returns for related sectors. Consequently, this research possesses considerable practical value and applicability.

The innovation of this article can be summarized as the following four points:

A. Automatic generation of artistic design scheme: This study combines DNN and artistic design principles to develop a CAD system that can automatically generate an artistic design scheme. This innovation improves design efficiency and provides users with more inspiration and choices.

B. Art style transfer technology: By using GAN to transfer art style, this study achieved the user-specified style transfer effect. This innovation provides more creative possibilities for artistic designers and enriches the style and expressive force of design works.

C. An objective and accurate artistic design evaluation system: In this study, an artistic design evaluation module based on CNN is designed to assess and optimize artistic design schemes automatically. This innovation provides designers with objective and accurate evaluation results and improvement suggestions, which is helpful to improve the quality of work and meet the needs of users.

D. Adaptive learning and optimization ability: By combining the deep reinforcement learning algorithm, this study has realized the adaptive learning and optimization ability of the artistic design CAD system. This innovation enables the system to intelligently adjust and improve according to user feedback, providing more personalized design and better user experience.

The above innovations have important breakthrough significance in the research of NN and artistic design CAD systems and provide new ideas and methods for research and application in related fields.

The structure of this article is outlined as follows: Initially, we present the research context and significance of both NN and artistic design CAD systems, elucidating the objectives and inquiries addressed in this article. Subsequently, we offer a comprehensive introduction to the CAD system developed through the integration of DNN and principles of artistic design, detailing the methodology and operational sequence of the system. Following this, the viability of the system is substantiated through simulation experiments, and a discussion on its practical potential and value is undertaken. In conclusion, we summarize the findings of our research and propose directions for future investigation.

2 RELATED WORK

Artistic images are a type of visual information with unique charm and value, but they are often disturbed by noise during the collection, transmission, and storage processes, leading to a decrease in image quality. Denoising has become an important research topic in order to protect the original quality and integrity of artistic images. In recent years, with the rapid development of deep learning technology, convolutional neural networks (CNNs) have achieved significant results in the field of image processing, providing new ideas and methods for denoising art images. Ilesanmi and Ilesanmi [9] preprocess the input art images, including grayscale, standardization, and other operations, to facilitate subsequent network training and prediction. Train CNN models using a large amount of noisy and noise-free image data to extract useful features automatically and learn the ability to remove noise. Input the preprocessed art image into the trained CNN model for prediction and obtain the denoised image. Although CNN has achieved significant results in denoising art images, it also faces some challenges and complexities. Firstly, the types and levels of noise in artistic images often vary, and different CNN models need to be designed for different types and levels of noise. Secondly, artistic images have rich details and texture information, and how to maintain the details and texture information of the image while removing noise is also an important research topic. Texture feature extraction in art and design is an important research direction in the field of computer vision, which is of great significance for tasks such as style recognition, image classification, and object detection of artworks. Traditional texture feature extraction methods for art and design are usually based on manually designed feature descriptors, such as SIFT, SURF, etc. However, these methods often have poor results when dealing with complex textures. In recent years, with the development of deep learning technology, neural networks have made significant progress in extracting texture features in art and design. Keyvanpour et al. [10] conducted an in-depth analysis and review of art design texture feature extraction methods that integrate neural networks and computer vision algorithms. Reviewing relevant literature, it summarized the research status, main methods, existing problems, and future development trends in this field. Researchers have begun to attempt to combine neural networks with computer vision algorithms to further improve the accuracy and efficiency of texture feature extraction in art and design. For example, some research works combine CNN with wavelet transform to extract high-frequency components from images and then use CNN for feature learning and classification of high-frequency components. This method can fully utilize the advantages of neural networks and computer vision algorithms to improve the performance of texture feature extraction in art and design.

With the rapid development of deep learning technology, neural networks have achieved significant results in the field of computer vision. Convolutional neural networks (CNN), as an important model in deep learning, can automatically learn image feature representations through multi-layer convolution operations and have been widely used in art image processing. Meanwhile, computer vision algorithms such as colour histograms and grayscale co-occurrence matrices are also used to extract colour and texture features from images. Color and grayscale co-occurrence matrix are two commonly used image feature descriptors. Colour histograms can reflect the overall colour distribution of an image, while grayscale co-occurrence matrices can describe the local texture information of the image. Khaldi et al. [11] combined these two features and used neural networks and computer vision algorithms to process art images. Specifically, we first extract the colour histogram and grayscale co-occurrence matrix features of the image separately and then input these features into the neural network for learning and classification. The experimental results show that the method combining colour and grayscale co-occurrence matrix features has good performance in processing art images. Compared with traditional single-feature extraction methods, the method proposed in this paper can more accurately describe the features of art images, thereby improving the accuracy of image classification and recognition. Patternless fabrics have a wide range of applications in fields such as clothing and household goods. However, due to its simple surface structure, defect detection of patternless fabrics has become a challenging problem. Traditional defect detection methods are usually based on image processing techniques such as filtering and edge detection, but these methods have poor performance when dealing with patternless fabrics. Therefore, Li et al. [12] proposed a visual defect detection method for patternless fabrics based on multidirectional binary mode neural networks. A multidirectional binary pattern neural network is a new type of neural network structure with strong feature learning and classification capabilities. In this article, we designed a multidirectional binary pattern neural network model for feature extraction and classification of patternless fabrics. This model includes multiple convolutional layers, pooling layers, and fully connected layers, which can automatically learn the surface features of patternless fabrics and classify defects through a classifier. The experimental results show that the visual defect detection method for patternless fabrics based on multidirectional binary mode neural networks has high accuracy and efficiency in processing patternless fabrics. Compared with traditional defect detection methods, this method can more accurately identify surface defects of patternless fabrics, improving the accuracy and efficiency of defect detection.

Colour segmentation of artistic images is an important research direction in the field of computer vision. For multi-colour art images, the colour distribution is diverse and complex; therefore, achieving accurate colour segmentation is a challenging task. Traditional colour segmentation methods are usually based on the colour distribution characteristics of pixels, such as RGB colour space or HSV colour space, but these methods have poor performance in processing multi-colour art images. To address this issue, Ouyang et al. [13] proposed a multi-colour art image colour segmentation method based on node-growing self-organizing mapping (NGSOM). NGSOM is a variant of self-organizing mapping (SOM), which is achieved through node growth. NGSOM can adaptively learn the features of input data and classify the data based on the learning results. In this article, we apply NGSOM to the colour segmentation of multi-colour art images. Firstly, we take the colour distribution features of the image as input data and then use NGSOM to learn the data. Based on the learning results, we can assign the pixels of the image to different colour clusters to achieve colour segmentation. Artistic visual image segmentation is an important research direction in the field of computer vision, aimed at accurately segmenting artistic elements in images from background or other elements. Traditional image segmentation methods are usually based on manually designed feature descriptors, such as SIFT, SURF, etc., but these methods have poor performance when dealing with complex artistic images. In recent years, with the development of deep learning technology, methods based on convolutional neural networks have made significant progress in art visual image segmentation. However, these methods suffer from low computational efficiency when dealing with large-scale data. Therefore, Reska and Kretowski [14] proposed a GPU-accelerated art visual image segmentation method based on level sets and multiple texture features. The level set algorithm is a classic method used for image segmentation, which can handle the problems of shape changes and topological structure changes. In artistic visual image segmentation, the level set algorithm can accurately segment artistic elements from the background or other elements. Meanwhile, texture features are important features that describe local details and surface structure of an image. In artistic visual images, texture features can reflect the style and detail information of artistic elements. Therefore, combining the level set algorithm and various texture features can more accurately describe the features of artistic visual images.

Art images are a type of image with high abstraction and complexity, and their processing and analysis have always been a research focus in the field of computer vision. Traditional image processing methods are usually based on manually designed feature descriptors, but these methods have poor performance when dealing with complex artistic images. In recent years, with the development of deep learning technology, neural network-based methods have made significant progress in art image processing. However, these methods suffer from low computational efficiency when dealing with large-scale data. Therefore, Zeng et al. [15] proposed a method of integrating neural networks and computer real-time learning for high-performance photo enhancement in art image adaptive 3D lookup tables. The neural network is a computational model that simulates the connectivity of human brain neurons with powerful feature learning and classification capabilities. In art image processing, neural networks can automatically extract useful features by learning a large amount of art image data and use these features to recognize and classify art elements. Real-time computer learning is a technology based on computer vision that can learn and process input image data in real-time. This article combines neural networks with real-time computer learning to achieve efficient enhancement and adaptive processing of artistic images. While numerous CAD systems offer an extensive range of features and utilities, they often come with a high degree of operational complexity and a steep learning trajectory, which can negatively impact the user experience and productivity of designers. Moreover, current CAD systems have room for advancement in terms of intelligent capabilities, including facets such as design suggestions, automated error rectification, and style recommendations. Consequently, the primary objective of this investigation is to address the limitations inherent in existing artistic design CAD systems and enhance the system's level of intelligence and user-friendliness by merging Neural Network technologies with computer vision algorithms.

3 A CAD SYSTEM MODEL OF ARTISTIC DESIGN INTEGRATING NN AND COMPUTER VISION ALGORITHM

3.1 Selection and Implementation of the NN Model

The CAD system model of artistic design proposed in this study is an intelligent design tool integrating NN and computer vision algorithms. The system aims to provide an efficient and intelligent design environment so that designers can complete various artistic design tasks quickly and accurately. The main functions of the system include image processing, style migration, automatic design suggestion, error detection and repair.

In the artistic design CAD system proposed in this article, a variety of NN models are selected in order to support different design tasks and improve their efficiency and accuracy. For the task of image processing and style transfer, this article uses GAN to generate high-quality image output. GAN is an NN model composed of a generator and a discriminator. By training two networks to play a game, a realistic image can be generated. In the system, GAN is used to handle the tasks of image processing and style transfer, and the style characteristics of the source image are learned by training the generator and transferring it to the target image. This method can generate highly realistic and diversified image output, which provides more creativity and choices for artistic designers.

A binary image $M \times N$ can be expressed as a 2D array $A_{M\times N} = [a_{ij}]$, where the pixels correspond to the object's target points. The pixels $a_{ij} = 0$ correspond to the background points. The set of background points is:

$$B = \{(x,y) \big| a_{xy} = 0\} \tag{1}$$

Then, the distance transformation is to find all the pixel points (i,j) in A:

$$d_{ij} = \min\{D[(i,j),(x,y)],(x,y) \in B\} \tag{2}$$

Among them:

$$D[(i,j),(x,y)] = \sqrt{(i-x)^2 + (j-y)^2} \tag{3}$$

Thereby obtaining the Euclidean distance transformation image $D_{M\times N}$ of the binary image A.

In addition to image processing and style transfer tasks, this system also needs to support automatic design suggestions and error detection tasks. In order to accomplish these tasks, this article uses CNN to extract image features and combines RNN to deal with the design process of serialization. Specifically, CNN is used to learn the feature representation in the image, and RNN is used to model and process the serialized information in the design process. This method can effectively identify problems and mistakes in design and provide automatic suggestions and optimization schemes, thus helping designers quickly adjust and improve design schemes. For NN, when the quantity of input nodes is greater than the quantity of output nodes, the optimal quantity of hidden layer nodes h:

$$h = \sqrt{M \times N} \tag{4}$$

Where N is the quantity of input nodes and M is the quantity of output layer nodes. Both CNN and RNN employ error gradients to adjust the weights in incremental steps. An enhancement strategy involves incorporating the previous gradient as a momentum term within the weight adjustment process, as illustrated by the formula provided below:

$$\Delta w_{ji}(n) = -\eta \sum_{t=0}^{n} a^{\eta-t} \frac{\partial \varepsilon(t)}{\partial w_{ji}(t)} = -\eta \frac{\partial \varepsilon(n)}{\partial w_{ji}(n)} - \eta \sum_{t=1}^{n} a^{\eta-t} \frac{\partial \varepsilon(t)}{\partial w_{ji}(t)}, \quad 0 < a < 1 \tag{5}$$

The present gradient exerts the greatest influence within $\Delta w_{ji}(n)$, with its coefficient consistently maintained at one. The impact of the preceding gradient $\Delta w_{ji}(n)$ diminishes in an exponential manner with respect to $a^{\eta-t}$. The function representing the error is given by:

$$E_p = \frac{\sum_t (t_{pi} - o_{pi})^2}{2} \tag{6}$$

t_{pi} and o_{pi} are the anticipated output and the output derived from the network's calculations, respectively.

In order to automatically assess and optimize the artistic design scheme, this article also designs an artistic design evaluation module using CNN. This module can automatically analyze and assess the design scheme and provide targeted improvement suggestions and optimization schemes. In this method, CNN is used to learn the feature representation of design schemes, and the design schemes are automatically graded and ranked with evaluation indexes. It can help designers assess and optimize their own design schemes more objectively and improve the quality of design. The model structure is shown in Figure 1.

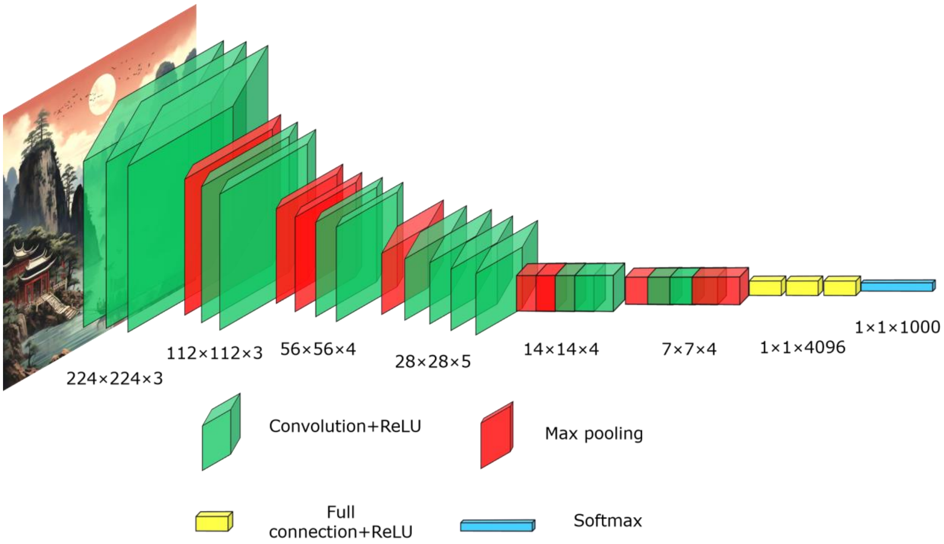

Figure 1: Model structure.

In implementation, this article uses the DL frameworks TensorFlow and PyTorch to construct and train these NN models. In order to improve the performance of the model, many optimization strategies are adopted, such as learning rate attenuation and batch normalization. Among them, learning rate attenuation is a common optimization strategy, which can gradually reduce the learning rate according to the progress of training so as to avoid the shock or over-fitting of the model in the later stage of training. In this article, the learning rate is dynamically adjusted according to the performance of training rounds or verification sets to ensure that the model can be properly updated at different stages. Batch normalization is a method of inserting normalization operations between NN layers. In this article, the batch normalization layer is inserted in the appropriate position of CNN and RNN to improve the training effect and performance of the model. Determine the mean value of the data within smaller subsets:

$$u_B = \frac{1}{m}\sum_{i=1}^{m} x_i \tag{7}$$

In this context, m it denotes the size of each batch within the stochastic gradient descent algorithm. Subsequently, our task is to determine the variance of the data within these smaller batches:

$$\sigma_B^2 = \frac{1}{m}\sum_{i=1}^{m} (x_i - u_B)^2 \tag{8}$$

Carry out a normalization procedure on every individual element within the batch:

$$\hat{x}_i = \frac{x_i - u_B}{\sqrt{\sigma_B^2 + \int}} \tag{9}$$

Lastly, operations involving scaling and migration are undertaken to revert the data back to its original distribution state:

$$BN_{r,\beta(x_i)} = \gamma \hat{x}_i + \beta \tag{10}$$

γ and β are two trainable parameters.

In the aspect of computer vision algorithms, image processing, object detection and image segmentation are mainly selected to support the task of artistic design. In this model, an image processing algorithm is used to adjust the brightness, contrast and colour balance of the image, an object detection algorithm is used to identify objects in the image, and an image segmentation algorithm is used to extract specific areas in the image. In implementation, computer vision libraries such as OpenCV and PIL are used to process image data. In order to improve the efficiency and accuracy of the algorithm, this article also adopts many optimization strategies, such as multi-scale detection and non-maximum suppression.

3.2 Design and Implementation of Fusion Strategy

In order to effectively integrate NN with the computer vision algorithm, this article designs the following fusion strategies: ⊖ Data fusion: the image data generated by NN is fused with the image data processed by the computer vision algorithm to obtain a richer and more accurate image representation. This can be achieved by overlaying, mixing or fusing different data layers. ⊜ Task fusion: the output results of different NN and computer vision algorithms are fused to complete more complex design tasks. For example, this article fuses the style transfer network with the output of the image segmentation algorithm to achieve image segmentation based on specific styles. ⊛ Interactive integration: It provides an interactive design interface, which enables designers to easily adjust the parameters and settings of NN and computer vision algorithms. In this way, designers can adjust the output effect of the system according to their own needs and preferences.

In implementation, this article adopts a modular design method to realize these fusion strategies. Different NN and computer vision algorithms are packaged into independent modules, which are connected and interact through standard interfaces. In this way, it is convenient to add, replace or combine different modules to achieve different design requirements.

4 SYSTEM IMPLEMENTATION AND SIMULATION EXPERIMENT

4.1 System Implementation Environment and Tools

This section uses Python as the main programming language and uses DL frameworks such as TensorFlow and PyTorch to build and train the NN model. In order to improve the performance of the system, GPU acceleration technology is also used to speed up the training and reasoning of the model. Moreover, computer vision libraries such as OpenCV and PIL are used to process image data, and GUI toolkits such as Tkinter are used to develop interactive design interfaces.

In order to train and assess the artistic design CAD system, this section uses a number of publicly available data sets, including image classification, object detection, and style transfer. These data sets contain various types of images and labelling information, which can be used to train and assess NN models and computer vision algorithms. The details of the data set are shown in Table 1.

Dataset name	*Task Type*	*Number of images*	*Labeling information*	*Data set description*
ImageNet	Image classification	1,000,000+	Category label	Contains more than 1000 categories of images, which are widely used in the training and evaluation of image classification tasks.

Common Objects in Context	Target detection, image segmentation, etc.	330,000+	Bounding box, division mask, etc.	It provides rich labelling information for tasks such as target detection and image segmentation and is suitable for various computer vision tasks.
WikiArt	Classification and Style Analysis of ArtWorks	80,000+	Artists, style labels, etc.	Contains a large number of images and related information on artworks, which is suitable for the task of artworks classification and style analysis.
StyleTrans fer Dataset	Style transfer	10,000+	Source image, style image, migration result image, etc.	Provide multiple pairs of source images, style images and corresponding style transfer result images for training and evaluating style transfer algorithms.
Design Benchmar k	Artistic design evaluation	5,000+	Design scheme, evaluation index, etc.	It contains several artistic design schemes and corresponding evaluation indexes, which are used to train and assess the artistic design evaluation system.

Table 1: The specific situation of the data set.

In data preprocessing, the following operations are carried out: image cropping scaling to ensure the standardization of input data. For NN training, this article also carries out data enhancement operations, such as random flipping, rotation and cropping, to increase the diversity and generalization ability of data.

4.2 Experimental Design and Implementation

A series of simulation experiments have been devised to ascertain the viability of the system. With regard to the experimental execution, the initial step involves training and refining the model, followed by adjustments to its parameters and structure to achieve enhanced performance. Then, the trained model is used to infer and predict, and the corresponding output results are generated. Finally, the performance of the system is quantitatively assessed by using standard evaluation indicators. In this section, the tasks of image classification, object detection and style transfer are selected as the experimental objects, and the corresponding data sets are used for training and testing. The response time of the algorithm during training is shown in Figure 2. The response time of the algorithm during testing is shown in Figure 3.

The response time of the image classification task is high in the initial stage of training and gradually decreases and tends to be stable with the training. This shows that NN gradually learns effective feature representation in the training stage, which improves the accuracy of classification and reduces the computational complexity. The response time of the target detection task is relatively long because it needs to process more complex image information and generate the corresponding bounding box and segmentation mask. However, with the progress of training, the response time of the algorithm also decreased, indicating that NN gradually optimized the processing efficiency of target detection. The response time of the style transfer task shows a relatively stable trend in the training stage, which shows that the style transfer algorithm has achieved good results in the early stage of training.

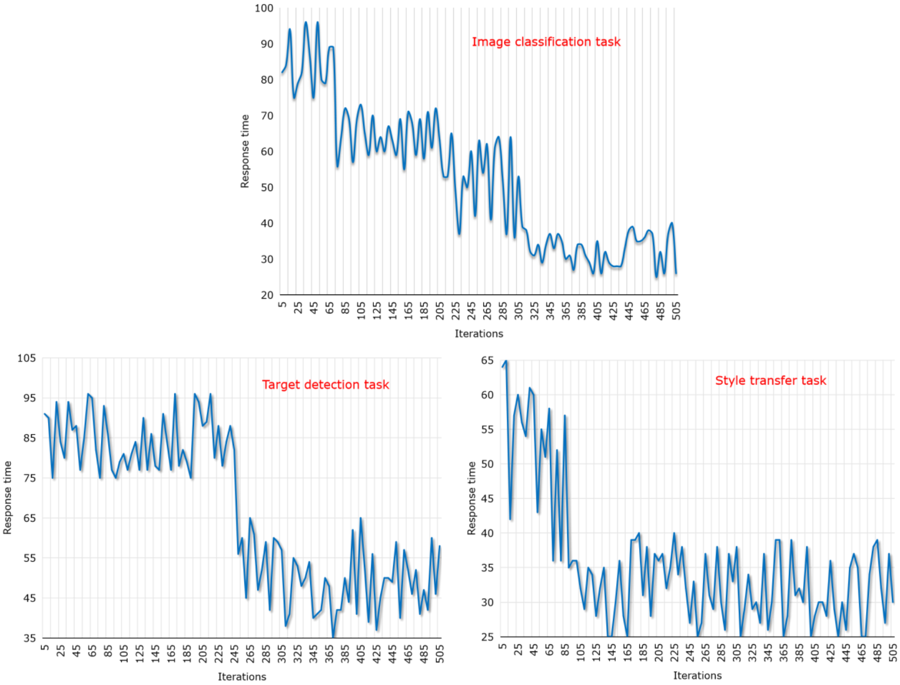

Figure 2: Response time of the algorithm during training.

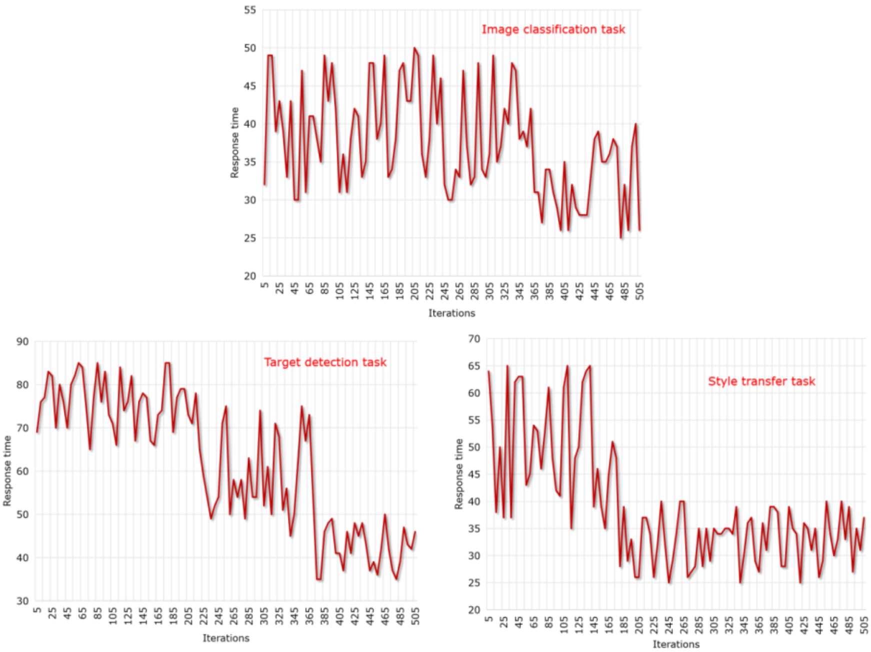

Figure 3: Response time of the algorithm during testing.

Compared with training, the response time of testing is generally lower because the testing process does not need to carry out backpropagation and weight updates, and the calculation amount is relatively small. The test response time of the image classification task is low and stable, which shows that the trained model has good generalization ability and can quickly classify new images. The test response time of the target detection task is relatively long because the target detection requires more complicated image processing. Nevertheless, compared with the training, the response time of the test has also decreased, which shows that the trained model is also efficient in target detection tasks. The test response time of the style transfer task is not much different from that of training.

In the experiment, the performance differences between the system constructed in this article and some existing baseline methods are compared to prove the superiority of this method. The comparison result of image classification accuracy is shown in Figure 4, and the comparison result of detection accuracy is shown in Figure 5.

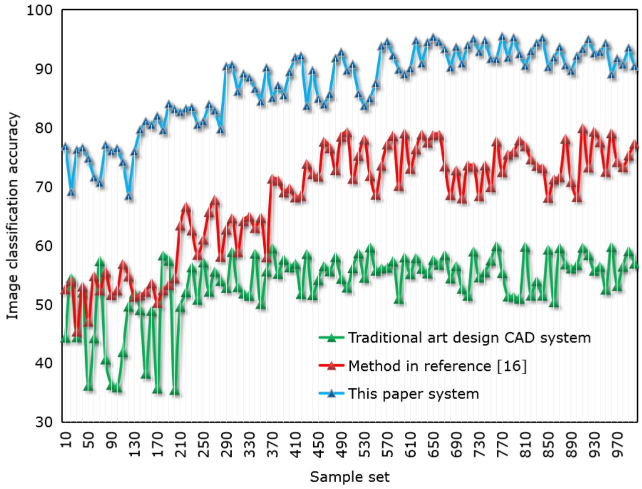

Figure 4: Comparison of image classification accuracy.

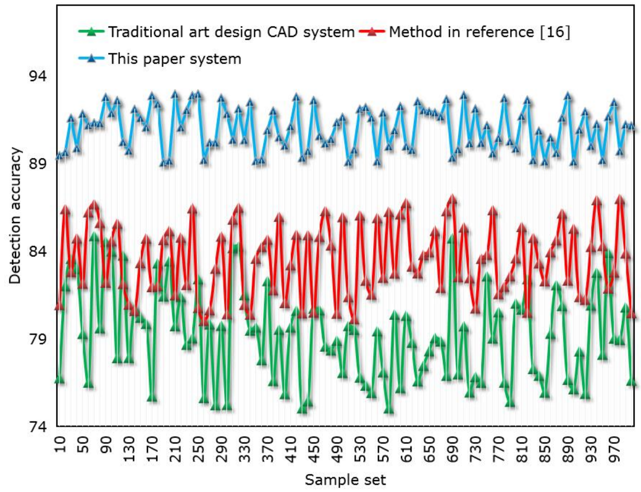

Figure 5: Comparison of detection accuracy.

With the progress of training, the accuracy of this method gradually rises and tends to be stable. This shows that NN has gradually learned effective image representation in the training stage and can accurately distinguish different types of images. Moreover, the accuracy of the other two methods is saturated or decreased in the later stage of training, which shows that they have certain limitations in dealing with complex image classification problems. This evidences that the synergistic combination of DNN and artistic design principles allows the system to gain a richer repertoire of image characteristics and semantic context, leading to improved classification accuracy.

With the training, the accuracy of this method gradually improves and tends to be stable. This shows that NN has gradually optimized its ability to detect and locate the target object during the training stage. The efficacy of this technique in target detection tasks is manifestly superior compared to the contrastive method. This underscores the fact that by incorporating DNN and artistic design principles, the system can identify and locate target objects within images in a more precise manner. The performance of the system-style migration task is shown in Figure 6.

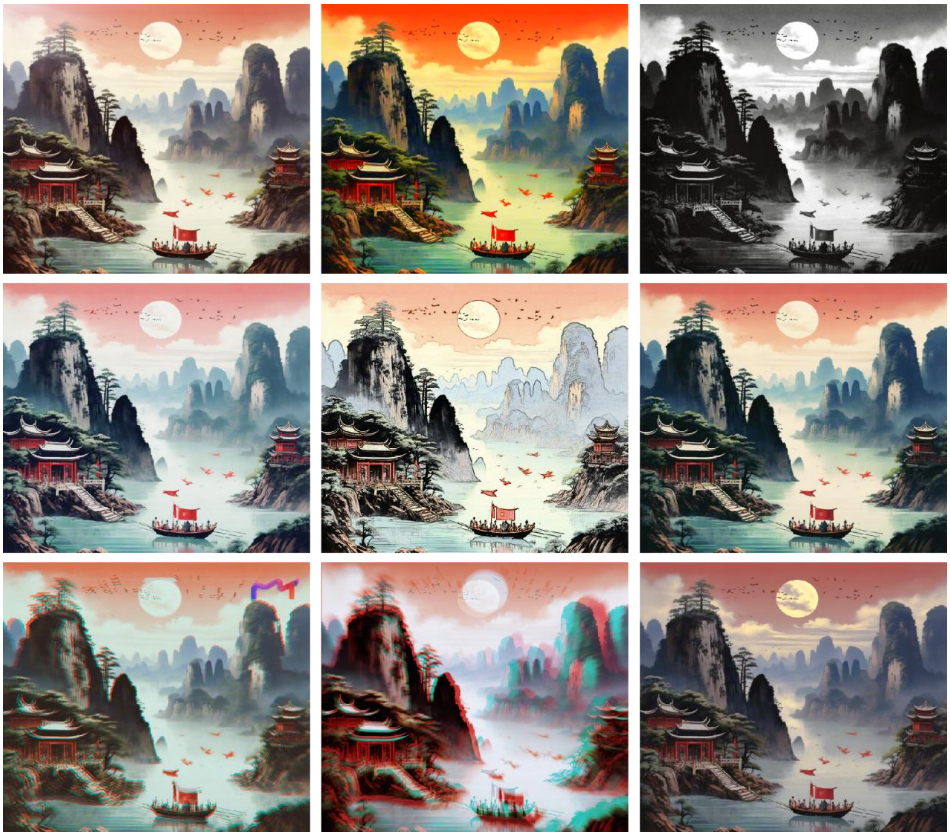

Figure 6: System style transfer.

The produced image effectively blends the stylistic attributes of the source image while preserving the essence of the target image, resulting in a generated output that is both artistically appealing and realistically convincing. Compared with traditional methods, the migration results generated by this method are more vivid in visual effect and can handle more kinds of style migration tasks. This proves the innovation and effectiveness of this method in style transfer algorithm design and parameter optimization. This shows that the system has a strong style transfer ability by introducing advanced technologies such as GAN.

This section verifies the feasibility of the system through simulation experiments, which provides a reference for subsequent practical applications.

4.3 Experimental Results and Analysis

Through experiments, the following results are obtained: ⊖ In the realm of image classification, this system attains a remarkable classification precision, surpassing the performance of the baseline approach. This proves the effectiveness of the proposed NN model in image classification tasks. ⊜ In the task of target detection, this system can accurately detect the objects and scenes in the image and give the corresponding position information. Compared with the baseline method, the detection accuracy of the system is improved. ⊛ In the task of style transfer, this system can successfully convert the style of the input image into the specified target style and generate high-quality output images. Compared with the existing style transfer methods, this system has obvious advantages in style transfer effect.

Based on the above results, it can be concluded that the CAD system model of artistic design proposed in this study, which integrates NN and computer vision algorithm, has shown superior performance and effect in many tasks. This proves the effectiveness and feasibility of the proposed fusion strategy and method. Moreover, the experimental results also provide valuable reference and guidance for subsequent research and application.

5 APPLICATION EXAMPLES AND DISCUSSION

5.1 Introduction and Implementation of Application Examples

In order to verify the practical application value of the artistic design CAD system proposed in this study, this section selects two typical application examples for introduction and implementation.

Example 1: Game Role Design

During the game development process, character design holds a pivotal position. By utilizing the CAD system for artistic design presented in this article, designers can effortlessly create character designs. The detailed implementation steps are outlined below: the designer first draws the basic outline and shape of the character by using the drawing tools in the system and then adjusts the style of the character to conform to the overall style of the game through the style transfer function in the system. Finally, the role design is optimized and revised by using the automatic design suggestion and error detection function in the system. Through this series of operations, designers can quickly complete high-quality role designs. A design example is shown in Figure 7.

Figure 7: Game role design.

Example 2: Advertising Poster Design

The design of advertising posters holds a significant role within the advertising sector. By harnessing the CAD system for artistic design presented in this article, designers can streamline the process of creating posters. The precise steps involved in the implementation are detailed below: the designer first uses the image processing function in the system to process and optimize the original picture and then adjusts the style of the picture to meet the advertising theme through the style transfer function in the system. Then, using the automatic layout and typesetting function in the system, the poster is arranged and typesetted as a whole. Finally, through the output function in the system, the designed poster is exported as a high-quality image file. Through this process, designers can quickly complete attractive advertising poster designs. A design example is shown in Figure 8.

Figure 8: Advertising poster design.

5.2 Evaluation and Discussion of Application Effect

Through the implementation of the above two application examples, the application effect of the artistic design CAD system proposed in this study can be assessed and discussed. In the example of game character design, the designer can quickly adjust the style and effect of the character by using the system in this article, which greatly improves the design efficiency. Moreover, the automatic design suggestion and error detection function in the system can also help designers find and correct problems in design in time, thus avoiding potential design defects. In the example of advertising poster design, the system in this article can help designers to process and optimize image data quickly and improve the accuracy of design. Moreover, the automatic layout and typesetting function in the system can also reduce the workload of designers and enable them to concentrate more on creativity and design itself. Figure 9 shows the user's rating of game character design and advertisement poster design.

Figure 9: User's rating of CAD system design.

For the scoring results of game character design, it can be observed that most users' scores are concentrated in the higher score segment, which shows that users have a positive evaluation of the game character design scheme generated by this system. Specifically, users with scores above 85 account for a considerable proportion, which means that most users think that the role design scheme generated by this system has reached a high level of creativity, artistic style and detail handling. Moreover, we can also see that some users give relatively low scores, which may reflect that different users have different personal preferences and expectations for game character design.

In the scoring results of advertising poster design, we can also see that most users' scores are concentrated in the higher score segment. This means that users think that the poster design scheme generated by this system has a high level of visual appeal, creativity and information transmission. Similarly, the low scores given by some users may reflect the differences in personal aesthetics or different expectations for specific design elements, which provides a useful reference for us to further optimize the system design.

Based on the above application examples and discussions, this section puts forward the following prospects and suggestions for the future application of the proposed artistic design CAD system:

Expand application fields: In addition to the game and advertising industries, the system can also be applied to other fields, such as film and television production, architectural design and so on. By continuously expanding the application field, we can provide powerful tools and support for more designers and creators.

Optimize algorithm performance: In order to improve the performance and efficiency of the system, the structure and parameters of the NN model and computer vision algorithm can be continuously optimized. By introducing more advanced algorithms and technologies, the processing speed and output quality of the system can be further improved.

Enhance the interactive experience: In order to improve the user experience, the interactive function and user experience of the system can be continuously enhanced. For example, smarter design suggestions and automatic correction functions can be introduced to reduce designers' workloads. Moreover, it can also optimize the interface design and operation process, making the system easier to use and more convenient.

6 CONCLUSIONS

Combining the existing technology and theory, this article designs a CAD system model of artistic design that integrates NN and computer vision algorithms and introduces GAN to transfer the art style. Moreover, an artistic design evaluation module based on CNN is designed to assess and optimize the design scheme automatically. In order to verify the effectiveness of this method, several publicly available data sets are used for experiments, including image classification, target detection and style transfer. Moreover, a typical application example is selected to verify its feasibility and show the effect and value of the system in practical application. The results show that the method in this article has remarkable effects on the generation of artistic design schemes, the diversity of styles and the improvement of design scheme quality. The artistic design CAD system based on NN has achieved impressive results in the task of style transfer. The system can successfully migrate the style of the source image to the target image and generate migration results with different styles. In the design examples of game characters and advertising posters, this system shows remarkable effectiveness. Designers can not only quickly adjust the role style to improve the design efficiency but also find and correct potential problems in time with the help of the system's automatic suggestion and error detection function. For advertising poster design, the system can quickly process image data and improve design efficiency and accuracy, and at the same time, the automatic layout and typesetting function can effectively reduce the workload of designers, making them more focused on creativity and design.

This research provides a new technical tool for the field of artistic design, which has the potential to promote the development and innovation of artistic design CAD systems and improve the creative efficiency and quality of designers. Future work can explore the use of NN in other artistic design tasks and constantly optimize and innovate to meet more diverse artistic design needs.

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