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Computer-Aided Optimization Design of Intelligent Commodity Packaging Based on Generative Adversarial Network

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Abstract. Packing design is another means to enhance the affinity between products and consumers besides the functional characteristics of products. Packing design includes modeling, color and visual design. Improving the quality of commodity packaging through machine vision technology has gradually become the focus of research in the field of artificial intelligence (AI) and commodity packaging. In this article, computer aided design (CAD) technology is applied to the design stage of commodity packaging, and a deep learning (DL) model consisting of a discriminator with sparse sampling function and a generator with image reconstruction function is designed based on the idea of generative countermeasure network (GAN) in AI, and the network parameters are optimized by using a new loss function consisting of countermeasure loss and reconstruction loss. The model is applied to the image feature recognition of commodity packaging to improve the product recognition precision of commodity packaging CAD system, thus further improving the work efficiency and quality. The model test results show that GAN is more accurate in identifying the characteristics of packaging images, and its identification precision is improved by about 20% compared with traditional Convolutional Neural Network (CNN), and it can accurately locate packaging images.

Keywords: Packing Design; Artificial Intelligence; CAD; Image Data Enhancement
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1 INTRODUCTION

In the stage of product development, excellent packing design is an important link. Through the comprehensive consideration of the function, shape and material of the product, the image of the whole product is more attractive by selecting suitable packaging materials, graphic design and clever technology. Anubha et al. [1] collected a large amount of plant image data, including images of different varieties, growth stages, and environmental conditions. Preprocess these images, including image enhancement, denoising, color space conversion, and other operations to improve image quality and feature extraction efficiency. Use traditional image processing methods, such as feature extraction, to process images. These methods include using algorithms such as SIFT, HOG, LBP to extract features from images, and then using classifiers to classify the features. Use depth learning algorithms, such as Convolutional neural network (CNN) or other depth models, to classify images. These methods can learn plant features and classification by training a large amount of plant image data. Packing design includes modeling, color and visual design, etc. It should not only create attractive personality forms, but also be perfectly combined with labels, products themselves, corporate culture and marketing concepts, and at the same time, it must be adapted to the realization of its functions and technologies. Boz et al. [2] conducted a consumer product usage guidance analysis on sustainable packaging. Consumers also consider the cost of packaging when purchasing products. Although sustainable packaging may be costly, companies can make consumers accept it through reasonable pricing and marketing strategies. For recyclable packaging, consumers are more inclined to choose packaging materials with higher sustainability. Therefore, enterprises need to consider the recyclability of packaging and use recyclable packaging materials. Consumers hope that companies can provide more transparent packaging information, such as the source of packaging materials, processing methods, etc. Enterprises can provide transparency through identification, labeling, and other means to enhance consumers' trust. Packing design is driven by culture and social responsibility, and its profound connotation will be refined and sublimated in this high-level competition. Packaging itself has become an important media, which directly spreads commodity information and deeply affects people's lives. In recent years, with the continuous improvement of the informatization level of industrial production, machine vision has been gradually applied in industrial design. Improving the quality of commodity packaging through machine vision technology has gradually become the focus of current research in the field of AI and commodity packaging. DL is used in image recognition and processing because of its powerful automatic feature extraction ability, and the effect is far superior to that of traditional methods. The CAD intelligent packaging system can ensure the safety and quality of food in the supply chain by monitoring and recording the internal and external environmental information of food, such as temperature, humidity, light, etc., as well as the quality and safety indicators of food, such as microbial quantity, chemical residue, etc. Intelligent packaging systems can prevent packaging from being tampered with or forged through anti-counterfeiting technologies such as QR codes and digital watermarks, protecting brand image and consumer interests. Chen et al. [3] analyzed that CAD intelligent packaging systems can reduce costs and environmental impacts by optimizing packaging design and material selection, such as using biodegradable materials and reducing waste of packaging materials. Chen and Cheng [4] conducted a theoretical framework encoding for user product perception images based on consumer developed pattern demand analysis. It creates a perceptual image analysis for system pattern customization by combining the mapping relationships of pattern element design using neural networks. Evaluate and optimize the generated patterns using the Kansei engineering method. This includes evaluating the aesthetics, innovation, market adaptability, and other aspects of the pattern, and adjusting and optimizing the BP neural network model based on the evaluation results. Test the system in real scenarios, collect user feedback, and improve and optimize the system based on the feedback results. By developing a product pattern design system based on the Kansei engineering and BP neural network, efficient and intelligent design of product patterns can be achieved. This system can automatically generate patterns that meet the requirements based on market demand and user preferences, improving the efficiency and effectiveness of design. At the same time, through user feedback and evaluation, continuously optimize and improve the system to improve the quality and competitiveness of the design.

Han et al. [5] conducted digital state parameter design, which constructed innovative visual textures for clothing development and design in artistic aesthetics. It uses intelligent algorithms to analyze a large number of clothing style designs and learn the design characteristics and patterns of different styles. Designers can use these algorithms to quickly and accurately design styles, and optimize historical data to achieve better design results. Through deep learning and computer vision technology, achieve fast and accurate 3D modeling and simulation. Designers can use these algorithms to conduct 3D modeling and simulation of clothing, in order to better showcase and evaluate the design effect. Li et al. [6] conducted an intelligent quantitative survey on the acceptability of video packaging. Based on the results of data analysis, summarize the cognitive situation and demand characteristics of consumers. It is possible to compare the differences between different groups, such as the cognitive and demand differences for smart food packaging among consumers of different ages, genders, and educational backgrounds. Propose design and promotion strategies for smart food packaging based on consumer needs and expectations, as well as suggestions for relevant policy formulation and regulatory measures. Through quantitative surveys, it is possible to gain a deeper understanding of Chinese consumers' understanding of smart food packaging, helping enterprises and relevant institutions better understand market demand and trends, and thus develop product strategies and market promotion strategies that are more in line with consumer needs. At the same time, it also provides valuable reference and guidance for the development of the industry. One of the characteristics of DL method, represented by CNN, is that it needs a lot of label data for full supervised learning. In these small sample scenarios, DL method will be helpless. Because of the lack of label data, network training is easy to fall into over-fitting, which greatly weakens the recognition performance. For small sample image feature recognition, data enhancement is the most intuitive. At present, GAN is widely used in image generation, video processing, voice generation and many other fields. Some researchers apply GAN to image feature data enhancement to deal with the problem of small sample recognition. In this article, CAD is applied to the design stage of commodity packaging, and a new image feature data enhancement method based on GAN is proposed, and solutions to the distortion phenomenon of plane labels after 3D mapping and the problems in data transmission between different software is proposed.

In the three levels of the overall product concept, packaging as a formal product is an important part of the product. It is helpful to improve the accuracy of recognition by using GAN to transfer styles of different domains to enhance data and generate pictures between different domains to train models. In the style coding network, a style class-aware attention mechanism is used to pay attention to the representation of style features to generate style codes. Its network structure can be regarded as the inverse structure of the discriminant network, and new data can be generated directionally or non-directionally through several layers of deconvolution calculation. Training and sampling data in the generated network can measure the level of researchers' analysis and calculation of high-dimensional probability distribution This article discusses the application of GAN in AI in commodity packaging CAD, and its main innovations and contributions are as follows:

(1) Research the application of CAD in the design stage of product packaging, and utilize GAN's powerful ability to generate realistic samples to construct data augmentation algorithms and optimize the image feature recognition stage of packing design systems.

(2) When constructing an image grayscale histogram, the human visual attention mechanism is integrated into it to form an image information histogram, in order to highlight the parts of the image that contain important information. On this basis, the human eye perception characteristics are integrated into the enhancement algorithm to reduce the amount of main grayscale information in the histogram.

(3) The article proposes solutions to the distortion phenomenon caused by 3D mapping of flat labels during the packing design process and the problems in data transmission between different software, avoiding unnecessary repetitive labor in traditional product packing design, making the design process more reasonable and improving design effectiveness.

The article first proposes a GAN based image data enhancement and feature extraction method, and then optimizes the CAD modeling stage of product packaging based on this method; The experimental part verifies the effectiveness of the proposed method by comparing its performance with traditional CNN models; Finally, a summary and outlook of the research work in this article were provided.

2 RELATED WORK

Mohammadian et al. [7] analyzed the environmental food propensity survey under artificial intelligence packaging. By using an intelligent monitoring system in packaging materials, sensing of gas and temperature changes inside the packaging can be achieved. When the gas or temperature inside the packaging changes, the intelligent packaging material will respond and generate corresponding color changes or electrical signals. The electrical signal output by the sensor is transmitted to data processing devices, such as computers or mobile devices, through a data transmission module. Data processing equipment can receive and process this data, analyze and make judgments. By analyzing and judging the data, we can understand the changes in gas and temperature inside the packaging, as well as the quality and safety of food. Based on data analysis results, real-time food status feedback can be provided and consumers or relevant personnel can be reminded to take appropriate measures. Salahuddin et al. [8] analyzed linear development of machine framework design layout based on finite element analysis. Use CAD software to establish a three-dimensional model of a high inclusion dough forming machine, including inclusion processing system, dough supply system, forming device, and control system. Set analysis conditions based on actual usage, such as the physical properties of the dough, processing pressure, molding speed, and other parameters. Split the 3D model into several units and perform static or dynamic analysis on each unit to obtain the stress and deformation of each part. Integrate the analysis results of each unit to obtain the stress and deformation situation of the entire equipment, and optimize the design based on the results. Through finite element analysis, the design quality and efficiency of high inclusion dough forming machines can be effectively improved, development costs can be reduced, and equipment reliability can be improved. When purchasing recycled packaging, consumers need to seek information to obtain relevant information about the product and its packaging. Information seeking includes obtaining product information from various channels, comparing the environmental performance of different products, and understanding the recycling potential of products. Information seeking behavior can help consumers better understand the importance of circular economy and make wiser purchasing decisions. Testa et al. [9] analyzed the design guidance of environmentally friendly and green consumer packaging under the circular economy. Through the centralized information circulation guidance of green consumption, it analyzed the intermediary model effect in the purchase management process. By understanding the relationship between circular economy and consumer behavior, as well as the mediating role of information seeking, enterprises can better consider consumer needs and preferences when designing and promoting circular packaging.

Togawa et al. [10] conducted an impact analysis on visual users based on packaging design. It constructs a visual processing style adjustment system based on food images. By analyzing the impact of packaging and processing visual effects on video images, it enhances users' expected effects on videos. Visual packaging design can enhance the perception of product flavor by using appropriate colors and textures. Visual packaging design can enhance the perception of product flavor by using appropriate images and patterns. For example, for seafood products, using patterns of ocean and seashells can make consumers feel more delicious. Visual packaging design can influence consumers' dietary decisions by conveying information about healthy eating. It should be noted that the visual taste correspondence effect of packaging is a psychological effect, and different consumers may have different feelings and reactions to the same packaging design. Therefore, designers should determine the most suitable visual packaging design for target consumers through market research and data analysis, and conduct testing and optimization to achieve the best results. At the same time, it is also necessary to consider the environmental protection and sustainability of packaging materials in order to achieve the goal of sustainable development. The visual analysis of product images in current industrial vision has heterogeneity from multiple perspectives. Wang et al. [11] analyzed a tensor based multi-attribute visual feature recognition method for industrial intelligence. By optimizing the model and adjusting parameters, better classification results can be achieved. Model optimization and parameter tuning can be achieved through methods such as cross validation and grid search. For classification results, evaluation and validation are needed to determine the performance and effectiveness of the method. Evaluation indicators such as accuracy, recall, F1 score, etc. can be used to evaluate the performance of the method, or validation sets or real data can be used for validation. By using tensor based multi-attribute visual feature recognition methods, fast and accurate recognition of target attributes in industrial scenes can be achieved. At the same time, it is necessary to pay attention to selecting appropriate preprocessing methods, feature extractors, and classification algorithms, and make appropriate adjustments and optimizations to adapt to different industrial application scenarios and needs. Yu and Sinigh [12] analyzed the CAD software technology analysis and design of product packaging design. It investigated the phenomenon of graphic design mapping between different software packaging solutions. In product packaging design, you can choose to use environmentally friendly materials, such as degradable paper, bamboo products, Corn starch, etc. Through CAD software, the physical properties and appearance effects of different materials can be simulated to select the most suitable environmentally friendly material. In product packaging design, CAD software can be used to optimize the structure and size of packaging to reduce the amount of packaging materials used. At the same time, optimizing the shape and design of the packaging can reduce the weight and volume of the packaging. In product packaging design, CAD software can be used to design reusable packaging. For example, detachable components and easily recyclable materials can be used to achieve packaging recycling. Yun and Leng [13] analyzed the network feedback data packaging design system under CAD assisted design. The current digital virtualization packaging design of products requires high hardware constraint feedback. Through CAD software, a virtual model of product packaging can be created and presented in a virtual environment. Designers can simulate real scenes in virtual reality, directly experience and evaluate packaging, in order to better understand the design effect of packaging. In virtual reality, designers can use interactive tools to directly manipulate and modify product packaging. Virtual models can be used to test different design ideas and observe the effectiveness of packaging in different designs, thereby making packaging design more flexible. By applying virtual reality technology to CAD software, the efficiency and effectiveness of product packaging design can be enhanced. Through virtual models, designers can have a more intuitive understanding of packaging design and engage in more flexible and sustainable design. At the same time, it can also save time and cost, and reduce the impact on the environment.

Zhang et al. [14] analyzed and constructed the transformation of multifunctional products in different spaces. It conducted similarity matrix matching analysis on functional matrix products, and this method designed the integration of component similarity matrices. By searching and retrieving sharable functional components, you can begin to combine and optimize them. This process requires consideration of the coordination and interaction between different components, as well as how to optimize their interfaces and connections. After combining and optimizing functional components, it is necessary to integrate multifunctional products. This process needs to consider the overall architecture, functional processes, interaction methods, and other aspects of the product, as well as how to organically integrate different functional components together. By searching for shareable functional components to achieve multifunctional product design, it can effectively improve the efficiency and flexibility of design. By sharing functional components, repetitive design work can be reduced, and the complexity and cost of design can be reduced. Zhang et al. [15] conducted an expandable and flexible design for product packaging design. It proposes a similarity assessment method that combines views with patterns. Firstly, establish a case library that includes various product packaging designs. This case library should contain product packaging cases of different types, design styles, materials, and processes for easy retrieval and reasoning in the future. On the basis of the case library, it is necessary to construct a knowledge map of product packaging design. This knowledge map should include various elements of product packaging design, such as materials, processes, structures, functions, etc., as well as the relationships and rules between these elements. Through knowledge maps and artificial intelligence technology, product packaging cases that meet design requirements can be retrieved and matched from the case library. This process can be achieved by analyzing and matching the knowledge graph to find cases that match the design requirements. For matching cases, in-depth analysis and learning are required. By analyzing the design elements, structure, function, materials, technology, and other aspects of these cases, useful information and inspiration for design can be obtained. Zhao et al. [16] analyzed the conceptual framework of appearance packaging for agricultural product sales. By reasonably combining packaging designs of different agricultural product colors, a three-dimensional environmental product information simulation for intelligent color testing design was constructed. Through computer graphics technology, we can simulate and generate the appearance of agricultural product packaging with different artistic styles. Algorithms and models can be used to generate images with specific artistic styles, or to innovate and optimize on the basis of existing artistic styles. With the assistance of intelligent computers, users can carry out personalized agricultural product packaging design. By designing software and interactive interfaces, users can input their needs and preferences, and display the effects and changes of the design in real-time. The appearance design of agricultural product packaging with artistic style assisted by intelligent computers can provide more personalized and artistic design solutions. Zhen et al. [17] conducted an application analysis of object detection in aerial images in multi-scale feature fusion. A neural network aggregation construction based on image object detection, which introduces experimental analysis of dataset modules at different stages. For different target detection tasks and datasets, adaptive multi-level feature fusion methods need to be adjusted and optimized according to the characteristics and task requirements of the dataset. Based on the fused features, target detection algorithms are used for target detection. By using adaptive multi-level feature fusion to achieve object detection in aerial images, the accuracy and robustness of object detection are effectively improved. At the same time, it is necessary to pay attention to selecting appropriate preprocessing methods, feature extractors, and object detection algorithms, and make appropriate adjustments and optimizations to adapt to different aviation image datasets and task requirements.

3 PRODUCT PACKAGING CAD METHOD OPTIMIZATION

3.1 Image Data Enhancement and Feature Extraction

The purpose of data conversion is to convert the preprocessed packaging image into tensor for better matrix operation. Firstly, each packaging image is extracted in sequence to construct a file queue. When reading pictures, each RGB color image can be regarded as a 3D matrix, and each number in the matrix represents the brightness of different colors in different positions of the image. GAN's excellent performance makes more people want to apply it to data enhancement tasks, because it can generate new training data, thus helping to train classification models with better performance. Images are not stored in the form of 3D matrix in the initial state, so it is need to convert the data type of images into 3D matrix, and then save them in files using picture format. Therefore, reading the packaging data needs to read the compressed and encoded results first, and then decode them, so that the two-dimensional image can be converted into a three-channel format containing RGB information. The main feature of this method is that it is superior to the existing methods in Gaussian noise image enhancement, and it does not need to adjust the parameters of fuzzy sets complicated.

When training high-resolution images, a deeper model is usually needed. The existing GAN is realized by a large model with multi-scale output. However, this model significantly increases the calculation cost and the training time is huge. In addition, the existing models need more data sets when generating high-resolution images. However, when a few samples are used to train and generate high-resolution images for data enhancement, the phenomenon of pattern collapse is easy to occur, that is, the generated samples are relatively single. The reason of pattern collapse is that the generator will tend to generate some samples that have deceived the discriminator, so the diversity of samples will decrease. Based on the ability of GAN to extract and estimate image features, a DL network model consisting of a discriminator with sparse sampling function and a generator with image reconstruction function is designed, which avoids the problem of information loss caused by artificially designing sampling matrix and reconstruction algorithm, thus improving the quality of image reconstruction and reducing the time of image reconstruction. In this article, a packaging image data enhancement model based on GAN is constructed. The GAN model is shown in Figure 1.

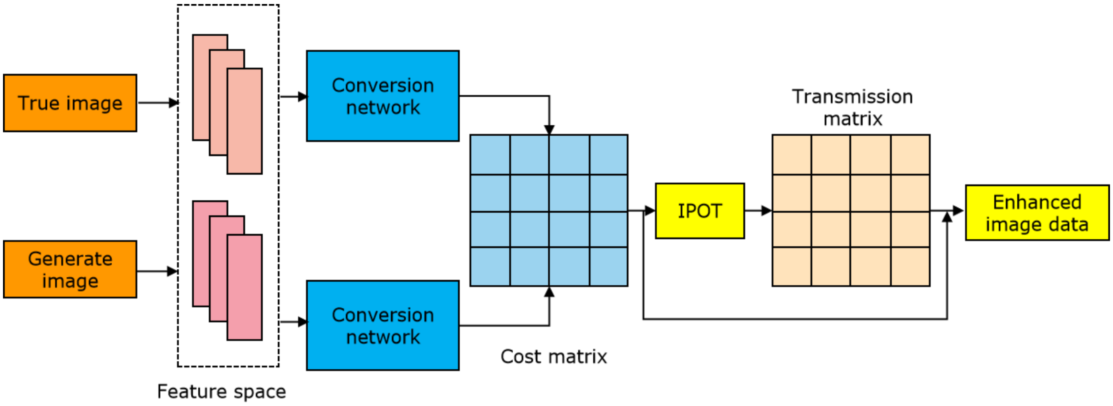

Figure 1: GAN model diagram.

Linkage features are the basic units that can express certain linkage semantics. Linkage semantics are semantic information closely related to feature linkage design, such as the dimensions and tolerances of linkage element features themselves and the linkage relationships between features. The intra feature correlation is manifested in the basic attributes of the linked feature elements themselves. After significant enhancement of the original image, the grayscale of important areas will occupy a large amount of data space. These grayscale levels are called primary grayscale levels, while the rest are called sub grayscale levels. Due to the large amount of data in the main grayscale, which affects the speed of image enhancement algorithms, it is necessary to limit the data in the main grayscale.

GAN includes two parts: generating network and identifying network. The core idea is the confrontation between production and discriminant: the production model aims to grasp the distribution of objects and try to produce samples that are consistent with the distribution of objects; The discriminant model tries to distinguish truth from birth, and its essence is binary classification, which distinguishes truth from birth and birth from birth. The discriminant equation is:

$$f = F\left(x;\varnothing_r\right) \tag{1}$$

$$D_{\varnothing}\left(s\right) = sigmoid\left(\varnothing_1, F\left(s;\varnothing_r\right)\right) = sigmoid\left(\varnothing_1, f\right) \tag{2}$$

The generator equation is:

$$g, h_t^M = M\left(f_t, h_{t-1}^M;\theta_m\right) \tag{3}$$

$$O_t, h_t^W = W\left(x_t, h_{t-1}^w;\theta_W\right) \tag{4}$$

Set m and n equal, and due to the constraint of optimal transmission quality conservation:

$$\sum_{j=1}^{n} T_{ij} = \frac{1}{m} \tag{5}$$

$$\sum_{i=1}^{m} T_{ij} = \frac{1}{n} \tag{6}$$

After the optimal PSNR is reached and stabilized in the model verification set, a discriminator is added in the second stage for confrontation training, and the confrontation loss function, perceptual consistency loss function and feature loss function are used as constraints respectively, and reasonable high-frequency details are learned to be added to the image with high peak signal-to-noise ratio, so that satisfactory results can be obtained in both pixel domain and feature domain. In order to ensure that the mixing level of packaging sample elements is high enough and get more diverse data distribution, it is need to use random batch statements to scramble all the data in the packaging tensor queue. After the data is scrambled, it is called randomly from the queue when it needs to be read, thus realizing the disorderly arrangement of the data. At present, the GAN model has been expanded in many applications, including image synthesis, artistic style transfer and video special effects production, showing the comprehensive properties of multi-function, diversification, high performance and high quality. GAN is put forward on the basis of the research of DL and CNN models, and has independent structural design and output performance. The antagonistic learning architecture of GAN is shown in figure 2.

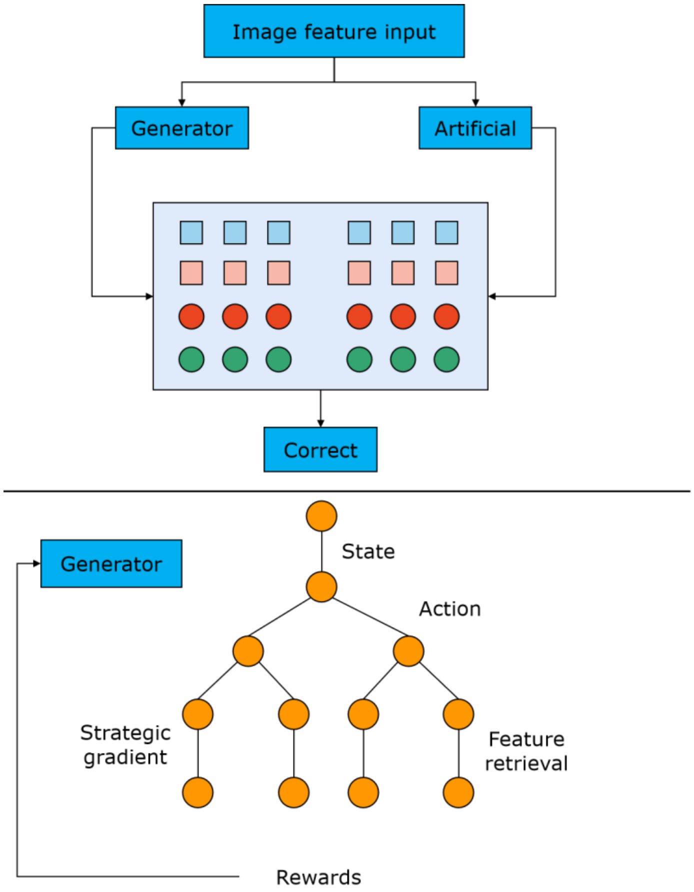

Figure 2: Antagonistic learning architecture.

The core of self-attention mechanism is to get as many global feature points as possible in the stage of identification, and compared with the traditional generation network, it only needs less computing resources to establish a good model relationship for the packaging generation network, thus realizing the full identification of sample packaging data and providing help for generating new packaging. With the gradual improvement of technology and the convenience of data acquisition, the possibility of optimizing the original application to generate new photo images into packaging images is greatly improved. However, packaging has a different visual expression and information transmission mode from traditional photo images. The basic GAN model needs special modification and adjustment to better identify packaging characteristics, obtain packaging data distribution, and control the change of loss function while outputting high-quality packaging. Let the gray value range of the original commodity packaging image $f(x,y)$ be (g_{min}, g_{max}), choose a suitable threshold T, and:

$$g_{min} \leq T \leq g_{max} \tag{7}$$

Image segmentation with a single threshold can be expressed as:

$$g(x,y) = \begin{cases} 1, & f(x,y) \geq T \\ 0, & f(x,y) < T \end{cases} \tag{8}$$

$g(x,y)$ is a binarized image. With the deepening of training, the traditional GAN will lose control of the iterative direction of the network for the input package with larger size and more pixels, which is related to its design structure and cannot be improved by a single algorithm or parameter changes. Therefore, it is need to add some auxiliary information to the generating network and the discriminating network to solve the problems of uncontrollable training and low output quality.

3.2 3D Modeling of Commodity Packaging CAD

Based on the improvement of computer technology, AI has been widely used in the field of commodity packaging. By adding monocular vision and light source information to the robot, the product recognition rate of the robot was improved. The generation of GAN is successfully controlled by adding conditions.

The visual mechanism of human eyes has the ability of multiple channel structures to transmit image signals, so that the visual channels can be decomposed according to direction and frequency; And the number of channels has a qualitative relationship with visual information. The multi-channel theory can better extract image features, and there is interaction between parallel channels. The visual perception system obtains the 3D image data of product modeling based on the principle of binocular stereo vision, and enhances the packaging image stereoscopically. The parallax principle of binocular stereo vision is shown in Figure 3.

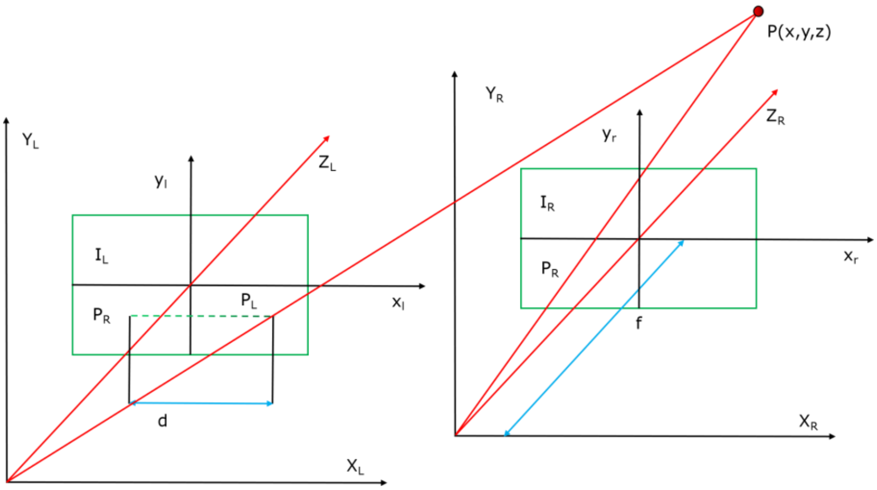

Figure 3: Parallax principle of binocular stereo vision.

Structural similarity is based on the realization of structural similarity theory. From the perspective of image composition, structural information is defined as the attribute that directly reflects the structure of the object without depending on brightness and contrast. Brightness, contrast and structure are the combination of three different factors to model image degradation and distortion. In the CAD model of commodity packaging, take any triangular patch T_0 and record its three vertices as I_t , C_t and Q_t respectively, then the unit vector of triangular patch T_0 can be expressed as:

$$R_t(p_{1t},Q_t)=p_{1t}\cdot\min(I_t+Q_t,D_t)-(p_{0t}\cdot Q_t+C_t\cdot AI_t)+R_{t-1} \tag{9}$$

By weighting the area of the vector of the triangle surface in the first-order neighborhood of vertex I_t, the vertex vector of C_t can be calculated I_{t+1}, and the vertex vector of vertex I_t:

$$I_{t+1}=I_t+Q_t-\min(I_t+Q_t,D_t)=\max(I_t+Q_t-D_t,0) \tag{10}$$

The curvature AI_t of the vertex can be calculated:

$$AI_t=\frac{(I_t+Q_t)}{2}\cdot\frac{(I_t+Q_t)}{D_t} \tag{11}$$

After the color design and modeling design are completed, the mapping operation can be performed, that is, the real-time realization of 3D visualization. The operator specifies the color file as the mapping material in the material editor of 3D Studio MAX, and then assigns the material to the modeling object. The bitmap files of renderings generated by 3D Studio MAX are often unsatisfactory and need to be reprocessed, because the 3D shape often changes unexpectedly when the two-dimensional shape is transformed into 3D shape due to the change of expansion and fixed viewpoint. At this time, the image processing function and special effects of Photoshop can be used to make the effect map realistic as a real photo. You can also use the good animation function of 3D Studio MAX software to make the scene of commodity packing design into animation and dynamically display its 3D effect.

4 MODEL TESTING AND ANALYSIS

In the task of image super-resolution modeling, there is often an ideal original image as a reference image. Therefore, in the evaluation, the difference between the super-resolution output image and the reference image can be measured according to the reference image, and the distortion of the super-resolution image relative to the reference image can be analyzed, so that the evaluation result of the generation quality of the super-resolution image can be obtained. The proposed algorithm is applied to commodity packing design, and an example is analyzed. The simulation operating system is Windows 11, the processor is Core i7 13700k, the graphics card is RTX 3080, the memory is 32GB, and the hard disk capacity is 1TB. In the training stage of GAN, if the branch set of target probability measurement has multiple connected branches, and GAN training obtains continuous mapping, it is possible that the value range of continuous mapping is concentrated on a connected branch; If a continuous map is forcibly used to cover all connected branches, the range of this continuous map will cover some areas outside, that is, GAN will generate some pictures with no practical significance. In order to solve the problem that high-resolution images are prone to mode collapse when data enhancement is carried out for GAN, a method of data enhancement for GAN based on twin normalization is proposed. The core innovations of this method are gradient normalization and attention normalization, which are verified by experiments on standard data sets FFHQ and Panda. Through the verification of this method, the test results in Figure 4 are obtained.

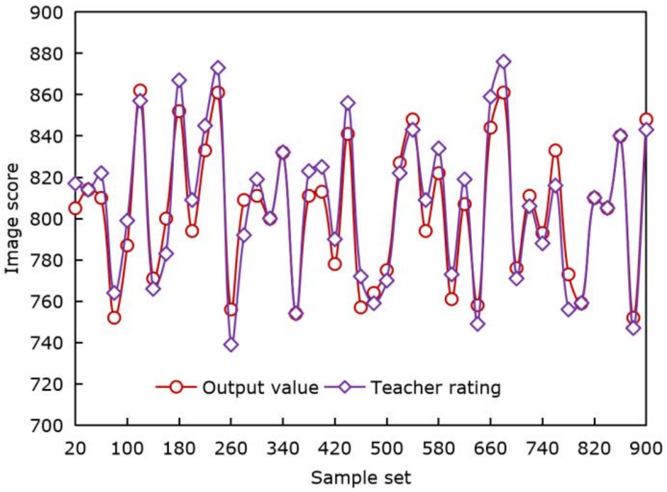

Figure 4: Product packaging modeling test.

In Figure 4, the horizontal coordinate is the test sample size, and the vertical coordinate is the score of the packaging image vocabulary. The results show that the method has achieved good performance in practical application, and the model output results are in high agreement with the actual results. GAN uses deep residual attention network as the only generator, and after two-stage training, it can reconstruct low-resolution images with super-resolution and generate high-quality images. In this process, firstly, the generator is optimized by ablation experiment.

In the generator, attention normalization is used in each layer when up-sampling; in the discriminator, attention normalization is used in each layer when down-sampling, because 1×1 convolution itself provides more nonlinearity, which is beneficial to feature extraction. In order to avoid too large parameters, 1×1 convolution layer does not use attention normalization. Using the contribution factor of weight to improve the effect of attention and improve the ability of feature extraction of generator and discriminator. This method takes into account both the required overall data capacity and the image optimization performance. Figure 5 shows a comparison of the execution time used in the calculation of GAN and conventional CNN.

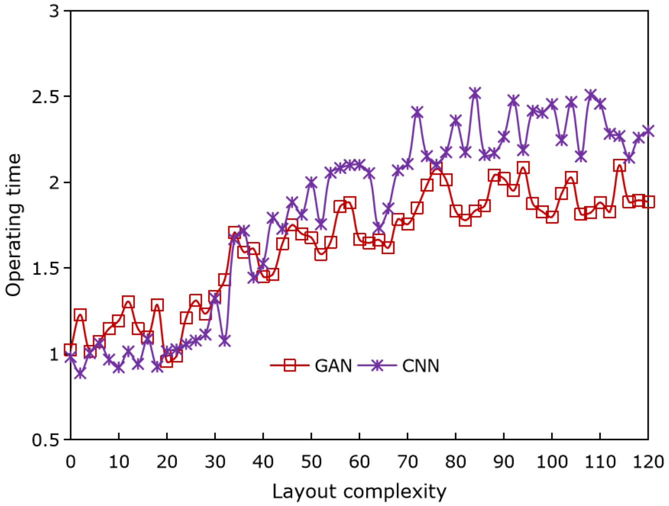

Figure 5: Calculation time comparison of algorithm.

Although GAN technology does not have obvious advantages in the initial stage, with the increasing complexity of commodity packaging pictures, GAN technology is getting better and better. Compared with CNN, GAN has the advantages of controllable parameters, clear objectives, short calculation time and small structural similarity, which can meet the requirements of product diversity and quality and significantly improve design efficiency.

The input of the image discriminator is an image in the pixel domain, and the goal of the discriminator is to distinguish the generated super-resolution image from the real high-resolution image according to the network extraction features. Because VGG structure can extract the features and structural information contained in real high-resolution images, the discriminator can distinguish the authenticity of images according to this information, thus guiding the generator to generate real structural details instead of random noise. In commodity packaging CAD, two methods are used to identify image features (Figure 6 and Figure 7), and their recall and precision are better than traditional algorithms.

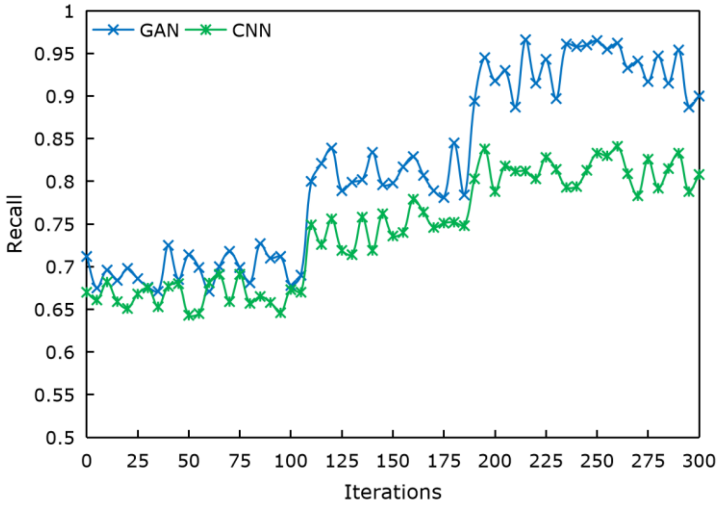

Figure 6: Recall of commodity packaging image feature recognition.

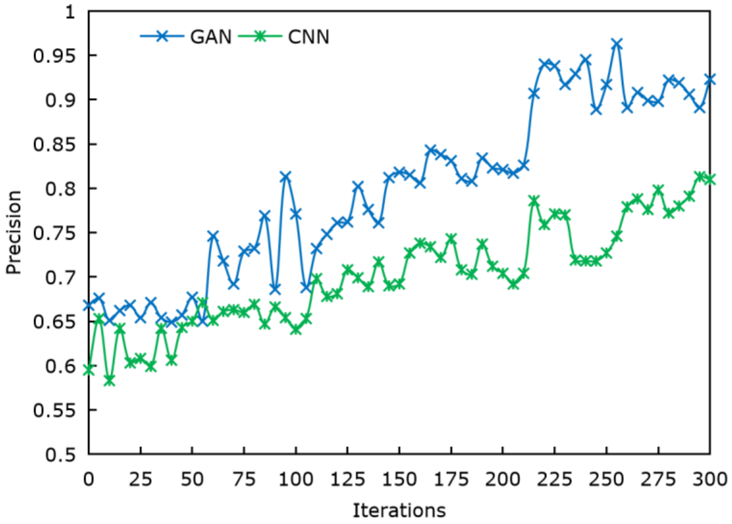

Figure 7: Commodity packaging image feature recognition precision.

GAN is more accurate in identifying the characteristics of packaging images, and its identification precision is about 20% higher than that of traditional CNN, and it can accurately locate packaging images. Compared with the existing algorithms, the algorithm is simple in calculation, flexible, suitable for parallel processing, strong in robustness and excellent in performance, and can be applied to solving complex nonlinear optimization problems. Compared with traditional CNN, GAN network is more suitable to simulate the specific design process.

5 CONCLUSIONS

In commodity packing design, image design accounts for most of the proportion. In this article, CAD is applied to the design stage of commodity packaging, and a new image feature data enhancement method based on GAN is proposed, and solutions to the distortion phenomenon of plane color after 3D mapping and the problems in data transmission between different softwares are proposed. The test results show that GAN is more accurate in identifying the characteristics of packaging images, and its identification precision is about 20% higher than that of traditional CNN, and it can accurately locate packaging images. In addition to verifying the feasibility of packing design supported by AI, we also tried to identify and obtain specific types of packaging, and successfully generated a new packaging with clear visual expression and certain indication intention, which provided certain guiding significance for the subsequent research on packaging CAD generation with more personalization, higher quality and higher efficiency.

By identifying and memorizing the sample data in the training set, GAN analyzed and mastered the data distribution, and judged and adjusted different inputs. This AI model brings new creative space and possibilities to many artists and designers. The influence of a certain dimension of GAN input on the output is unclear, so how to control GAN to avoid randomly generating pictures and generate specific pictures by controlling the input parameters to better meet the needs of data enhancement is a problem to be solved in the future.

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