www.cad-journal.net
Computer-Aided Design AND APPLICATIONS

Computer Aided Creative Design of Paper Packaging Based on Image Recognition in Graphic Design Teaching

Yanpeng Chen[1] and Dahua Meng[2]

[1]College of Art, Guangdong University of Foreign Studies, Guangzhou, Guangdong 510006, China, 200811699@oamail.gdufs.edu.cn
[2]Guangzhou Qianshan Qipin Graphic Design Co., Ltd, Guangzhou, Guangdong 510275, China, nicolemeng@kipinlive.com

Corresponding author: Yanpeng Chen, 200811699@oamail.gdufs.edu.cn

Abstract. In the teaching of graphic design, making full use of computer aided design (CAD) can effectively improve the teaching level and enhance the teaching effect. In order to promote the innovation of graphic design teaching method and strengthen the application of CAD tools in paper packaging design, this article puts forward a packaging image recognition and integrity monitoring method based on improved Convolutional Neural Network (CNN), and realizes packaging creative design based on CAD modeling optimization. In order to train the sparse coding model end-to-end, the network regards the optimization process of solving the sparse minimization problem as a recursive network layer, and carries out end-to-end training together with the spatial pyramid pool layer and a deep CNN. The test results show that the paper packaging image recognition model in this article obviously improves the recognition rate. After the processing of this algorithm, the packaging image is effectively controlled by noise, the basic outline of the image is clearly visible, and the contrast of the image is improved to a certain extent, and the image is effectively enhanced, which can improve the creative design of paper packaging.

Keywords: Graphic Design; Image Recognition; Computer Aided Design; Paper Packaging
DOI: https://doi.org/10.14733/cadaps.2024.S10.16-31

1 INTRODUCTION

When the quality of products cannot be deeply understood, the external packaging of products is the primary factor affecting consumers' choice of products. If the product packaging design is exquisite and unique, it can attract consumers' attention and improve their desire to buy. Based on the growth of commodity economy and the concept of sustainable consumption, more and more merchants pay more attention to environmental protection in the selection of packaging materials, which also makes the packaging materials of products gradually show a paper-based trend.

Anguish et al. [1] collected a CAD model image dataset with multiple views, each with images from different angles and views. Divide each model image into multiple small blocks, each representing a view. Construct a multi view convolutional neural network model. This model includes multiple convolutional layers, pooling layers, and fully connected layers. Each convolutional layer corresponds to a view and features are extracted from the image blocks of that view. Input the small image of each view into the corresponding convolutional layer of the multi view convolutional neural network, and extract the feature vectors of each view. Splice these feature vectors into a long vector as the final feature representation of the model. Train multi view convolutional neural network models using labeled CAD model datasets. By optimizing the loss function, the model can extract meaningful features from multiple views and classify the model based on these features. In the process of promoting quality education in an all-round way and cultivating broad-caliber compound innovative talents with solid theoretical foundation and strong practical ability, the traditional teaching method of centralized teaching and students' vague imagination can no longer meet the current training requirements of graphic design professionals. Bao [2] analyzed the application of intelligent algorithms in 3D graphics engine animation design. Intelligent algorithms play an important role in 3D graphics engine animation design, mainly including optimizing animation performance, improving animation fidelity, and reducing human involvement. It analyzes that optimizing animation performance is an important application of intelligent algorithms in 3D graphics engine animation design. Intelligent algorithms can automate the complex computation and rendering process of 3D animation, such as reducing redundant geometric shapes and utilizing GPU for parallel computation, which can greatly improve the performance and smoothness of animation. Its improved animation fidelity is also an important application of intelligent algorithms in 3D graphics engine animation design. Intelligent algorithms can automate the processing of lighting and materials in scenes, making objects in animations appear more realistic. For example, deep learning algorithms can be used to automate the processing of textures and details in scenes, thereby improving the realism of animation. Graphic design is a course expressed through visual language. How to convey information to the public through visual language, how to make graphic design meet aesthetic needs and be more practical, how to let students master creative thinking and cultivate their design skills in a short time, and how to skillfully express creativity by using design software, which is the problem that teachers need to solve in teaching. The study of modern packaging design and artistic thinking in the context of big data is an emerging research field that involves multiple aspects such as packaging design, artistic thinking, and big data technology. In the context of big data technology, modern packaging design is undergoing unprecedented changes, and the application of artistic thinking in packaging design is becoming increasingly important. Cao [3] uses data analysis to understand consumers' needs and preferences, in order to better design packaging. In addition, big data can also be used to optimize the production and transportation processes of packaging, improve efficiency, and reduce costs. Artistic thinking can provide unlimited creativity and inspiration for packaging design. Designers can create unique packaging designs through artistic thinking, attract consumer attention, and enhance product value. At the same time, artistic thinking can also be used to solve difficult problems in packaging design, such as how to endow packaging with artistic and emotional value while ensuring its functionality. Graphic design is a professional design course closely combined with design software teaching. In the actual teaching process, how to give full play to the role of CAD in graphic design teaching is the focus of this article.

Computer graphics processing plays an important role in visual communication design. Fan and Li [4] create various visual effects by using computer graphics processing tools. This includes 2D graphics, 3D models, animations, and virtual reality. These tools enable designers to design and modify their works more efficiently, and to better control the quality and accuracy of images. Intelligent and fuzzy systems are also widely used in visual communication design. Intelligent systems can automatically generate design works through machine learning and deep learning techniques, such as automatic typesetting, automatic color matching, etc. Fuzzy systems can handle uncertain design problems through fuzzy logic and fuzzy reasoning techniques, such as selecting design styles and matching design elements. The application of these technologies can

help designers complete design tasks faster and better control the quality and style of design works. The core element of graphic design is image. Whether designers can successfully transmit information with the help of images and whether readers can successfully interpret design information through images depends on the core of graphic design-image recognition. Image is a method of expressing creative thinking in design, and it is the carrier of conveying design theme information and ideological content. In packaging graphic design, different information content will have different expression images. Images use their vivid visual intuition to convey ideas and explain facts, which can make the audience understand the design content and accept the design information in a short time better than words. Images in paper packaging design works can attract readers' attention and enhance the persuasiveness of design works. CAD can effectively help teachers to arrange words and graphics, save a lot of time in preparing lessons, increase the diversity of courseware, expand the imagination of teachers and students, and cultivate innovative thinking of both sides. In the teaching of graphic design, making full use of CAD can effectively improve the teaching level and enhance the teaching effect. Analyzing and modeling non-destructive testing data in a 3D CAD environment is a complex but very important process. It involves the collection, processing, analysis, and interpretation of data, as well as the creation of physical models based on this data. Holland et al. [5] collected non-destructive testing data. This may involve the use of non-destructive testing techniques such as ultrasound, radiation, and eddy current to obtain data. Data is usually stored in digital form, such as point cloud data or scanning data. Before data analysis, it is necessary to preprocess non-destructive testing data. This may include removing noise, filling or removing data vulnerabilities, standardizing or normalizing data, etc. It uses various data analysis techniques to understand and interpret non-destructive testing data. This may include statistical methods, signal processing techniques, machine learning, etc. By analyzing this data, information about the internal structure and properties of parts or constructions can be obtained. Analyzing and modeling non-destructive testing data in a 3D CAD environment is a complex process that requires interdisciplinary knowledge and skills, including mechanical engineering, non-destructive testing technology, data analysis, computer science, and more. However, by using appropriate tools and techniques, accurate data models can be created, which is crucial for product quality control, product design, and manufacturing process optimization.

Aiming at the problem of computer-aided creative design of paper packaging based on image recognition in graphic design teaching, this article has completed the following work:

⊖ Although the image recognition model based on feature coding has shown excellent classification performance, there are still some imperfect problems in deciding shift-invariant feature coding, balancing time and performance, and end-to-end training feature coding. Aiming at the shortcomings of the existing models, this article proposes a novel and effective feature coding model to improve the performance of image recognition from two aspects: classifier and image feature transformation.

⊖ Make full use of the advantages of CNN in image feature processing, select the improved CNN model as the feature extraction tool for paper packaging images, and grade the categories of image classification. The scoring features are fused with the image texture features, and then used as the input of the classifier.

This article first introduces the application of CAD in graphic design teaching; Then, the paper packaging image feature recognition and completeness detection algorithm based on image recognition is proposed. Then, the detection and recognition performance of the model is simulated and analyzed, which proves the effectiveness of the model. Finally, the innovation and contribution of the research to graphic design teaching are summarized, and the possible improvement direction of image recognition processing is put forward.

2 RELATED WORK

Hsu et al. [6] utilized graphic design software to enable students to create virtual cosmetic models. This can include various types of cosmetics, such as lipstick, eye shadow, foundation make-up, etc. These models can be based on real or imagined products, providing students with a space for creation and innovation. By utilizing the rendering function of the software, students can simulate the effect of cosmetics on real skin. This can help them identify and solve problems during the design process, such as color matching, texture, etc. Teachers can use graphic design software to create tutorials and demonstrations related to cosmetic design. This can include how to use specific tools, how to handle specific materials, and how to achieve specific effects. Teachers can also use graphic design software for online teaching. Through real-time display and interaction, students can watch and follow the teacher's steps on their own devices. The application of computer-aided design software in environmental art and design teaching has become increasingly widespread, mainly including AutoCAD, SketchUp, 3D Max, etc. Jin and Yang [7] analyzed the application of computer-aided design software in environmental art design teaching. Computer aided design software plays an important role in environmental art design teaching. They can not only help students better understand and master design ideas and skills, but also improve teaching quality and effectiveness. AutoCAD is a software used for drawing two-dimensional drawings. In environmental art design, students can use AutoCAD to draw accurate plans, elevations, and sections. Teachers can also use AutoCAD to demonstrate design ideas and techniques, helping students master design methods. Jing and Song [8] analyzed the application of 3D reality technology and CAD in animation design. 3D reality technology can create realistic 3D animation shapes in a virtual environment through 3D modeling and rendering techniques. This technology can greatly improve the quality and efficiency of animation design, while also saving production costs. For example, using 3D modeling technology, various shapes of objects can be created by editing points, lines, and faces of objects, as well as using different modeling tools. In addition, through rendering techniques, various materials and lighting effects can be added to the shape, making it look more realistic. Secondly, CAD also plays an important role in animation design. CAD software provides a series of functions that can assist designers in efficient animation design. For example, using CAD software can quickly perform tasks such as 2D drawing, 3D modeling, and graphic rendering. These features enable designers to create and modify animation shapes more conveniently, thereby improving design efficiency and quality.

For people with English listening disabilities, language barriers are a major issue. They may not be able to understand English pronunciation, or may find it difficult to understand English intonation, pronunciation, etc. Therefore, product design needs to consider how to help them overcome language barriers through other means (such as text, images, etc.). For those who use computer-aided teaching software, technical barriers are also a problem. English hearing-impaired individuals may not be familiar with how to use computer-aided teaching software, or may encounter difficulties during the use process. Therefore, product design needs to consider how to simplify the operational process or provide necessary assistance and guidance. Li and Ji [9] provided text and images to help English hearing-impaired people understand English content. For example, while playing English listening materials, corresponding text and images can be synchronously displayed. The product design can provide voice to text conversion function to help English hearing-impaired people hear English content. For example, while playing English listening materials, voice can be converted into text and displayed on the screen. The design and research of intelligent packaging based on big data image processing is a quite complex and challenging field. This field covers knowledge from multiple disciplines, including big data analysis, image processing, machine learning, artificial intelligence, and packaging design. In intelligent packaging design, big data analysis is mainly used to understand and predict consumer behavior, as well as the product lifecycle. Li et al. [10] can better understand the usage of packaging by collecting, organizing, and analyzing a large amount of packaging related data, such as the way packaging is opened, the frequency of product use, and storage conditions. Image processing is mainly used for product recognition and tracking in intelligent packaging design. Through high-definition image capture and precise image analysis, various features of the product can be identified, such as

color, shape, size, material, etc. This helps optimize the design and production process of packaging. Computer assisted full slide image analysis is a widely used field in medical diagnosis, image recognition, and computer vision. Below, I will outline the main steps and related technologies in this field, including methods from datasets to feature extraction, segmentation, classification, and detection, as well as the application of artificial intelligence in it. Li et al. [11] analyzed the process of object detection, recognition, and localization of specific objects in images. In full slide image analysis, object detection may include identifying and locating tumors, organs, or other key structures. This can be achieved by using deep learning models such as YOLO and Faster R-CNN. The application of artificial intelligence in full slide image analysis has become increasingly common. Deep learning and machine learning algorithms have been widely used in tasks such as feature extraction, image segmentation, image classification, and object detection. The advantages of artificial intelligence include the ability to process large amounts of data, improve diagnostic accuracy, and automate and simplify the analysis process. JomMachine learning is a technology based on machine learning and artificial intelligence. Liow et al. [12] aim to bring art works and design laboratories closer together. It uses deep learning algorithms to analyze art works and design laboratory data, and extract useful information from them to help artists and designers better understand their works. By using JomMachine to learn, artists and designers can better understand their works and discover new creative inspiration. It can also help them complete design tasks faster, improve the quality and efficiency of their works. Overall, JomMachine learning is a very useful technique that can help artists and designers better understand their works and discover new creative inspiration. Contemporary art computer-aided design is a highly practical discipline. In the teaching process, attention should be paid to practical teaching, such as teaching the use of software tools, design skills, etc., so that students can proficiently master CAD technology. In contemporary art computer-aided design teaching, evaluation and feedback are very important links.

Liu and Yang [13] help students identify problems and shortcomings by evaluating and providing feedback on their works, thereby improving their design skills and creativity. In contemporary art computer-aided design practice, team collaboration ability is also very important. Therefore, in the teaching process, it is important to focus on cultivating students' teamwork skills, such as organizing group discussions and collaborating to complete design projects. By analyzing excellent design cases, guide students to engage in design practice, thereby improving their design level and creativity. Liu et al. [14] used quantum mechanics principles and algorithms to simulate and predict the behavior of molecules and materials. These algorithms may be used to calculate the electronic structure of materials, chemical reaction properties, molecular properties, etc., which are difficult to accurately measure using traditional experimental methods. Then, the tool may utilize the results of these simulations and predictions, as well as a large amount of chemical data, to train and learn through machine learning algorithms. Machine learning algorithms can identify and extract patterns from data, thereby predicting the properties and behaviors of new, unproven chemical products. Finally, the tool may provide a user-friendly interface that allows researchers and designers to input their design goals, such as the properties of the required materials, the conditions of chemical reactions, etc., and then provide possible results for chemical product design and prediction. This can greatly accelerate the design and development process of chemical products. This is a very complex and interdisciplinary tool that requires in-depth knowledge of quantum mechanics, machine learning, and chemistry. However, its application may greatly improve the efficiency and accuracy of chemical product design, while reducing the cost and time of experiments. Özgen et al. [15] evaluated the level of mastery of basic design concepts and skills by two groups of students through standardized tests. The test includes objective multiple-choice questions and subjective drawing questions to evaluate students' theoretical mastery and practical application abilities. In addition, we also collected feedback from students on using virtual reality or paper textbooks for learning. The results showed that in the objective multiple-choice questions section, the VR group performed similarly to the paper group. However, in terms of subjective drawing questions, the VR group performed significantly better than the paper group, demonstrating their advantages in practical application

abilities. In addition, students in the VR group generally expressed satisfaction with using virtual reality to learn basic design, believing that it improved their learning efficiency and fun. The applicability of 3D factory simulation software in computer-aided participatory design of industrial workplaces and processes is high. This software provides a three-dimensional environment, allowing users to understand and design the layout and processes of factories in a more intuitive and vivid way. Pelliccia et al. [16] analyzed the applicability of 3D factory simulation software in computer-aided participatory design of industrial workplaces and processes. 3D factory simulation software can help engineers and designers plan and layout factory facilities, production lines, and logistics routes in a virtual environment, greatly improving design efficiency and reducing subsequent modification and adjustment costs. By simulating the operational process of a factory, 3D factory simulation software can help engineers and designers identify and solve potential problems, optimize logistics and production lines, and improve production efficiency. Through 3D factory simulation software, engineers and designers can predict and evaluate various possible scenarios before actual construction, thereby better controlling costs.

Pradhan and Dhupal [17] use CAD software to create a geometric model of a hot abrasive jet machining device. This model should include all important physical characteristics, such as size, material properties, etc. It imports CAD models into simulation software. This process may require some preprocessing of the model, such as cleaning, simplifying, or converting file formats. In the simulation software, set appropriate physical models and parameters. These parameters may include the characteristics, pressure, velocity, etc. of the hot abrasive. Finally, run the simulation, observe and record the results. These results may include processing efficiency, material removal rate, heat affected zone, etc. Based on the simulation results, modify the CAD model and optimize the design. This process may need to be repeated until a satisfactory result is obtained. Through this method, the simulation, modeling, and CAD of hot abrasive jet machining devices can be effectively integrated, improving design efficiency and quality. CAD software can provide detailed insights into product design, including appearance, internal structure, material selection, etc. This helps to create product designs that are more optimized, in line with functional requirements and market expectations. Saleh et al. [18] used CAD software to create and modify designs in a short period of time, greatly improving design speed. This not only shortens the product development cycle, but also enables new products to be brought to the market faster. Using CAD software for product design can reduce the need for expensive physical prototypes, thereby reducing development costs. In addition, CAD software can be used for simulation and testing, further reducing the potential errors and damages that may occur during the development phase of the product. Computer assisted automated green design is an important part of sustainable development. BIM (Building Information Modeling) technology plays a crucial role in this process, helping us better understand and manage the lifecycle of buildings and infrastructure, thereby achieving more environmentally friendly and sustainable design and construction. Sędzicki et al. [19] utilized the BIM model to analyze and optimize the sources and use of building materials, using renewable and recyclable materials as much as possible. By integrating energy analysis into BIM models, more energy-efficient buildings and infrastructure can be designed. In addition, BIM can also help optimize the design and operation of distributed energy systems, such as solar and wind energy. By integrating water resource analysis into BIM models, more water-saving buildings and infrastructure can be designed, such as rainwater collection and reuse systems. The appearance design of agricultural product packaging art style under intelligent computer assistance is optimized by combining artificial intelligence and computer vision technology to optimize the appearance design process of agricultural product packaging. Zhao et al. [20] collected a large number of agricultural product packaging images and artistic style images. These data will be used to train and optimize the system's algorithms. The system will use computer vision technology to extract key features in packaging images, such as color, shape, texture, etc. These features will be used for subsequent style classification and matching. The system will use deep learning algorithms to classify and recognize artistic styles. When a user selects a specific artistic style, the system will search for matching features in agricultural product packaging images based on the characteristics of that style and perform corresponding appearance design. Through this system,

users can more conveniently design and produce agricultural product packaging with specific artistic styles, thereby improving the attractiveness and market competitiveness of the products. At the same time, this system can also help designers carry out packaging design work more efficiently, reducing repetitive labor and tedious manual adjustments.

3 IMAGE RECOGNITION AND INTEGRITY DETECTION ALGORITHM OF PAPER PACKAGING

3.1 Image Feature Recognition

Image recognition is the research focus in the field of computer vision, and effective image recognition methods can greatly improve the performance of computer vision models. In order to promote the innovation of graphic design teaching method and strengthen the application of CAD tools in paper packaging design, this article studies the packaging image recognition method based on improved CNN. Deep learning (DL) is essentially an artificial neural network, but more training skills, more training data and more computing power make DL work effectively. In a broad sense, feature learning is a mapping from the original feature space to the new feature space, so it is not that only DL is feature learning, and other feature transformation methods can also be called feature learning. Even these feature transformation methods may be a supplement or explanation of DL. As shown in Figure 1, the packaging image recognition model proposed in this article mainly includes two identical components CNN. This set of CNN models respectively corresponds to the experimental image sets of different paper packaging types. Parameters are shared between two CNN models, and each CNN includes three convolution+pooling layer groups. After the convolution+pooling layer group is a fully connected layer, which is used to generate a representation for each input sample. Finally, the distribution of target expression is obtained by using a loss function for multi-data set network model, and the classification error is calculated to fine-tune the parameters.

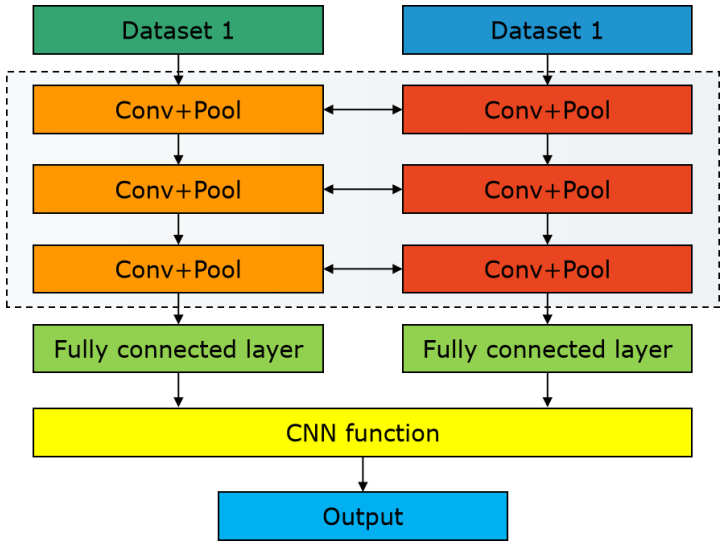

Figure 1: Packaging image recognition model.

The traditional image classification technology is mainly to preprocess the input image first, and analyze the features of the image with the goal of extracting the features of the real image object. Then the input images are classified according to the selected image features with significant

expression. In this article, by grouping the input feature graphs, grouping convolution can improve the receptive field of the network and increase the diversity of features while reducing the computational complexity, thus effectively improving the performance of CNN. In addition, block convolution can also reduce the amount of parameters and storage, so that the neural network can still operate efficiently in the restricted environment. For small networks, when the quantity of input nodes is greater than the quantity of output nodes, the optimal quantity of hidden layer nodes h:

$$h = \sqrt{M \times N} \tag{1}$$

Where N is the quantity of input nodes and M is the quantity of output layer nodes.

Almost all neuron learning algorithms can be regarded as variants of Hebb learning rules. Specific to the aforementioned neuron model, the Hebb rule can be expressed as the following algorithm:

$$\Delta w_{ij} = \lambda x_i y_j \tag{2}$$

Δw_{ij} is the correction of the i th weight, and λ is the coefficient that controls the learning speed.

In the field of image recognition, feature coding model is a very important and popular method. A dictionary is trained for the corresponding image blocks or image features, and the relevant representation coefficients are obtained through the dictionary for image classification. The feature coding model can be regarded as a feature transformation model, and the original image features can be more refined and representative after feature coding. In the process of DL, image feature learning can also be completed by means of multi-layer feature learning. Among them, it is mainly done by subspace learning. This method is mainly to analyze the nature of relevant data in the dimension reduction space, and can also be understood as a dimension reduction algorithm. For the feature coding method, the feature coding model based on CNN features is obviously superior to the traditional feature coding method based on manual features in recognition performance.

Self-encoder is an unsupervised learning method, which is mainly used in data dimensionality reduction and feature extraction. Self-encoder consists of encoder and decoder:

$$h^1 = f_1\left(w^1 x + b^1\right) \tag{3}$$

$$y = f_2\left(w^2 h^1 + b^2\right) \tag{4}$$

Where x is the input of the network, w^1, b^1 is the weight and bias of the encoder, w^2, b^2 is the weight and bias of the decoder, f_1, f_2 is the nonlinear change, and y is the reconstruction input, and the mean square error function is usually used to compare the values of x, y, and finally h^1 is used as the encoding result of the encoder.

Input the test set image data into the trained classifier to classify the images. Like the training set, the test set image data also needs the same image preprocessing and feature extraction. Then, the characteristics of the test set image are input into the classifier that has been trained with the training set data, and the classifier judges and classifies, and then the classification results are output. Generally speaking, feature coding can be regarded as an operation that gives each feature a description based on vector form. In the context of image representation and recognition, feature coding means constructing corresponding coding vectors from image blocks or image features. The result of feature coding is usually a fixed-length vector, because most classifiers used for image recognition generally only receive fixed-length input vectors. See Figure 2 for the inspection window of package integrity.

Figure 2: Package integrity detection window.

In practical application, the distribution of error in the weight space of the network is very complicated, and there are many peaks and valleys, that is, local minima. One of the improved methods is to add the previous gradient as the momentum term in the weight modifier:

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

The current gradient is the most influential component in $\Delta w_{ji}(n)$, and its coefficient is always one. The influence of the previous gradient on $\Delta w_{ji}(n)$ decreases exponentially with $\alpha^{\eta-t}$.

Error function:

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

t_{pi}, o_{pi} is the expected output and the actual calculated output of the network.

3.2 Packaging Image Integrity Detection

Labeled visual data is scarce, and unlabeled data is easy to obtain, while DL can just train and extract features from unlabeled visual data unsupervised using a large amount of data in natural language field. In order to better grasp the learning and classification methods of image features in DL background, in the specific application process, we should make full use of the related systems in back propagation to carry out the activation function and the use of convolution layer and aggregation layer. In this way, we can effectively train CNN systematically. By introducing multi-task deep convolution network, the improvement of DL in feature learning and classification under multi-task background is further strengthened. Therefore, in order to solve the problem of labeling data and training time, we can consider using transfer learning. The CNN identification model is shown in Figure 3.

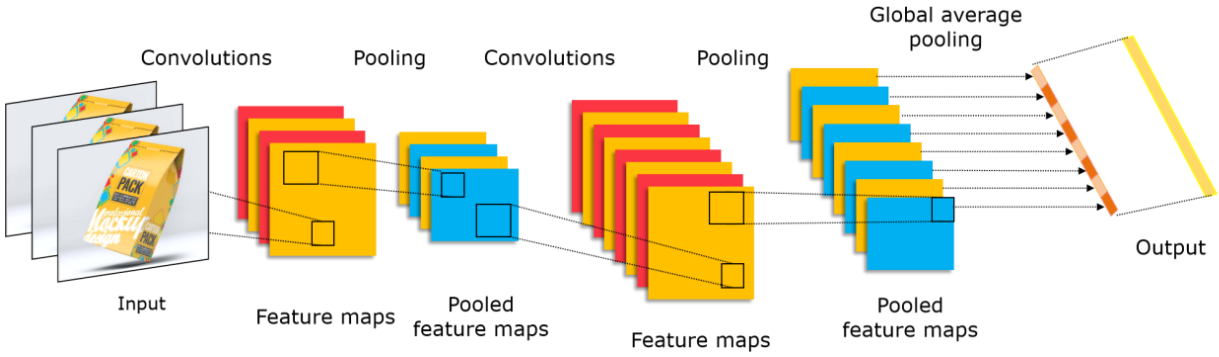

Figure 3: CNN recognition model.

In the original feature bag model, an input image is decomposed into a local visual feature bag which is described by a set of visual words. The dual attention mechanism combines channel attention and spatial attention to help the classifier pay attention to the channels that are meaningful to the network and reduce the interference of other information to the classifier, thus improving the classification performance. Correlation matrix can reflect the correlation of data sets from a macro perspective:

$$CM = \sum_{i=0}^{N} CM_i \tag{7}$$

Because the conditional probability between some objects in the matrix is small, these data are not common and will become noise. In order to filter out these noises, this article uses a threshold ε to binarize the matrix CM :

$$CM_{ij} = \begin{cases} 0, P_{ij} \le \varepsilon \\ 1, P_{ij} > \varepsilon \end{cases} \varepsilon \in [0,1] \tag{8}$$

The matrix representing the weighted graph $G = (V, E, w)$ is called the weighted adjacency matrix, and is set as W . Convolution of graphic signal to get the definition of graphic convolution:

$$y = U g_\theta(\Lambda) U^T x \tag{9}$$

Where x is the input graph signal and $U^T x$ is the matrix form of Fourier transform of graph signal x , where U is the characteristic vector of graph Laplacian matrix.

Using large data sets to train the model, and then using small sample data sets to fine-tune the parameters of the trained model, so that the finally trained model has the dual advantages of being suitable for small data sets and high precision. In the algorithm, firstly, feature maps are grouped and processed by channel attention and spatial attention, and then the processed features are fused. By introducing packet convolution and dual attention mechanism, the algorithm can improve the network performance and reduce the quantity of parameters.

The existing algorithms have made remarkable progress in the visual quality of generated images. However, the concrete expression of natural language texts is very subjective, which makes it difficult to maintain semantic consistency with language texts with different expressions in the generation of visual content. In order to generate more abundant and accurate language texts, this article introduces the loss function based on language attributes on the basis of

traditional sentence-based supervision, which makes the original single-stage language text generation process become a multi-stage generation process from coarse to fine.

Assuming that the image size is $M \times N$, the gray level is $\{0,1,\cdots,L-1\}$, and the quantity of pixels in gray level i is n_i, the frequency of gray level i is:

$$p_i = \frac{n_i}{MN} \tag{10}$$

If the image pixels are divided into two types of C_0, C_1 by the threshold T, the probabilities are:

$$w_0 = \sum_{i=0}^{T} p_i,\ w_1 = 1 - w_0 \tag{11}$$

The average gray values of the two classes are:

$$\mu_0 = \frac{1}{w_0} \sum_{i=0}^{T} i p_i \tag{12}$$

$$\mu_1 = \frac{1}{w_1} \sum_{i=T+1}^{L-1} i p_i \tag{13}$$

Open operation is performed on image A through structural element B, which can be recorded as $A \cdot B$, and can be expressed as:

$$A \cdot B = (A \oplus B) \Theta B \tag{14}$$

The closing operation of paper packaging image is that paper packaging image A is firstly expanded by B, and then corroded by structural element B. Closing the image of paper packaging can not only smooth the image of paper packaging to a certain extent, but also connect the tiny broken parts and fill the tiny holes in the image of paper packaging.

4 SIMULATION TEST OF PACKAGING IMAGE RECOGNITION

In the training of CNN model, the quantity of samples is very large. In general networks, the quantity of training samples should reach at least hundreds of thousands of orders of magnitude. In the experiment, let the batch size of training be 64 and the learning rate be 1.2. In data preprocessing, all the pictures are scaled to a height of 32, and the width is set according to the width-height ratio of the original picture. In order to test the effectiveness of this algorithm, it is compared with the accuracy of packaging pattern integrity detection by shape matching method and support vector machine (SVM) algorithm, as shown in Table 1.

Commodity number	*Paper algorithm*	*Shape matching*	*SVM*
1	96.881	85.385	91.921
2	96.220	84.527	89.612
3	94.551	84.219	91.828

Table 1: Accuracy of packaging pattern integrity detection by different methods.

The average integrity detection accuracy of the packaging pattern of this algorithm is 95.884%, which is 11.17% higher than that of the shape matching method. For the integrity detection of paper packaging patterns, the accuracy of shape matching method is worse than that of this algorithm. The main reason is that shape matching is an approximate matching process, and there

are shortcomings in matching accuracy. In addition, it can be seen that the accuracy of packaging pattern integrity detection by SVM method is higher than that by shape matching method, which shows that SVM moment has stronger expression ability for packaging pattern shape characteristics.

Because the length of all the pictures is inconsistent, if the width of the picture is smaller than the width of the input block, these paper-packed pictures need to be filled in the horizontal direction. A natural way is to fill with background color, but this filling method can't bring extra information for training. Moreover, when the width of the input picture is large and the width of the original picture is small, the information of the original picture will account for a small part, which may lead to incomplete information expression. In order to further analyze the expressive ability and recognition performance of the three descriptors, and to study the influence of the quantity of training samples on the detection accuracy, the detection accuracy of the proposed algorithm, shape matching method and SVM under different off-line training sample sets is tested, as shown in Figure 4, Figure 5 and Figure 6.

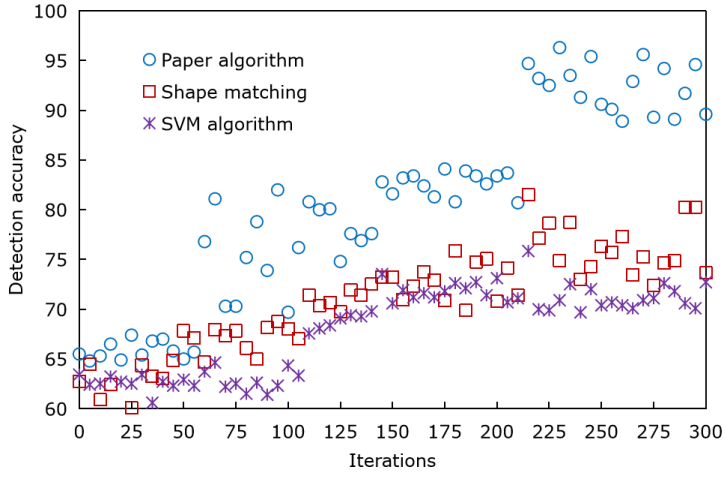

Figure 4: Identification performance of commodity 1.

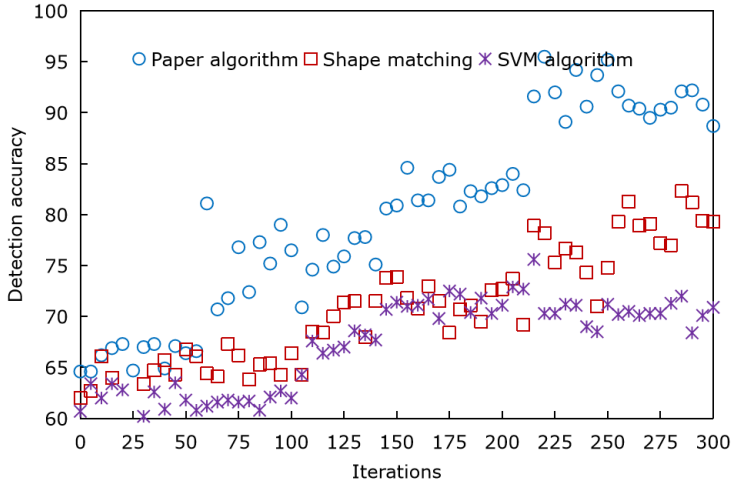

Figure 5: Identification performance of commodity 2.

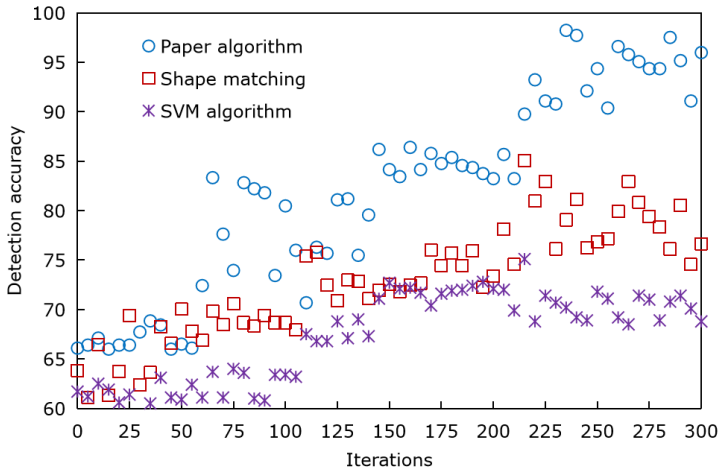

Figure 6: Identification performance of commodity 3.

On the basis of retaining the main information, this algorithm improves the recognition performance and the accuracy of packaging pattern integrity detection. SVM has stronger feature description ability than shape matching method, and the accuracy of packaging pattern integrity detection is higher, mainly because high-order SVM has very strong detail description ability.

Multi-task learning can improve the recognition effect by learning multiple related tasks at the same time. In this article, CNN is regarded as the bottom feature learning model, and the output of the last aggregation layer is regarded as the shared feature of language classification and paper packaging classification. See Figure 7 for the comparison of the optimization effects of packaging images processed by different methods.

Figure 7: Comparison of packaging image optimization effect.

After the processing of this algorithm, the packaging image is effectively controlled by noise, the basic outline of the image is clearly visible, and the contrast of the image is improved to some extent, and the image is effectively enhanced. By introducing local correlation soft allocation coding coefficients, only the most relevant coding coefficients can be retained in the proposed feature coding model and the distant coding coefficients can be discarded, thus reducing the adverse impact of irrelevant coding coefficients on the model. This design can effectively enhance the judgment ability of coding coefficients.

The proposed model and network not only prove the effectiveness of feature coding classifier in the field of image classification, but also prove that CNN with prior feature coding can obtain feature coding with stronger representation ability to improve image recognition performance. When the transfer learning method is used to identify the characteristics of packaging images, all or part of the parameters of the pre-trained model can be transferred according to the actual situation, and the model can be fine-tuned by using the experimental data set to improve the classification accuracy of the model and prevent the phenomenon of over-fitting. The identification time of packaging features by different methods is shown in Figure 8.

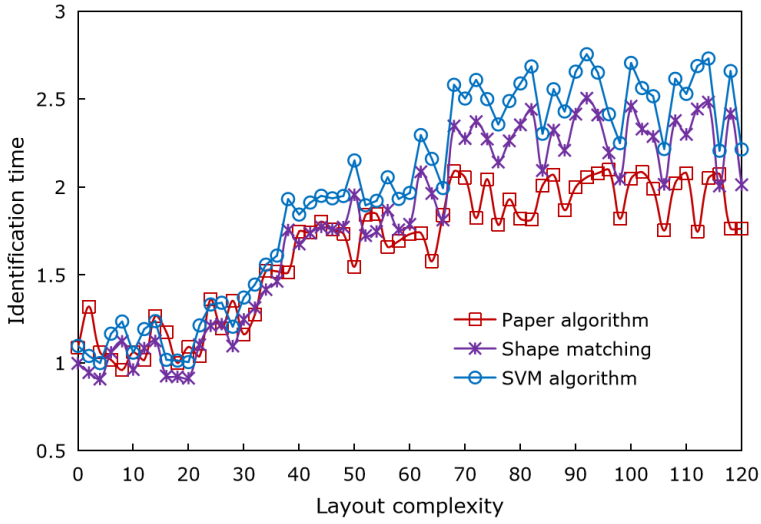

Figure 8: Comparison of packaging feature recognition time.

By analyzing Figure 8, it is found that the user image recognition method in this study takes less time in the experiment. In the process of DL, image classification is mainly to judge the semantic content of the whole image at the macro level. In the current whole market field, image classification has great application potential in both information retrieval and user demand analysis. From the above data tasks and learning, it is necessary to deepen the original feature analysis method effectively, so as to further obtain the specific features such as the size and edge of the relevant depth-of-field image. Because the proposed multi-channel feature coding network can aggregate corresponding feature codes from different levels of features, the feature codes aggregated by this multi-channel network will have more image expression ability.

5 CONCLUSIONS

Graphic design is a professional design course closely combined with the teaching of design software. CAD can effectively help teachers to arrange words and graphics, save a lot of time in preparing lessons, increase the diversity of courseware and expand the imagination of teachers

and students. In this article, a method of packaging image recognition and integrity monitoring based on improved CNN is proposed to realize packaging creative design based on CAD modeling optimization. Aiming at the shortcomings of the existing models, this article proposes a novel and effective feature coding model to improve the performance of image recognition from two aspects: classifier and image feature transformation. Simulation results show that, on the basis of retaining the main information, this algorithm improves the recognition performance and the accuracy of packaging pattern integrity detection. Compared with shape matching method, SVM has stronger feature description ability and higher accuracy of packaging pattern integrity detection, mainly because high-order SVM has very strong detail description ability. By introducing local correlation soft allocation coding coefficients, only the most relevant coding coefficients can be retained in the proposed feature coding model and the distant coding coefficients can be discarded, thus reducing the adverse effects of irrelevant coding coefficients on the model. Although the method of reducing the quantity of features to reduce the initialization time is proposed in this article, there should be corresponding methods to reduce the initialization time. In the aspect of reducing initialization time, it is still worth further study.

6 ACKNOWLEDGEMENT

This work was supported by Ministry of Education supply and Demand matching employment Education Project: Art design professional talent innovation ability cultivation under the background of digital media (No. 20230110550); Social Science Project, Guangdong University of Foreign Studies: Research on Innovation and Application of Chaozhou embroidery from the Perspective of Cultural Creativity (No. 20TS11).

Yanpeng Chen, https://orcid.org/0009-0007-9684-955X
Dahua Meng, https://orcid.org/0009-0009-6134-5401

REFERENCES

[1] Angrish, A.; Bharadwaj, A.; Starly, B.: MVCNN++: computer-aided design model shape classification and retrieval using multi-view convolutional neural networks, Journal of Computing and Information Science in Engineering, 21(1), 2021, 011001. https://doi.org/10.1115/1.4047486

[2] Bao, W.: The application of intelligent algorithms in the animation design of 3D graphics engines, International Journal of Gaming and Computer-Mediated Simulations, 13(2), 2021, 26-37. https://doi.org/10.4018/IJGCMS.2021040103

[3] Cao, Q.: The art of packaging: an investigation on modern packaging design and artistic thinking under the background of big data, Journal of Applied Science and Engineering, 24(4), 2021, 807-812. https://doi.org/10.6180/jase.202110_24(5).0017

[4] Fan, M.; Li, Y.: The application of computer graphics processing in visual communication design, Journal of Intelligent & Fuzzy Systems, 39(4), 2020, 5183-5191. https://doi.org/10.3233/JIFS-189003

[5] Holland, S.; Mcinnis, C.; Radkowski, R.: NDE data analysis and modeling in 3D cad context, Materials Evaluation, 78(1), 2020, 95-103. https://doi.org/10.32548/2020.me-04095

[6] Hsu, H.-H.; Wu, C.-F.; Cho, W.-J.; Wang, S.-B.: Applying computer graphic design software in a computer-assisted instruction teaching model of makeup design, Symmetry, 13(4), 2021, 654. https://doi.org/10.3390/sym13040654

[7] Jin, H.; Yang, J.: Using computer-aided design software in teaching environmental art design, Computer-Aided Design and Applications, 19(S1), 2021, 173-183. https://doi.org/10.14733/cadaps.2022.S1.173-183

[8] Jing, Y.; Song, Y.: Application of 3D reality technology combined with CAD in animation modeling design, Computer-Aided Design and Applications, 18(S3), 2020, 164-175. https://doi.org/10.14733/cadaps.2021.S3.164-175

[9] Li, H.; Ji, J.: Analysis of English listening obstacles based on computer assisted instruction, Computer-Aided Design and Applications, 18(S4), 2021, 130-140. https://doi.org/10.14733/cadaps.2021.S4.130-140
[10] Li, H.; Jin, C.; Kong, R.; Su, M.: Intelligent packaging design and research based on big data image processing, Journal of Electronic Imaging, 32(1), 2023, 011218-011218. https://doi.org/10.1117/1.JEI.32.1.011218
[11] Li, X.; Li, C.; Rahaman, M.-M.; Sun, H.; Li, X.; Wu, J.; Grzegorzek, M.: A comprehensive review of computer-aided whole-slide image analysis: from datasets to feature extraction, segmentation, classification and detection approaches, Artificial Intelligence Review, 55(6), 2022, 4809-4878. https://doi.org/10.1007/s10462-021-10121-0
[12] Liow, K.-M.; Ng, P.; Eaw, H.-C.: Jommachinelearning: bringing artwork nearer with designlab, International Journal of Business Strategy and Automation, 2(2), 2021, 54-71. https://doi.org/10.4018/IJBSA.20210401.oa5
[13] Liu, F.; Yang, K.: Exploration on the teaching mode of contemporary art computer aided design centered on creativity, Computer-Aided Design and Applications, 19(S1), 2021, 105-116. https://doi.org/10.14733/cadaps.2022.S1.105-116
[14] Liu, Q.; Tang, K.; Zhang, J.; Feng, Y.; Xu, C.; Liu, L.; Zhang, L.: QMaC: a quantum mechanics/machine learning-based computational tool for chemical product design, Computer Aided Chemical Engineering, 48(5), 2020, 1807-1812. https://doi.org/10.1016/B978-0-12-823377-1.50302-5
[15] Özgen, D.-S.; Afacan, Y.; Sürer, E.: Usability of virtual reality for basic design education: a comparative study with paper-based design, International Journal of Technology and Design Education, 31(21), 2021, 357-377. https://doi.org/10.1007/s10798-019-09554-0
[16] Pelliccia, L.; Bojko, M.; Prielipp, R.: Applicability of 3D-factory simulation software for computer-aided participatory design for industrial workplaces and processes, Procedia CIRP, 99(1), 2021, 122-126. https://doi.org/10.1016/j.procir.2021.03.019
[17] Pradhan, S.; Dhupal, D.: An integrated approach of simulation, modeling and CAD of hot abrasive jet machining setup, Journal of Advanced Manufacturing Systems, 21(03), 2022, 427-472. https://doi.org/10.1142/S0219686722500123
[18] Saleh, B.; Rasul, M.-S.; Affandi, H.-M.: The Importance of quality product design aspect based on computer aided design (CAD), Environment-Behaviour Proceedings Journal, 5(3), 2020, 129-134. https://doi.org/10.21834/ebpj.v5iSI3.2545
[19] Sędzicki, D.; Cudzik, J.; Bonenberg, W.; Nyka, L.: Computer-aided automated greenery design—towards a green BIM, Sustainability, 14(14), 2022, 8927. https://doi.org/10.3390/su14148927
[20] Zhao, Z.; Zheng, H.; Liu, Y.: The appearance design of agricultural product packaging art style under the intelligent computer aid, Computer-Aided Design and Applications, 19(S3), 2021, 164-173. https://doi.org/10.14733/cadaps.2022.S3.164-173