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Design of Graphic Design Assistant System Based on Artificial Intelligence

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ABSTRACT

With the development of technology, graphic design tools are becoming more and more perfect, which allows graphic designers to realize their dream designs, achieve more special effects, and thus expand their conceptual choices. The application of various new technologies in graphic design can promote the development of the graphic design industry. The emergence of artificial intelligence (AI) has broken through the layout design in traditional graphic design. In this article, the author proposes the creation of a graphic design assistant system based on AI drawing on the deep learning (DL) theory. According to the DL theory, the image is segmented by the class variance. The voxelized image matrix of a two-dimensional (2D) model is input into a convolution-automatic encoder (CAE) as input data. The input data first pass through the convolution layer of the CAE, which mainly completes the mapping of features. The research results show that the average aesthetic evaluation of the system design works in this study is higher than that of CAD software and PS software, and the total average score is as high as 8.788, which shows that the system design works in this study are more in line with the requirements of professional understanding.

KEYWORDS

artificial intelligence, convolution-automatic encoder, deep learning, graphic design

CREATION OF A GRAPHIC DESIGN ASSISTANT SYSTEM BASED ON ARTIFICIAL INTELLIGENCE

Graphic design works should have concise language and intense artistry, which can effectively reflect the author's artistic style. Although multimedia is developing rapidly and three-dimensional (3D) technology is widely used today, graphic design images also have high application value (Tan & Yang, 2021). Artificial intelligence (AI) computer-aided design has been gradually applied to graphic design-aided systems, which is closely related to graphic design modernization. With the development of AI technology, machine learning based on design image data makes AI-aided design possible. In this regard, deep learning (DL) has shown great application potential in design image analysis and generation (Beik, 2020). The mainstream graphic design methods in the market can no longer meet graphic designers' growing design inspiration. More and more, graphic designers put

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forward new requirements for design forms. With the development of technology, graphic design tools are becoming more and more perfect, which allows graphic designers to realize their dream designs, achieve more special effects, and expand their conceptual choices.

Design is an innovative, open and repetitive work to solve problems. In the design process, designers will constantly and better study issues and evaluate better schemes, and improve design (Dong et al., 2021), so iteration is constructed as the most effective innovation pice. It provides a mechanism to support design innovation (Zheng et al., 2019). Bhatti et al. (2020) applied region segmentation to artistic image style, used a down-sampling method to express it step by step, then used a canny operator to refine the edges, and finally filled the corresponding colors and textures according to the blocks. Kim et al. (2022) proposed a mosaic method of image blocks, which first matched the original texture with the existing texture, found the texture mapping between the source image and the target image, and then cut off the redundant boundaries. Long and Han (2020) proposed a new component-based model and a room classification method using data obtained from visual sensors. Zhang et al. (2018) used convolutional neural network (CNN) to identify the items placed in the room in the image, in order to determine the room type which was used for the service robot working in the home environment, so that it could identify the room it visited. Zhang et al. proposed a method of clustering architectural forms. The evaluation indexes of this clustering algorithm can be defined artificially, such as lighting, cooling, and heating load. With the deepening of image graphics based on DL, AI has been applied to practice, and the development of computer vision has become more and more rapid. However, the problem is feature extraction of 3D models (Zhang, Cai et al., 2018).

The development of human science and technology is a process of constantly improving its needs. The fundamental purpose of developing and applying science and technology is to continuously meet people's living and spiritual needs, among which spiritual needs are critical. For graphic designers, the satisfaction of spiritual needs is the realization of design ideas. The existing graphical design system can provide a graphical platform for users, but it cannot offer more graphical geometric basis for users in the graphical process. Therefore, in this paper, the author proposes a new AI-based graphic design assistant system, which can complete the aesthetic analysis of geometric element proportion in graphic design, thus helping users to perceive the feeling of visual aesthetic and providing users with design support related to geometric aesthetic principles.

RESEARCH METHOD

Overall Structure Design of the System

Applying various new technologies in graphic design can promote the development of the graphic design industry. The emergence of AI has broken through the layout design in traditional graphic design. On the one hand, this dramatically improves the speed of layout and typesetting, and, on the other hand, it can save a large amount of human resources. In addition to the basic principles and methods of graphic design, graphic designers also need to have a deeper understanding of other disciplines to better use multidisciplinary knowledge and carry out corresponding design work. For example, to make 3D effects in PS, it is often necessary to use the method of multi-layer superposition, which is complicated and error-prone; Now, you can create 3D graphics with software 3D tools, and make 3D rotation or scaling effects.

Iteration is a natural feature of a design function, a conversion process from information processing to decision. In the process of repetition, problems will be more apparent, ideas will be improved, mistakes will be confirmed, and new knowledge will be gained. In addition to the iterative cycle between different design activities, there will also be iterative behavior within each design activity. For example, the forward transition sequence can indicate the natural process from the scope of the problem to the solution, which is usually described in the design process model (Huang et al., 2022). Extant research on the definition of the scope of the problem shows that the relevant iterative path of definition runs through the whole process (Kim & Kim, 2020), and the main behaviors related to this activity are information collection and constrained migration.

Perceptual image words are a common form of intuitively reflecting design images. The study of design image also involves many fields of knowledge, including psychology, semiotics, linguistics, aesthetics, sociology, industrial design, computer technology, and ergonomics. Ideally, the design image experienced by users is consistent with the design image that designers want to express. Still, in fact, the designer's design concept and user's perception are often different, to some extent, leading to the cognitive contradiction between designers and users and the deviation between product design and user's needs. To make up the cognitive difference between designers and users, it is necessary to establish a scientific evaluation method for design images.

Due to the ubiquitous existence of the network in the real world, graph analysis has attracted more and more attention in recent years. The graph (also called network) is used to represent information in various fields, including biology (e.g., protein-protein interaction network), social science (e.g., social network) and linguistics (e.g., word cooccurrence network). In contrast, the most significant advantage of graph neural network (GNN) is that it can not only represent a node semantically (Zhou et al., 2020), but also, for example, the semantic information of a subgraph; it is not easy for graph embedding to express the semantics of a small number of nodes in the network.

The plan view can be converted into a bubble function relationship diagram, which is the data structure (Jang et al., 2019). Given a building function bubble diagram $G = \left(V, E\right)$, the researcher first embeds all the rooms and connections into a dimensional real-valued vector space. For a given graph $G = \left(V, E\right)$, they use $N\left(i, r\right)$ to represent the set of all neighboring nodes within the radius r of node v_i, where $N\left(i, 0\right) = \left\{i\right\}$. Therefore, they can define the radius r subgraph of node v_i as follows:

$$v_i^{(r)} = \left(V_i^{(r)}, E_i^{(r)}\right) \quad (1)$$

Among them,

$$V_i^{(r)} = \left\{v_j \middle| j \in N\left(i, r\right)\right\} \quad (2)$$
$$E_i^{(r)} = \left\{e_{mn} \in E \middle| \left(m, n\right) \in N\left(i, r\right) * N\left(i, r-1\right)\right\} \quad (3)$$

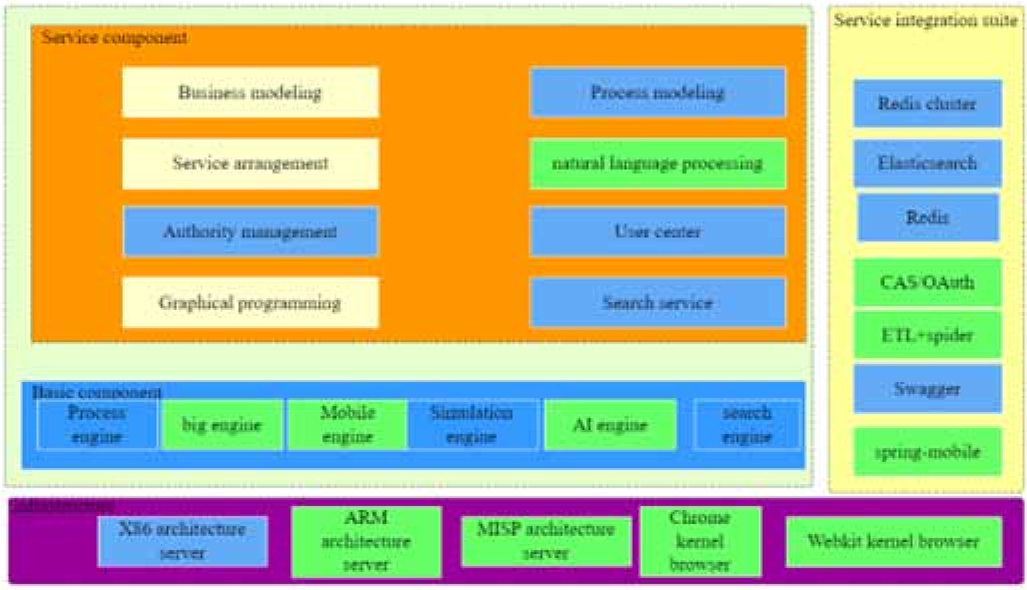
In addition, we define the subgraph of the radius r of the edge e_{ij} as follows:

$$e_{ij}^{(r)} = \left(V_i^{(r-1)} \cup V_j^{(r-1)}, E_i^{(r)} \cup E_j^{(r)}\right) \quad (4)$$

$v_i^{(r)} \in R^d, e_{ij}^{(r)} \in R^d$ is randomly initialized during supervised learning, and then trained by backpropagation.

As a powerful theoretical tool, graph theory is applied to organization plane elements in road design, which has good adaptability. At present, the method of dealing with plane elements adopts the theory of linked list, which is inflexible, slow, and narrow in application. Graphic design must conform to the principle of "geometry," to some extent, to give the graphics "cohesion." The aesthetic principles of these geometries are the key for understanding many graphic design works and the aesthetic tenets of analyzing graphic design work. In this study, the author developed a graphic design assistant system based on AI by using DL technology. Figure 1 shows the overall framework of this design system.

Figure 1. Design of the overall framework of the system



The man-machine interface of the graphic design assistant system is just a user interface. Its implementation can take different forms or be very complicated. To make the machine intelligent, knowledge must be expressed in a specific form that is acceptable to the computer. AI expert system is often composed of knowledge base and inference engine. Among them, the role of the reasoning engine is to judge which rule is in line with reality or the purpose, rank it, and make logical reasoning. An automatic knowledge input mode set for users and set by knowledge collectors. The reasoning mechanism refers to the efficient selection of knowledge in the knowledge base using specific reasoning strategies. Based on the users' questions, the engine carries out the reasoning and finally produces a conclusion acceptable to users (Zhang et al., 2019).

Each part of the above functions can be completed, in addition to information query, but it is also possible to output the corresponding results table, and then all the results tables after the graphic design is completed. These are completed by clicking on the function menus in the main interface. The system can calculate various curve types such as single intersection, convex, S-type, C-type, double intersection (i.e., imaginary intersection, tangent baseline, and turning back curve), multiple intersection, complex curve, and single egg curve. Users do not need to create multiple directories to manage the uplink and downlink separately. In the same directory, each project has only one database file. When users design, all operations are in the current database. Thus, a plurality of files is not needed to record the original data and the result data.

Key Technology Realization

The traditional graphic design began to break through the plane scope, develop into a diversified cross-media integration, and gradually realize the multilevel expression. The way in which graphic design works transmit information has also changed greatly in the Internet information age. Besides traditional printed matter, graphic design information can also be sent by the Internet, APP and other technical means. Therefore, graphic designers should not only reflect the design elements of goods, but also creatively transform the graphic packaging to obtain better visual effects. Designers must have a deep understanding and mastery of materials and printing technology.

Image recognition and generation is the research frontier and hotspot in AI, and deep CNN has excellent image expression ability. In landscape architecture, the application of depth model is still in its infancy, and the existing research can be divided into two major fields: Design image classification and design image generation. In the scene of design discipline, automatic graphic recognition and generation often need to use the generative proactive network model with input conditions (e.g.,the virtual scene experience of amusement park and holographic stage effect). These scenes are the latest application of the combination of graphic design art and new technology. The above examples show that technology development blurs the technical bottleneck, simplifies the application threshold of various special effects, and enables designers to realize their own design ideas more easily than before, thus realizing the integration of plane, 3D, and even virtual design effects.

The characteristics of the CNN, such as local connection, weight sharing, and pooling operation, can effectively reduce the complexity of the network, reduce the number of training parameters, make the model invariant to translation, distortion, and scaling to a certain extent, and have strong robustness and fault tolerance, and are also easy to train and optimize. Over time, the layers of the CNN have become deeper and deeper; more and more features can be learned and used in many aspects, such as image recognition and voice analysis. Its naming and principle are derived from the transmission mode of biological neurotransmitters. On this basis, with the sharing of weights and the improvement of computer computing power, the CNN has more and more layers.

An auto encoder (AE) is an unsupervised learning neural network consisting of three layers: Input layer, output layer, and middle layer. In the AE, the number of neurons in the output layer is equal to that in the input layer, and the number of neurons in the input layer and output layer is always greater than that in the middle layer. The principle of the AE is the features of input data are extracted by the encoder. Then, the decoder reconstructs the data, and the whole error is reduced by fine-tuning the weights. A convolution-automatic encoder (CAE) is a combination of the CNN network and the AE, using the CNN to make up for the lack of ability of the AE to extract local features and strengthen the ability of the AE to stabilize the local features of images.

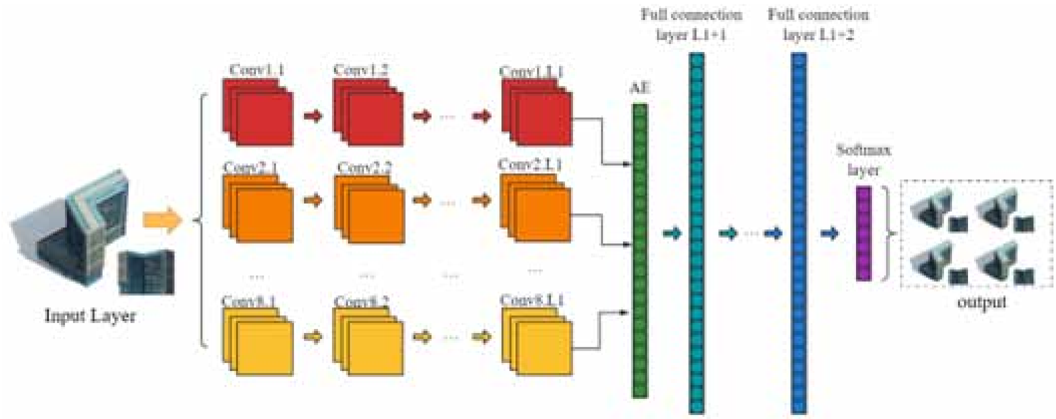
When a computer-aided system is used for graphic design, based on the DL principle, the dividing line is drawn by man-machine interaction, and the proportional relationship between dividing line and full map, dividing line and dividing line is combined makes the whole design more geometric and visually more harmonious. In this part, the author will divide categories according to the principle of DL and the differences between types. The improved CAE the author proposes in this paper combines the CNN and the AE. The initial input data is a binary image obtained by extracting the voxel matrix of a two-dimensional (2D) model. In the feature extraction stage, the CNN part uses the method of minimizing error to correct the weight. The deconvolution results allow to understand the convolution effect of the corresponding layer, establish the loss function according to the corresponding layer, and finally minimize the iteration to get the stylized effect. It is possible to obtain different style transfer results by modifying the style and content weight proportion in the loss function. Figure 2 shows the structure of CAE.

The voxelized image matrix of the 2D model is input into the CAE as input data. The input data first pass through the convolution layer of the CAE, which mainly completes the mapping of the features. According to the needs for the experiment, a certain number of convolution mapping and pooling operations are carried out. After meeting the requirements, the AE feature mapping and learning stage are carried out.

According to the graphic structure of the sample plan, the randomly initialized node vector is updated to obtain the whole plan vector, and the neural network parameters including the whole plan vector are learned by backpropagation to predict the plan score. M is the number of all r radius subgraphs in a graph. The subgraph vector is updated with the following formula:

$$x_i^{(t+1)} = x_i^{(t)} + \sum\nolimits_{j \in N(i)} x_{ij}^{(t)} \quad (5)$$

Figure 2. The CAE structure diagram



where x_i is the i subgraph vector and x_j is the subgraph vector of all its neighbors.

This method adopts three different ways, namely, content, style, and adding white noise. In this case, it is necessary to construct a content loss function between the white noise image and the content image, and between the style image. On this basis, the CNN is used to construct the image with content and the image with white noise, and the distance function between the four-level results is constructed by the dual-mode method, which is used as the loss function as follows:

$$L_{content}\left(\vec{p},\vec{x},l\right)=\frac{1}{2}\sum_{i,j}\left(F_{i,j}^{l}\right)^{2} \tag{6}$$

where, $\vec{x}$ is the image with white noise to be generated, $\vec{p}$ is the content image, l refers to each convolution layer, and F^l, p^l is the matrix composed of M -sized response results of l layer, F is the image result to be generated, and p is the response result of the content image.

In this study, the author adopted the segmentation algorithm of DeepLab2 and the pretrained ResNet-101 deep full convolution network. After normal CNN processing, the resolution of the original image will be greatly reduced. Hole convolution can get a large resolution field of view at any depth convolution network layer, and it will not increase the number of parameters and the amount of calculation.

The formula of hole convolution of one-dimensional signal is:

$$y_{[i]}=\sum_{k=1}^{K}x_{[i+r*k]}w_{[k]} \tag{7}$$

$x_{[i]}$ is the one-dimensional input signal, $w_{[k]}$ is the filter, r is the sampling step size of the input signal, k is the length, and $y_{[i]}$ is the final multispace convolution output result.

When classifying design images, Softmax is used as the classifier, and the calculation formula is:

$$Design\ image_{p}=\frac{1}{1+\exp\left(-h_{FC3}\right)} \tag{8}$$

where $Design\ image_p$ represents the probability output of the design image and the output of the last fully connected layer $FC3$. According to the probability output of the design image, the specific design image of the input sample picture can be obtained.

The full connection between the interlayer neurons of the deep confidence network is changed into partial connection. The bottom part of the model adopts back propagation neural network, and the direction is from bottom to top. The final output value is O_i:

$$O_i = f\left(net_i\right) = \frac{1}{1 + e^{-\left(net_i\right)}} \tag{9}$$

The output of the i-th neuron in this layer is O_i, and the weighted sum is net_i.

ANALYSIS AND DISCUSSION OF THE RESULTS

To make the network have a more accurate weight and deviation matrix, it is necessary to train the network with many feasible examples. In the training process, the network will learn according to the example data the researcher inputs, hold a set of rules by itself, and make judgments and correct decisions according to this law in practical application. In this study, the author collected 100 graphic design samples. The researcher input the scores obtained from these examples into the MATLAB neural network toolbox in the form of matrix to train the 8-15-5 network they had designed. They initialized the weights and deviations of each layer with small random numbers to ensure that large weighted inputs did not saturate the network.

All the experiments were based on the Pytorch DL framework, with Windows 10 as the running environment, single channel NVIDIA GeForce GTX1060 as the graphics card, Intel i7-6700 from eight nuclear as the CPU, and memory size of 16GB.

The researcher divided the design samples of 100 self-made data sets into 94 samples for training and cross-validation to perform grid search on the combination of the above superparameters, and used six samples as test sets. The trained DL model can accurately predict the author's initial evaluation score. Finally, the researcher got the standardized root mean square error (RMSE) between the true scores of six test samples randomly selected from 100 samples and the predicted neural network values.

The adaptive Simpson's method and GSL formula method are used to calculate the fresnel integral. In this study, the author used VS2010 programming to compare the calculation speed and accuracy of the above three methods. Table 1 shows the calculation results.

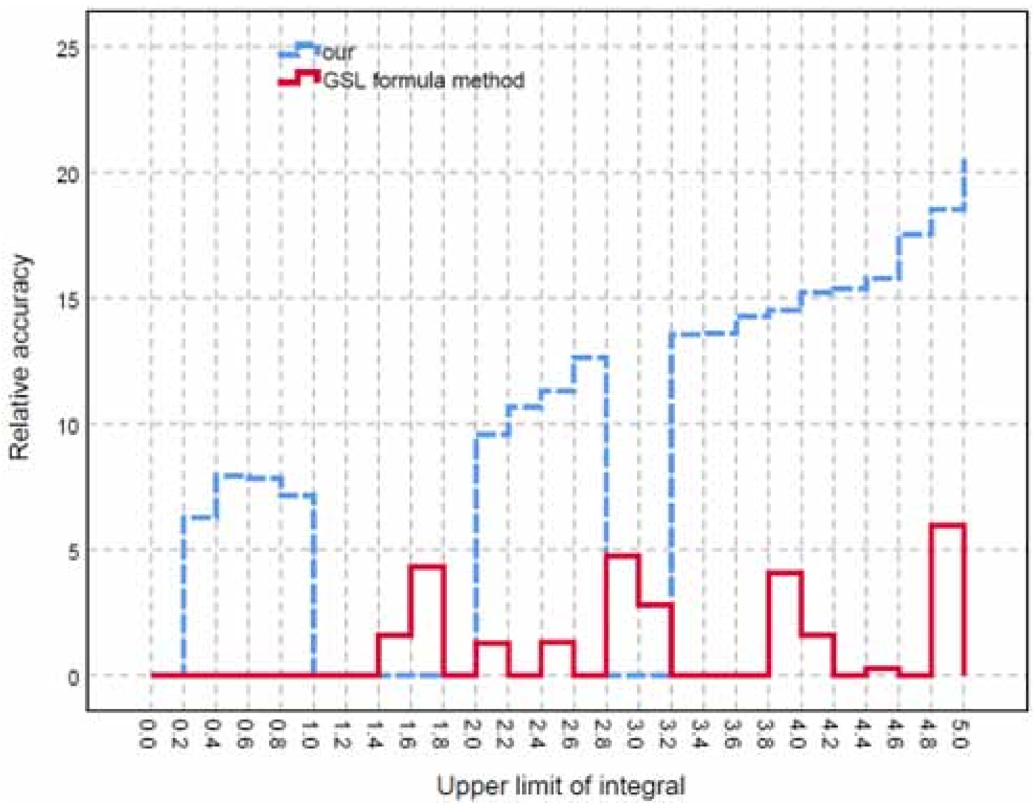
Because the accuracy of the adaptive Simpson's method is controllable and the calculation speed is too slow, the author did not compare the accuracy of the adaptive Simpson's method with other methods, but only the accuracy of the adaptive Simpson's method with the GSL formula. Figure 3 shows the calculation accuracy of the two methods.

The accuracy of the integration method of adding series increases with the number of terms. In the test, the author adopted the maximum achievable accuracy. The results evidenced that the relative

Table 1. Calculation time comparison

Method	Time(s)
The author's method	0.000924
Adaptive Simpson's method	2.6809
GSL formula	0.000671

Figure 3. Comparison of relative accuracy



accuracy of GSL method is always less than 6. However, the accuracy of series addition changes greatly and finally approaches 20. The original data represent the addition of series, and the final relative error is close to 40%, which is no longer a correct result.

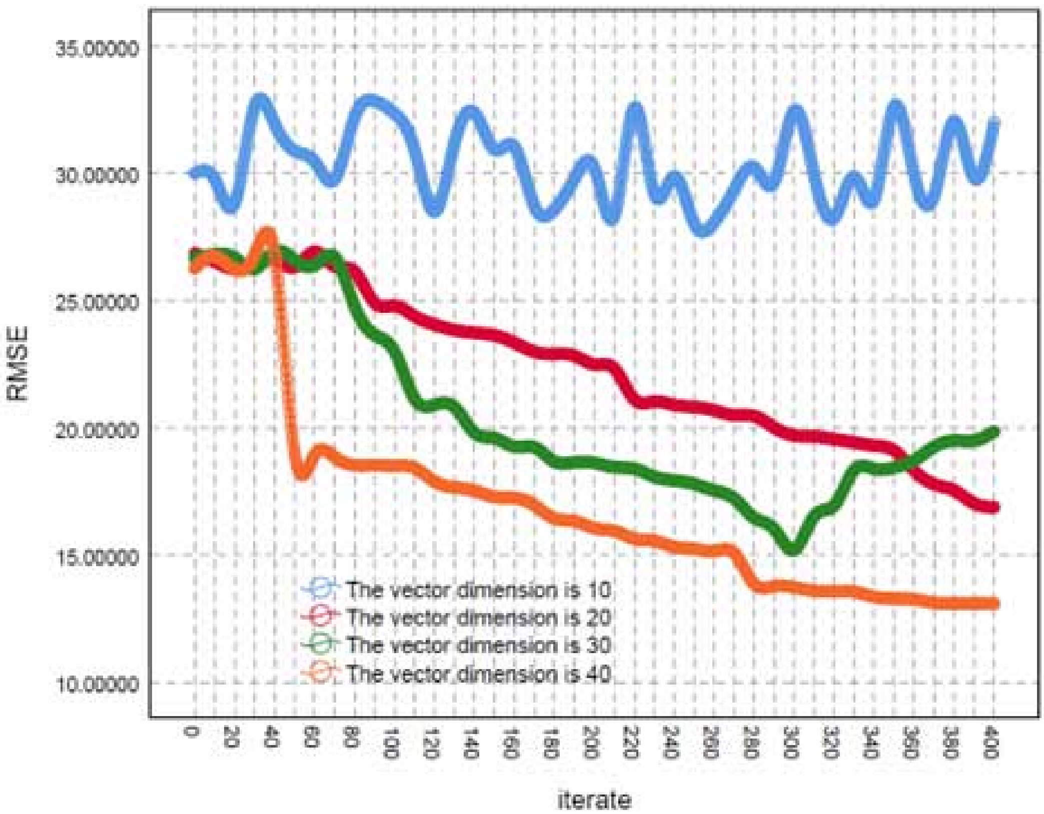
The researcher set the window size to 6, the subgraph radius to 3, and the GNN time step to 3, which are fixed. Figure 4 shows the influence of embedding vector dimension on the prediction accuracy of the model.

The RMSE is low when the graph is embedded with a vector with a relatively high dimension. However, when the embedding dimension continues to increase, there is no further improvement on the error. When the dimension we usethe researcher used was is greater than or equal to 40, these vectors have reached a saturated state in the representation learning of subgraphs. These results show that the GNN regression model based on end-to-end representation learning can be modeled in a 20-40 dimensional vector space.

As Figure 5 shows, the accuracy of each DL algorithm is constantly changing with the change of the number of feature graphs. It can be seen that the highest accuracy based on the CAE is when the number of feature graphs is 54. In addition, the accuracy of the CAE does not fluctuate too much, and the accuracy is higher than 80%, which shows that the CAE has an increased ability to extract features from 2D models. The accuracy does not fluctuate greatly with the feature map, which is suitable for this experiment.

The laboratory uses a 105×20 evolution function matrix structure, and the sample data is generated in the interactive evaluation stage. What is input into the evolution function matrix is a 2D model feature extracted based on the DL method, and an output result is obtained after passing through the

Figure 4. Influence of embedding vector dimension on the prediction accuracy of the model



evolution function matrix. The population size is 10 and the number of iterations is 300. Figure 6 is the convergence diagram of this algorithm.

Figure 6 shows that the CAE is stable, with the best effect and fast convergence. The CAE fitness value converges very quickly with the increase of iteration times, and basically tends to be stable after 100 iterations, approaching 0.7. Therefore, the author chose the training evolution function matrix stage CAE algorithm in the training evolution function matrix.

At the same time, the author would also use the same resource CAD and PS software to make 50 works completed by using this system. The evaluation result is composed of 1 to 10, and the higher the evaluation result, the higher the evaluation degree of the appraisers to the corresponding evaluation indicators in the evaluation process. Figure 7 shows the results of the evaluation.

Figure 7 shows that, in aesthetics, the average score of system design in this study is higher than that of CAD software and PS software. Its average score is 8.788, while the average scores of CAD software and PS software are 7.537 and 6.508, respectively, which shows that the author's system design is more in line with the needs of professional design.

CONCLUSION

With the development of AI technology, machine learning based on design image data makes AI-aided design possible. In this regard, DL has shown great application potential in design image analysis and generation. Although the existing graphic design system can provide a graphical platform for users, it cannot provide more graphical geometric basis for users in the process of graphics. Therefore, in

Figure 5. Accuracy of graph classification varying with the number of feature graphs

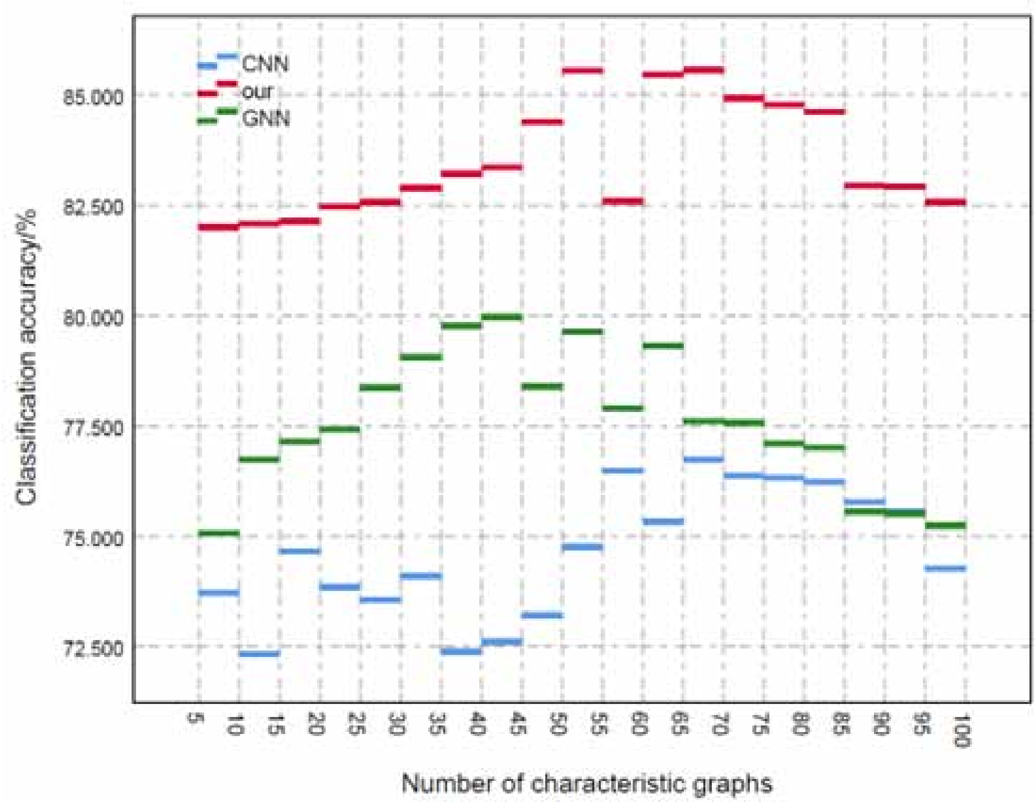


Figure 6. Convergence diagram of this algorithm

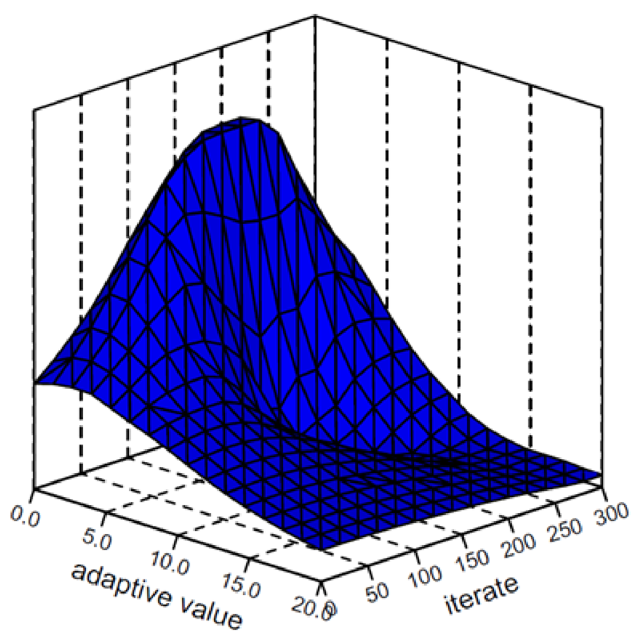
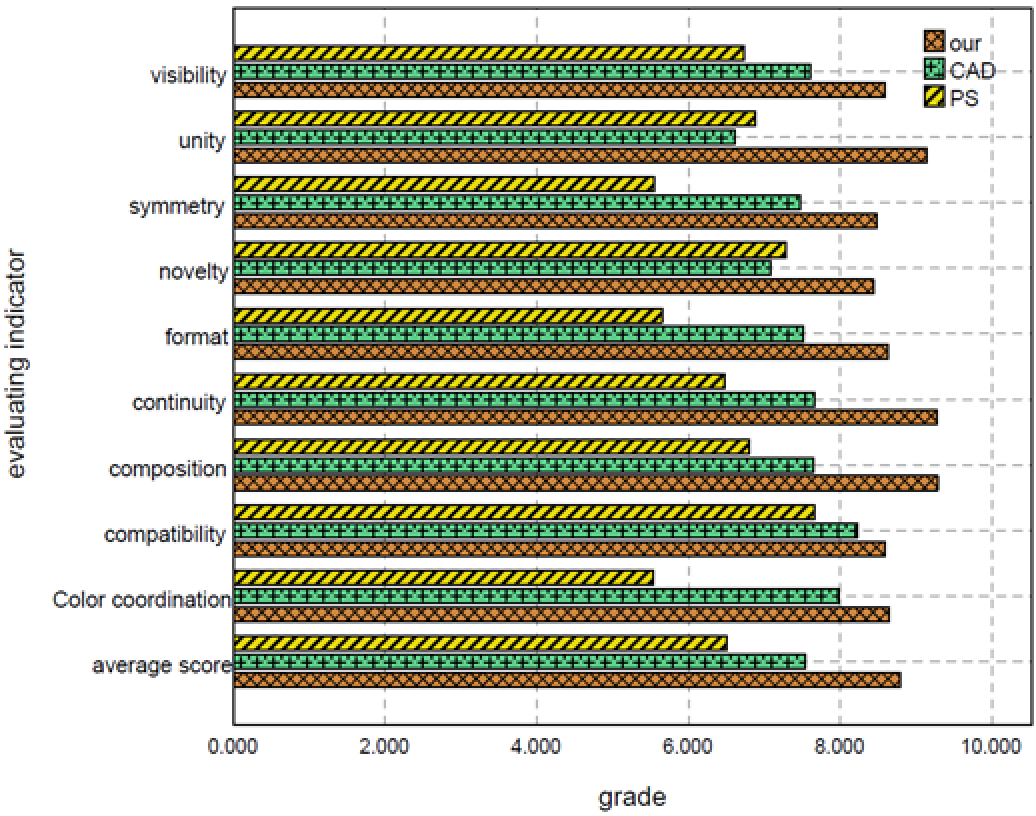


Figure 7. Evaluation results



this study, the author created a new AI-based graphic design assistant system, which can complete the aesthetic analysis of geometric element proportion in graphic design, thus helping users to perceive the feeling of visual aesthetic and providing users with design support related to geometric aesthetic principles. The results show that, from the aesthetic point of view, the overall score of the appraisers is 8.788, which is better than CAD and PS software, indicating that the design of this study can meet the needs of professional design better.

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