Extraction of Visual Communication Design Elements Based on Machine Learning

Lin Liu

Hunan Mass Media Vocational and Technical College, Changsha 410000, China, liulin19910600@163.com

Corresponding author: Lin Liu, liulin19910600@163.com

Abstract. As visual communication design (VCD) rapidly evolves, traditional methods for extracting design elements struggle to meet the demands for efficiency and accuracy. This article deeply explores the application achievements of machine learning in the intelligent extraction of elements in educational applications. Based on this method, an algorithm for automatically extracting classifications from a comprehensive dataset was studied and constructed. In the design and classification process of intelligent application machine learning, the potential educational applications of the algorithm for automatic classification were deeply explored. In this teaching application, design elements can effectively conduct precision case study exercises in systematic practical learning cases.

Keywords: Machine Learning; Visual Communication Design; Design Element Extraction; Teaching Effect Assessment
DOI: https://doi.org/10.14733/cadaps.2025.S4.181-194

1 INTRODUCTION

One method to obtain a three-dimensional projection is to determine the position of the viewpoint so that the vector of the view relative to the viewing direction of each eye and the angle of view information can be obtained based on the viewpoint coordinate position. An optical system designed by simulating the visual principles of the human eye can make planar images appear three-dimensional and configure a stereoscopic visual effect [1]. Alternatively, 3D binocular cameras can be used to capture real-life scenes and objects, which can also generate such stereoscopic views. These two stereoscopic views are generated by computers and related algorithms. When people observe two stereoscopic views through a head-mounted display, they will see the fused image, which presents a single and complete image in front of their eyes [2]. At present, various styles of virtual reality head-mounted displays have emerged in the market, including all-in-one and embedded mobile phone types, but not all technologies have yet been integrated into one. Head-mounted devices such as gyroscope sensors and real-time line-of-sight tracking systems can be used as visual interactive input devices [3]. The gyroscope sensor and line of sight tracking system inside the device can track a person's face and eyes, resulting in better 3D image presentation.

Essentially, computer 3D graphics are flat, they are just two-dimensional images displayed on a computer screen, but they can provide the illusion of depth (or third dimension). To enable observers to experience realistic virtual scene environments and generate immersion, the construction and rendering of 3D graphics are essential. The term three-dimensional (or 3D) refers to an object being described or displayed having three dimensions: width, height, and depth [4]. Due to the lack of any surface colour and texture in 3D graphics, observers will experience visual confusion. Perspective projection alone is sufficient to depict the appearance of three-dimensional graphics. This means that during the observation process, sometimes graphics cannot provide enough information to help the brain determine what it is perceiving. People can perceive and recognize objects through different clues. When the object distance changes, the perspective effect changes, which is a visual effect combined with a colour change. Texture, lighting, coloring, various color intensities, and graphic effects together constitute our perception of three-dimensional objects and scenes. Compared with traditional computer interfaces such as keyboards, mice, and graphical display interfaces, virtual reality not only has significant technological advancements but also has a good user experience [5]. The content goal of virtual reality is to pursue an immersive experience, and the realization of this immersion requires the cooperation of VR content and visual interaction methods. Users can visually interact with real 3D scenes and experience the realism of the virtual environment. In terms of interaction, we seek all possibilities of all senses to experience and perceive personally. In terms of VR content production, we need to understand that this is a real virtual world, where realism comes from the three-dimensional sense of all the constructed objects. In advertising design, VMIE technology can be used to hide brand or promotional information in seemingly ordinary fractal images [6]. Only recipients who hold the correct key can decrypt and obtain complete information, which ensures the security of the information and increases the interest and interactivity of the advertisement.

Integrating encryption technology into visual communication design not only protects intellectual property but also adds a unique artistic effect or interactive experience to the design work. It helps to remove redundant information from images, preserve key features, and provide a more compact data foundation for subsequent encryption operations [7]. In the scheme, the BP neural network is used to efficiently compress images, which is itself an application of machine learning technology in image processing. Designers can utilize this unpredictability to create design works with dynamic effects and visual impact, such as dynamic graphics, interactive advertisements, etc. One method to obtain a three-dimensional projection is to determine the position of the viewpoint so that the vector of the view relative to the viewing direction of each eye and the angle of view information can be obtained based on the viewpoint coordinate position [8]. An optical system designed by simulating the visual principles of the human eye, which can make planar images appear three-dimensional and configure a stereoscopic visual effect. Alternatively, 3D binocular cameras can be used to capture real-life scenes and objects, which can also generate such stereoscopic views. These two stereoscopic views are generated by computers and related algorithms [9]. When people observe two stereoscopic views through a head-mounted display, they will see the fused image, which presents a single and complete image in front of their eyes. At present, various styles of virtual reality head-mounted displays have emerged in the market, including all-in-one and embedded mobile phone types, but all technologies have not yet been integrated into one. To enable observers to experience realistic virtual scene environments and generate immersion, the construction and rendering of 3D graphics are essential [10]. The term three-dimensional (or 3D) refers to an object being described or displayed having three dimensions: width, height, and depth. Head-mounted devices such as gyroscope sensors and real-time line-of-sight tracking systems can be used as visual interactive input devices [11]. The gyroscope sensor and line of sight tracking system inside the device can track a person's face and eyes, resulting in better 3D image presentation [12]. This means that during the observation process, sometimes graphics cannot provide enough information to help the brain determine what it is perceiving. But people can perceive and recognize objects through different clues, and when the object distance changes, the perspective effect will change. Perspective projection alone is sufficient to depict the appearance of three-dimensional graphics. However, due to the lack of any surface color and texture in 3D graphics, observers will experience visual confusion.

Essentially, computer 3D graphics are flat, they are just two-dimensional images displayed on a computer screen, but they can provide an illusion of depth (or third dimension). This visual effect, combined with colour variations, textures, lighting, colouring, various colour intensities and graphic effects, constitutes our perception of three-dimensional objects and scenes [13]. The objective of this study is to investigate the application of ML in extracting VCD elements, aiming to enhance design efficiency and quality while providing novel auxiliary tools for design education. The primary objective of this study is to devise a computer-aided VCD element extraction system leveraging ML technology and implement its utilization in design education. The innovations are as follows: firstly, a new design element extraction method is proposed, which combines traditional image processing and DL (Deep learning) technology; The second is to construct a teaching-oriented auxiliary system, and assess its effect in teaching practice through empirical research.

This article is structured into six sections. Initially, it outlines the research background, significance, current state, objectives, and innovative aspects. Subsequently, it introduces the fundamental theory and application status of VCD and ML. Following this, the method for extracting design elements based on ML is elaborated, encompassing data acquisition, preprocessing, feature extraction, and model training. Based on this methodology, a computer-aided VCD teaching system is developed, with its demand analysis, design, and implementation process being discussed. The effectiveness and practicality of the system are then verified through teaching application and effect evaluation. Lastly, the research outcomes and conclusions are summarized.

2 RELATED WORK

Visual secret sharing is a unique image protection technique that disperses secret images into multiple shares without losing their intuitive decryption properties. Visual secret sharing not only protects the security of image content but also reveals the process of original images through stacked sharing, providing a unique way to express design creativity. Xiang [14] designed a series of seemingly unrelated patterns or images that contain a common secret, and users can only reveal hidden information or complete design concepts by physically or digitally combining these patterns. The field of computer-aided visual communication design based on machine learning has brought new perspectives and potential application value.

Images play an increasingly important role in transmitting information in daily life. However, factors such as camera vibration, object movement, thermal radiation, and damage to transmission and storage devices have caused blurry images, reducing people's normal demand for image information. In the first stage, the encoder-decoder is used to extract contextual features, which are then combined with the image reconstruction module in the second stage to fully preserve the original information. The research on image deblurring is to remove and reduce various blurs in the image and restore clear information about the image. Compared with traditional denoising methods, convolutional neural networks can quickly and effectively handle ambiguity problems. This algorithm proposes a complex layer motion image deblurring network algorithm, which uses a complex layer network as the basic framework of the algorithm network to restore blurry images to clear images. Therefore, based on existing research results, Yamamoto et al. [15] proposed a complex layer motion image deblurring network algorithm and a multi-scale network deblurring algorithm based on basic attention. It adopts a two-stage progressive image deblurring network, which adopts a two-stage progressive learning restoration structure to effectively prevent feature loss. In recent years, with the introduction of learning into image deblurring research by researchers, this direction has made rapid development and achieved excellent deblurring effects. Yang et al. [16] proposed a multi-scale network deblurring algorithm based on basic attention, which uses a three-stage motion image deblurring network to restore clear images caused by various sources in an end-to-end manner. Insert an image supervision module between two stages to reweight features, retaining useful features for the second stage and avoiding loss of valuable information. The experimental results show that a complex motion image deblurring network can effectively remove blur and alleviate the edge blur problem in image restoration. Realize the improvement of deblurring to enhance the deblurring effect, and use basic attention modules to screen features. Yang et al. [17] extracted multi-level image features through an encoder-decoder architecture and added basic attention modules to the encoder-decoder. Introduce a feature reconstruction module in the third stage to enhance the deblurring ability. Introduce a feature supervision module between the three stages to enhance information, remove non-important information, and retain the original feature information. The experiment shows that this method can significantly reduce edge blur in the image and restore image details, improving the deblurring effect,

To solve the problem of the low restoration effect of convolutional neural network image deblurring, Yuan et al. [18] proposed a corresponding convolutional neural network image deblurring algorithm to improve the deblurring effect of images. The main content is a complex motion image deblurring network algorithm, which adopts a two-stage progressive image deblurring network. The network adopts a two-stage progressive learning restoration structure, effectively preventing feature loss. We will conduct in-depth research on the theories of several typical networks that have received widespread attention in the field of deep learning in recent years, and apply some of the construction ideas to future research on deblurring networks. This article briefly introduces the development history and several basic frameworks of convolutional neural networks, including several network algorithms that have had a profound impact on them, as well as their inherent basic structural framework. This article introduces the principles of traditional algorithms and deblurring algorithms based on convolutional neural networks and explains the disadvantages of traditional deblurring algorithms in terms of restoration performance. They introduced research related to convolutional neural networks. Because of the two-stage feature of the deblurring algorithm in the network and the use of the encoder-decoder algorithm module, the restoration effect can be significantly improved, and the effectiveness of this method has been proven through experiments. This design not only enhances the randomness and unpredictability of the encryption process but also cleverly interferes with the strong correlation of the image. Zhao and Zhang [19] introduced a bidirectional random scrambling algorithm based on Chaos Magic Transform (CMT) to perturb the wavelet packet coefficient matrix of an image finely. In the encryption and compression stages, the secret image is encrypted using a chaotic measurement matrix and a newly designed random chaotic pixel diffusion strategy, and data compression is achieved through parallel compressive sensing technology. More importantly, due to the use of parallel processing, this scheme performs well in processing large-scale image data, meeting the demand for efficient processing capabilities in the ML-CAD field. This process not only effectively reduces the amount of encrypted image data but also further improves the security of encryption.

3 DESIGN ELEMENT EXTRACTION METHOD

3.1 Data Acquisition and Preprocessing

To extract design elements effectively, it is necessary to construct a data set containing rich design works. This step involves collecting design images from various sources, such as online design platforms, design competition websites, and professional designers' portfolios. During data collection, this article emphasizes diversity and representativeness to ensure the dataset encompasses design works from various styles, fields, and periods.

Because of the problems of different quality and diverse formats of the collected original image data, it is necessary to preprocess it. Pretreatment steps include image cleaning, that is, removing noise, correcting distortion, adjusting resolution, etc., to improve image quality. The overall algorithm of image preprocessing is expressed as:

$$\begin{aligned} \mathrm{I}_{\mathrm{final}} &= \mathrm{f}_{\mathrm{preprocess}}(\mathrm{I}_{\mathrm{raw}}) = \\ & \mathrm{f}_{\mathrm{resolution\_adjust}}\ \mathrm{f}_{\mathrm{distortion\_correct}}\ \mathrm{f}_{\mathrm{noise\_remove}}\ \mathrm{I}_{\mathrm{raw}}, \theta_{\mathrm{noise}}\ , \theta_{\mathrm{distortion}}\ , \theta_{\mathrm{resolution}} \end{aligned} \tag{1}$$

Among them:

$\mathrm{I}_{\mathrm{raw}}$ stands for original image data.

θ_{noise} is a noise removal parameter.

$\theta_{distortion}$ is the distortion correction parameter.

$\theta_{resolution}$ is the resolution adjustment parameter.

f_{noise_remove} is a noise removal function.

$f_{distortion\_correct}$ is a distortion correction function.

$f_{resolution\_adjust}$ is the resolution adjustment function.

I_{final} is the final preprocessed image.

This formula summarizes the whole conversion process from the original image to the preprocessed image. Labelling the image is another key step, which provides data labels for the subsequent ML model training. Labeling is done by professional designers or trained personnel who carefully classify and label images according to the characteristics of design elements.

3.2 DL Feature Extraction Method

In the feature extraction stage, this article adopts DL technology to learn advanced features in design images automatically. CNN is a commonly used DL model that can effectively extract feature information from images through the convolution layer, pooling layer, and fully connected layer. By training the CNN model, we can extract feature vectors with recognition from design images, which can represent the key attributes of design elements. The structure of the CNN model is shown in Figure 1:

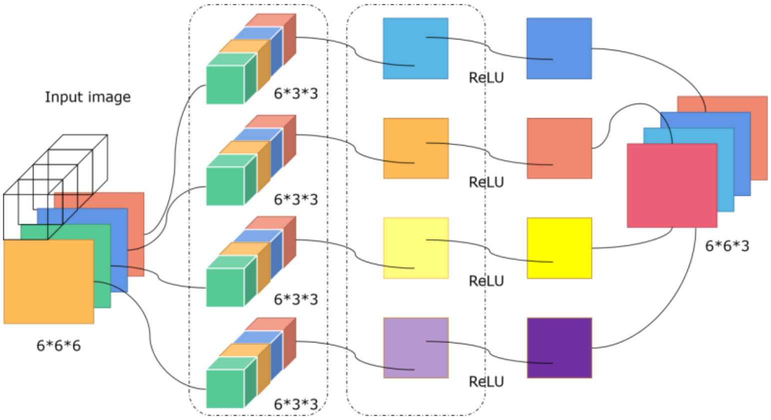


Figure 1: CNN model structure diagram.

In the feature extraction stage, the convolution layer propagates forward:

$$a_{ij}^{l} = \sigma\left(\sum_{m}\sum_{n} w_{mn}^{l} a_{i+m\ \ j+n}^{l-1} + b^{l}\right) \tag{2}$$

Where a_{ij}^{l} is the activation value of the convolution layer at the l layer at the position i,j, σ is the activation function, w_{mn}^{l} is the weight of the convolution kernel at the l layer, and b^{l} is the offset term.

Full connection layer forward propagation:

$$z^l = W^l a^{l-1} + b^l \tag{3}$$

Where z^l is the input of the fully connected layer of layer l, W^l is the weight matrix, a^{l-1} is the activation value vector of the previous layer, and b^l is the offset vector.

The loss function of the CNN model is as follows:

$$L = -\sum_{c=1}^{M} y_{o,c} \log \ p_{o,c} \tag{4}$$

Where M is the number of categories, $y_{o,c}$ is a binary indicator (0 or 1), and if the category c is the correct category o, it is 1 and $p_{o,c}$ is the prediction probability that o belongs to the category c.

After extracting the feature vectors of design elements, the next step is to identify and classify them. In this article, a classification algorithm-neural network classifier is used to classify the feature vectors. Forward propagation of classifier in the identification and classification stage;

$$\hat{y} = \sigma \ W^T x + b \tag{5}$$

Where $\hat{y}$ is the predicted output, σ is the activation function, W^T is the weight matrix, x is the input feature vector, and b is the offset vector?

Classifier loss function (also using cross-entropy loss):

$$L = -\sum_{i=1}^{N}\sum_{c=1}^{M} y_{ic} \log \ \hat{y}_{ic} \tag{6}$$

Where N is the number of samples, y_{ic} what is the real label, and $\hat{y}_{ic}$ what is the prediction probability?

Accuracy calculation of classifier:

$$Accuracy = \frac{1}{N}\sum_{i=1}^{N} I \ \hat{y}_i = y_i \tag{7}$$

Where $I \ \cdot$ is the indicator function, and returns 1 when the prediction is correct, otherwise returns 0. The goal of classification is to accurately classify design elements into predefined categories, such as shape, colour, texture and so on. By training the classification model, the design elements can be automatically identified and classified.

During the ML model training process, we utilize a substantial amount of labelled data and implement optimization techniques to enhance the model's performance and stability. The backpropagation algorithm is employed to update the weights during network training:

$$\frac{\partial L}{\partial w} = \frac{\partial L}{\partial y} \cdot \frac{\partial y}{\partial w} \tag{8}$$

Where L is the loss function, y is the output of the network, and w is the weight of the network?

3.3 Experimental Results and Analysis

Through experimental verification, this section assesses the performance of the design element extraction method based on ML and guides subsequent research and application.

The accuracy of model identification is shown in Figure 2.

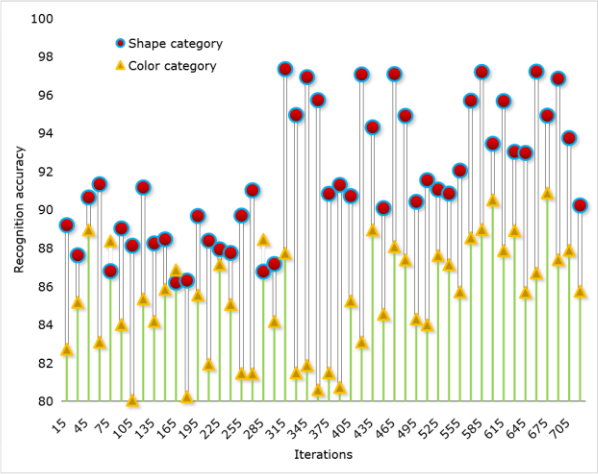


Figure 2: Accuracy of model recognition.

It can be seen that the overall accuracy of the model on the test set is about 92%, and the model correctly identifies 92% of the design elements, showing a high recognition ability. Further analysis shows that the model performs particularly well in the "shape" category, reaching 95%, while the accuracy of the "colour" category is slightly lower, reaching 88%. This difference stems from the complexity of some categories of characteristics. The model identification time is shown in Figure 3.

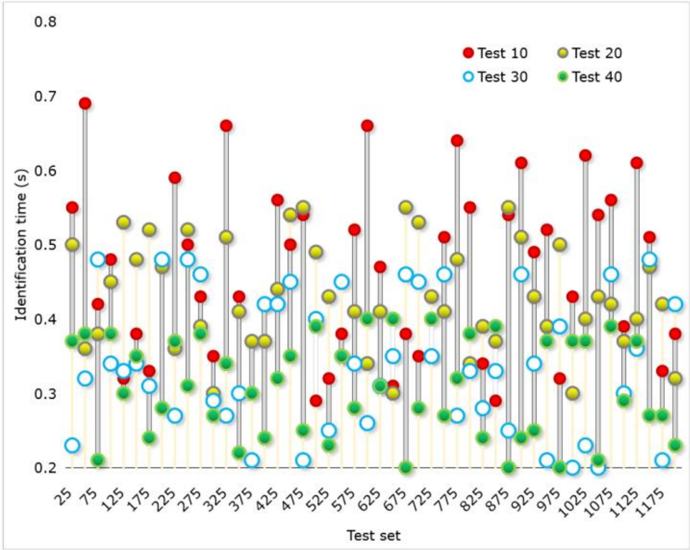


Figure 3: Identification time.

It can be seen that the average time for the model to process each design image is 0.5 seconds, which shows that this method can respond quickly and is suitable for practical application scenarios. By analyzing the distribution of processing time, we can find that most images (such as 90%) can be processed within 0.5 seconds, while a few complex images need a longer time, but they are still within the acceptable range.

The above experimental results show that this method has achieved high accuracy in the task of identifying and classifying design elements, and can deal with diverse design images quickly and effectively.

4 CONSTRUCTION OF COMPUTER-AIDED VCD SYSTEM

4.1 System Architecture Design

Before constructing the teaching system of computer-aided VCD, this article makes a detailed demand analysis. First of all, we have defined the teaching goal, that is, to help students master the basic principles and skills of VCD and improve their creative ability. Secondly, the needs of users, including students, teachers and designers, are considered. Through investigation and interviews, this section collected a lot of user feedback and suggestions, which provided a basis for the functional design of the system. According to the results of the demand analysis, the system is divided into several functional modules. These modules include design element library, display and analysis of design works, design practice and guidance, user interaction and feedback, etc. Each module undertakes specific teaching tasks and functions, which together constitute a complete CAD teaching system.

During the system architecture design stage, this article prioritizes scalability, stability, and user-friendliness. We employ a client-server architecture, dividing the system into front-end and back-end components. The front end handles user interface display and interaction, while the back end manages data processing and business logic implementation. For technology selection, we choose a technology stack suitable for Web development, including JavaScript and Python, and utilize a database for system data storage and management.

User interface and interaction design are important links in system construction. This article pays attention to the beauty, ease of use and response speed of the interface; At the same time, rich interactive functions are designed, such as dragging, zooming, clicking, etc., to enhance the user's sense of participation and ease of operation. Through reasonable layout, intuitive icons and clear navigation design, the system provides a good user experience.

4.2 System Implementation and Test Optimization

In the process of system implementation, we encountered some key technical challenges and solved them accordingly. For example, to realize automatic identification and classification of design elements, a DL model is adopted, and the model is optimized and trained. To realize the real-time response and interactive effect of the user interface, the front-end framework and technology are used to build a dynamic user interface.

After the system development is completed, conduct a comprehensive test, and the test results are shown in Table 1.

Test Aspect	*Test Item*	*Test Result*	*Remarks*
Functional Test	Functional Completeness	Passed	All preset functions are implemented without any missing.
	Functional Correctness	Passed	All functions work as expected without any errors.
	Functional Usability	Passed	Functional operation processes are clear and easy to understand and use.
Performance Test	System Response Time	≤2 seconds	95% of operations have a response time of 2 seconds, meeting the requirement for quick response.
	System Stability	Passed	Continuous operation for 72 hours without crashes or major failures.

	Resource Utilization	Low	CPU and memory utilization are low, not affecting the operation of other programs.
User Test	User Satisfaction	85%	According to user feedback, 85% of users expressed satisfaction or high satisfaction.
	User Interface Friendliness	Passed	The user interface is simple and clear, easy to navigate and operate.
	Improvement in Teaching Effectiveness	Significant	Most users reported a significant improvement in teaching effectiveness and learning efficiency.

Table 1: Comprehensive test results of computer-assisted VCD teaching system.

This table summarizes the comprehensive test results of the computer-assisted VCD teaching system, including functional tests, performance tests, and user tests. The test results indicate that the system performs well in terms of functional completeness, correctness, and usability. The performance tests also meet the expected standards. User tests show that the system has high user satisfaction and significantly improves teaching effectiveness.

This section verifies the stability and availability of the system through functional testing, performance testing and user testing. At the same time, according to users' feedback and suggestions, we optimized and improved the system to improve the user experience and teaching effect. Finally, a computer-aided VCD teaching system with perfect function, stable performance and user-friendly is obtained.

5 APPLICATION AND EFFECT ASSESSMENT

5.1 Case Design

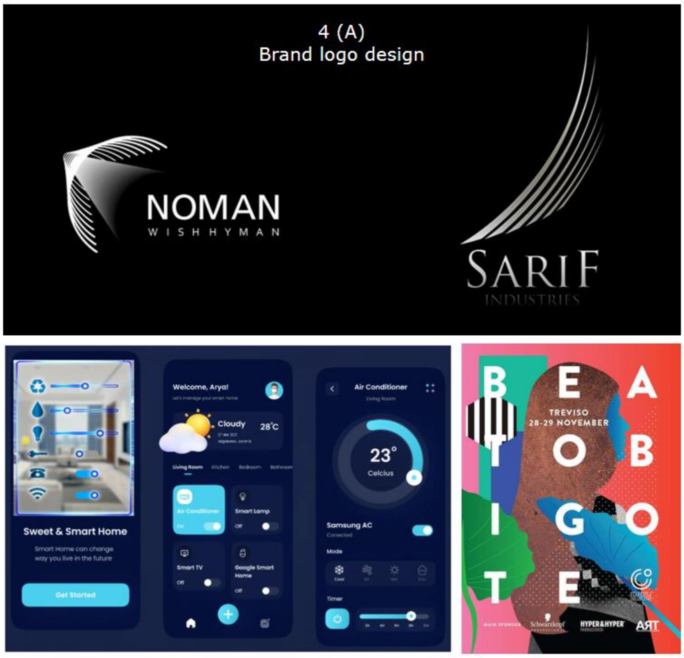
To verify the effectiveness of the CAD teaching system based on ML, several teaching cases are carefully designed in this section. These cases aim to cover the core areas of VCD, such as brand logo design, poster design, UI interface design, etc., and ensure that each case contains clear design objectives, constraints, and expected results. Teaching cases include designing a modern brand logo, making an eye-catching poster, and designing a user-friendly APP interface (Figure 4). These tasks are not only representative but also can fully demonstrate the application of ML in design element extraction, style transfer, and layout optimization. In this article, a set of detailed teaching flows is formulated, and ML technology is integrated into it. The process includes design theory explanation, design case analysis, design practice guidance, and design works assessment. In each link, the functions provided by the CAD teaching system are fully utilized, such as retrieving the design element library, automatically analyzing and assessing design works, etc.

Figure 4 (A) shows the brand logo designed by students. The logo has simple lines and bright colours, which fully embodies the modern sense. Through the optimization of the ML algorithm, the layout of design elements in the logo is reasonable, which not only highlights the core characteristics of the brand but also is easy to identify and remember.

Figure 4 (B) shows the poster made by the students, which has bright colours and ingenious composition and successfully attracts the attention of the audience. Through the style transfer technology of the ML algorithm, the poster retains the original theme and incorporates popular design elements and styles, making the poster more attractive and modern.

Figure 4 (C) shows the APP interface designed by students, which has a reasonable layout, harmonious colour matching and clear functional area division. Through the optimization of the ML algorithm, the arrangement of elements in the interface is more in line with users' cognition and usage habits, and the user experience is improved.

The typical teaching case shown in Figure 4 fully demonstrates the application of ML in design element extraction, style transfer and layout optimization. Through the practice of these cases, students can better understand and master the application methods of ML technology in the design field, and improve their design ability and innovation ability.



4 (C) APP interface design 4 (B) Poster design

Figure 4: Typical teaching case display.

5.2 Effect Assessment

To assess the teaching effect, this section adopts a variety of assessment methods. First of all, the experiment compares the quality of students' design works before and after using the CAD teaching system and finds that students have significantly improved in the application of design elements, colour matching and layout design (as shown in Table 2). Secondly, students' mastery of design theory and skills is assessed through test scores and classroom performance (Figure 5). Finally, professional designers were invited to assess the student's work to get more comprehensive feedback (Figure 6).

Assessment Aspect	*Average Score Before Use*	*Average Score After Use*	*Improvement*
Application of Design Elements	65.0	86.5	+21.5
Colour Coordination	61.1	92.3	+31.2
Layout Design	54.0	88.0	+34.0
Creative Expression	60.0	78.9	+18.9
Overall Quality of Works	62.5	82.0	+19.5

Table 2: Comparative analysis of design quality before and after using the computer-assisted design teaching system.

Table 2 compares and analyzes the quality of students' design works before and after using the CAD teaching system. All the data fully demonstrate the remarkable effect of the CAD teaching system in improving the quality of students' design works. Through comparison, it is found that students can extract and apply design elements more accurately after using the system, and the overall style and colour matching of the works are more harmonious. In addition, students have also shown obvious progress in layout design and creative expression.

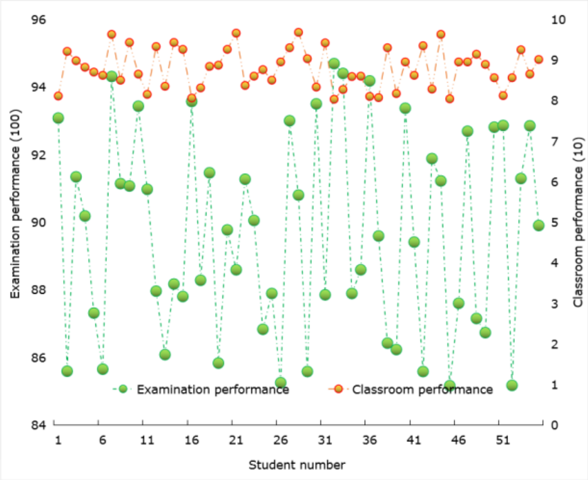


Figure 5: Assessment of test scores and classroom performance.

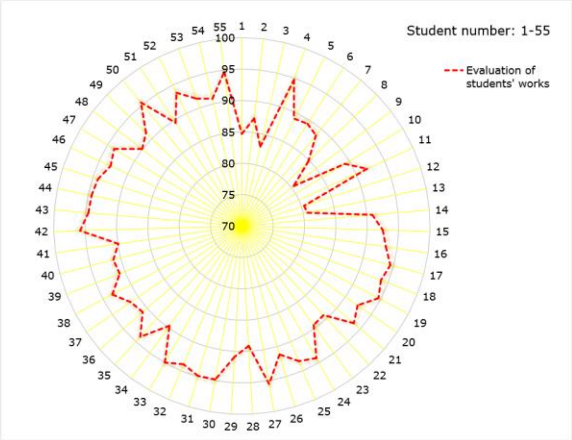


Figure 6: Assessment results of students' works.

Overall performance: Combined with examination results, classroom performance, and professional designers' assessment, it can be seen that students have a relatively solid grasp of design theory and skills, with a high average score and passing rate. In future teaching, we can focus on guiding students to carry out innovative designs, encouraging them to combine theoretical knowledge with practical application, and at the same time, paying attention to improving the level of detail handling of works.

In addition, this article distributed a satisfaction questionnaire to students to collect their feedback on the CAD teaching system. The results are shown in Table 3 and Figure 7.

Feedback Aspect	*Specific Feedback Points*	*Student Feedback Overview*
Satisfaction	Richness of Design Resources	Provides a wide range of design resources, helpful for enhancing design skills
	Convenience of Design Tools	Design tools are easy to use, greatly improving design efficiency
	Overall Satisfaction	Most students are satisfied with the system, believing it provides great assistance
Areas for Improvement	Interface Layout	Some students suggest optimizing the interface layout, such as the position of certain function buttons, to enhance user experience
	Interaction Design	Some students point out deficiencies in interaction design, such as slow response time and unsmooth operation processes, which need improvement to enhance user-friendliness

Table 3: Detailed Student Feedback on CAD Teaching System.

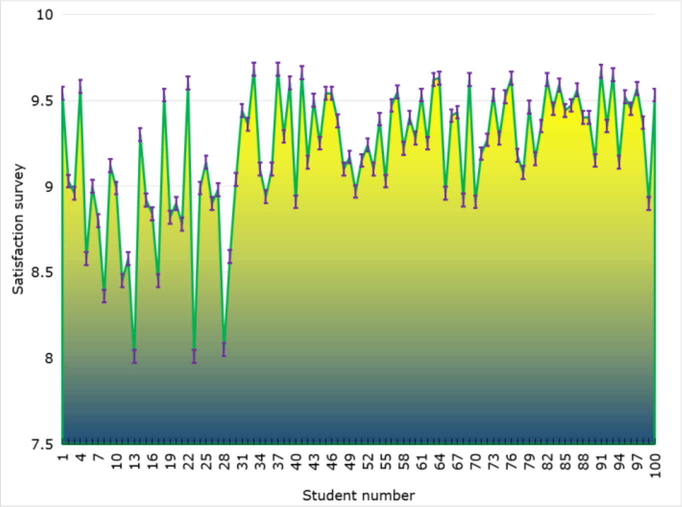


Figure 7: Student satisfaction survey.

The survey results show that most students are satisfied with the system (the overall satisfaction reaches more than 9 points) and think that it provides rich design resources and convenient design tools. At the same time, students also said that some areas need to be improved in the use of the system, such as interface layout and interaction design.

6 CONCLUSIONS

This article systematically studies the construction and application of computer-aided VCD teaching systems based on ML. In this article, a new design element extraction method is proposed, and the automatic identification and classification of design elements are realized by combining DL technology. While this study has achieved some successes, it is not without limitations. Specifically, the design element library requires further expansion and enrichment. Additionally, the system's user interface and interaction design necessitate optimization and improvement. In future work, we plan to enhance the design element library, refine the system interface and interactive design, and explore additional application scenarios for ML in VCD.

Lin Liu, https://orcid.org/0009-0004-2178-8172

REFERENCES

[1] Bai, S.; Zhou, L.; Yan, M.; Ji, X.; Tao, X.: Image cryptosystem for visually meaningful encryption based on fractal graph generating, IETE Technical Review, 38(1), 2021, 130-141. https://doi.org/10.1080/02564602.2020.1799875

[2] Chen, W.; Wang, Y.; Xiao, Y.; Hei, X.: Explore the potential of deep learning and hyperchaotic map in the meaningful visual image encryption scheme, IET Image Processing, 17(11), 2023, 3235-3257. https://doi.org/10.1049/ipr2.12858

[3] Chu, R.; Zhang, S.; Mou, J.: A multi-image compression and encryption scheme based on fractional chaotic map, Physica Scripta, 98(7), 2023, 075213. https://doi.org/10.1088/1402-4896/acdb01

[4] Gan, Z.; Sun, M.; Song, Y.; Chai, X.; Jiang, D.; Long, G.; He, X.: Visually meaningful image encryption scheme using multi-parameter fractal theory and block synchronous sorting diffusion, Physica Scripta, 98(8), 2023, 085216. https://doi.org/10.1088/1402-4896/ace28b

[5] Gdawiec, K.; Adewinbi, H.: Procedural generation of artistic patterns using a modified orbit trap method, Applied Sciences, 12(6), 2022, 2923. https://doi.org/10.3390/app12062923

[6] Han, Z.; Shang, M.; Liu, Z.: SeqViews2SeqLabels: Learning 3D Global Features via Aggregating Sequential Views by RNN With Attention, IEEE Transactions on Image Processing, 28(2), 2019, 658-672. https://doi.org/10.1109/TIP.2018.2868426

[7] Jain, R.; Xu, W.: RHDSI: a novel dimensionality reduction based algorithm on high dimensional feature selection with interactions, Information Sciences, 574(11), 2021, 590-605. https://doi.org/10.1016/j.ins.2021.06.096

[8] MokhtariArdakan, M.; Ramezani, R.; Latif, A.: Visual secret sharing of gray and color images using fuzzy random grids, Applied Soft Computing, 146(1), 2023, 110648. https://doi.org/10.1016/j.asoc.2023.110648

[9] Nakamura, K.: Iterated inversion system: an algorithm for efficiently visualizing Kleinian groups and extending the possibilities of fractal art, Journal of Mathematics and the Arts, 15(2), 2021, 106-136. https://doi.org/10.1080/17513472.2021.1943998

[10] Ouyang, P.; Chung, K.-W.; Nicolas, A.; Gdawiec, K.: Self-similar fractal drawings inspired by MC Escher's print Square Limit, ACM Transactions on Graphics (TOG), 40(3), 2021, 1-34. https://doi.org/10.1145/3456298

[11] Ren, Q.; Teng, L.; Jiang, D.; Si, R.; Wang, X.: Visual image encryption algorithm based on compressed sensing and 2D cosine-type logistic map, Physica Scripta, 98(9), 2023, 095212. https://doi.org/10.1088/1402-4896/aceb24

[12] Wang, H.: Application of non-local mean image denoising algorithm based on machine learning technology in visual communication design, Journal of Intelligent & Fuzzy Systems: Applications in Engineering and Technology, 45(6), 2023, 10213-10225. https://doi.org/10.3233/JIFS-234632

[13] Wang, X.; Liu, C.; Jiang, D.: Visually meaningful image encryption scheme based on new-designed chaotic map and random scrambling diffusion strategy, Chaos, Solitons & Fractals, 164(1), 2022, 112625. https://doi.org/10.1016/j.chaos.2022.112625

[14] Xiang, S.-L.: The application of big data and Artificial intelligence in visual communication design, Journal of Computational Methods in Sciences and Engineering, 23(2), 2022, 639-649. https://doi.org/10.3233/JCM-226627

[15] Yamamoto, S.; Suzuki, R.; Shinagawa, S.: Analysis of Use of Figures and Tables in Computer Vision Papers Using Image Recognition Technique, Journal of the Japan Society for Precision Engineering, 87(12), 2021, 995-1002. https://doi.org/10.2493/jjspe.87.995

[16] Yang, Y.-G.; Wang, B.-P.; Yang, Y.-L.; Zhou, Y.-H.; Shi, W.-M.; Liao, X.: Visually meaningful image encryption based on universal embedding model, Information Sciences, 562(1), 2021, 304-324. https://doi.org/10.1016/j.ins.2021.01.041

[17] Yang, Y.-G.; Zou, L.; Zhou, Y.-H.; Shi, W.-M.: Visually meaningful encryption for color images by using Qi hyper-chaotic system and singular value decomposition in YCbCr color space, Optik, 213(1), 2020, 164422. https://doi.org/10.1016/j.ijleo.2020.164422

[18] Yuan, Z.; Huang, S.; Huang, L.; Du, Y.; Cai, S.; Xiong, X.: Safe-LBP: A visually meaningful image encryption scheme based on LBP and compressive sensing, Journal of Information Security and Applications, 78(1), 2023, 103591. https://doi.org/10.1016/j.jisa.2023.103591

[19] Zhao, H.; Zhang, K.: Modelling and generating abstract images of Paul Klee style, International Journal of Arts and Technology, 11(4), 2019, 380-392. https://doi.org/10.1504/IJART.2019.103490