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Computer-Aided Design AND APPLICATIONS

Construction of 3D Digitization System for Visual Communication Design Teaching

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Abstract. Graphic design is a major that pursues visual aesthetics with procedural beauty as its core. The introduction of computer-aided design (CAD) tools can make graphic design works more visually superior. Aiming at the influence and requirements of the digital age on visual transmission design, this article discusses how to build a 3D CAD system in the digital age, designs and implements the image feature extraction and enhancement algorithm in the 3D CAD system, and makes some innovations in the teaching of visual transmission design. The simulation results show that compared with the traditional deep learning (DL) model, the performance of this method in all aspects of 3D image processing has been improved to varying degrees. Therefore, the algorithm can effectively solve the problem of simplifying the spatial model, and at the same time, it can make the distortion of the simplified model within the control range under the control of parameters. Applying this algorithm to the construction of 3D CAD system can innovate the teaching of visual design and promote the progress and growth in the field of visual transmission design.

Keywords: Visual Transmission; Graphic Design; Computer Aided Design; Digitization; Image Enhancement
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1 INTRODUCTION

Creativity is the soul of design, which is particularly evident in the visual transmission design major. Through the cultivation of artistic design thinking ability and the basic training of design methods and skills, students can have the basic qualities of artistic design and innovative design. Digital spatial models can also help students understand complex concepts. For example, 3D models can be used to display complex interactions in molecular structures, geological structures, or economic systems. These applications typically require students to solve complex problems, such as mathematical problems, programming challenges, or to innovate and invent new solutions.

Anamova et al. [1] used virtual technology to combine the digital and physical worlds, allowing students to learn and explore in the interaction between reality and virtual reality. Students can interact with other students and teachers in the digital space, share learning resources and perspectives, and carry out collaborative projects. However, it should be noted that although digital spatial models have many potential applications in education, their effective use requires good teaching strategies and teacher guidance. In addition, excessive reliance on technology may also bring some problems, such as weakening students' basic skills and not all students having equal access to these technologies. Therefore, when using digital space models, it is necessary to consider these factors to ensure the fairness and effectiveness of education. In the information society, the visual impact brought by computer-designed graphic and image works is very common. The creator's rich creative means endow the computer graphics and image processing technology with the possibility of unlimited development. Images are information carriers, and high-quality images can convey information more effectively in visual transmission. Choosing a classifier suitable for automatic music classification is crucial. Consider using classifiers such as support vector machines (SVM) and neural networks. These classifiers have strong learning and adaptive abilities, which can adapt to different types of music. Ge et al. [2] designed an easy-to-use and highly interactive system by selecting representative training and testing datasets. Further optimize the selection and partitioning methods of the dataset to improve the classification accuracy and generalization ability of the system. The user interface and interaction design can be further optimized to make it more convenient for users to use and operate the system. Through the above optimization measures, the performance and accuracy of the computer-aided design system for music automatic classification based on feature analysis can be further improved, providing users with a better user experience.

Today in the information age, information transmission based on static graphics is surrounded by more and more dynamic vision. The dynamic effect of visual communication in web design refers to the use of dynamic elements and techniques to enhance the beauty and interactivity of a website. Computer aided design (CAD) and application technology can help achieve this dynamic effect. The dynamic effects of visual communication are very important in web design and can be achieved through various technologies and tools. Computer assisted design and application technology can help designers create high-quality dynamic web designs more efficiently. Kiu [3] uses HTML5 video elements to embed videos, while Canvas can be used to create dynamic graphics and animations. Combining JavaScript to achieve interactive control of videos. In addition, some web design tools, such as Adobe Dreamweaver and Microsoft Visual Studio, also provide visual design and development tools that can help designers quickly create dynamic web applications. In the traditional sense, the static design experience mastered by graphic designers is inevitably stretched in the face of the emerging demand for dynamic graphics under the background of contemporary information desig. Lavicza et al. [4] integrated digital technology into STEAM education to enhance students' learning experience and practical abilities. For example, using virtual reality (VR) and augmented reality (AR) technologies to simulate experiments and explore scientific phenomena, or using programming languages and robotics technology to help students understand engineering and computer science. Understand the effectiveness of educational innovation by evaluating students' learning outcomes. You can use various evaluation methods, such as exams, portfolios, project reports, etc., to measure students' mastery of STEAM subject knowledge and innovation ability. Collaborate with other teachers and educational institutions to share resources and experiences to expand the impact of educational innovation. For example, you can collaborate with local enterprises and educational institutions to provide practical opportunities and resources for students, and also collaborate with other teachers to carry out STEAM education projects. The visual transmission design has developed from the traditional plane visual representation to today's multi-dimensional spatial representation, and changed from static visual effect to dynamic visual effect. In the visual aesthetics of graphic design, the application of CAD technology can make designers have a higher experience in geometric design of designed works. Visual transmission design requires designers to have good artistic skills, but also need to master CAD software to express their creativity. Computer aided design systems can help designers design and optimize product designs. Li and Li create a 3D model of the product using CAD software. And conduct various simulations and analyses to test the performance and reliability of the product. This helps designers identify and solve problems in the early stages of product development, reducing the time and cost of later modifications and rework. Computer aided design systems can be combined with rapid prototyping technology to achieve rapid prototyping of products. Designers can use CAD software to design a three-dimensional model of a product, and then use a rapid prototyping machine to convert the model into a physical prototype. This accelerates product development and allows designers to conduct testing and modifications before manufacturing the final product [5].

Lin et al. [6] constructed or selected a CNN model suitable for image classification tasks. This may include multiple convolutional layers, pooling layers, fully connected layers, etc. Some commonly used CNN models such as VGG, ResNet, Inception, etc. can also be applied to this task. Then, use the collected dataset to train the CNN model. During the training process, it may be necessary to adjust the parameters of the model, such as learning rate, batch size, etc., to optimize the performance of the model. In addition, some techniques such as data augmentation, regularization, etc. can also be used to prevent overfitting. After the training is completed, a test set needs to be used to evaluate the performance of the model. The classification performance of the model can be evaluated by calculating indicators such as accuracy, precision, and recall. In addition, it can also be compared with other traditional image classification methods to verify the superiority of CNN. The lack of ability of design talents in the face of dynamic technology and information humanities will lead to the limitation of cross-border cooperation of design disciplines in professional fields. The lack of talents in the field of dynamic graphics will try to fill the "dynamic" gap in graphic design with the help of the professional strength of the original animation, film and other disciplines. The arrival of the digital age has also had a certain impact on the field of visual transmission design, injecting more vitality into visual transmission design and bringing greater challenges to it. Under the background of the digital age, only when the teaching of visual transmission design fully adapts to the new environment can it be deeply integrated with social growth, and then cultivate visual transmission design professionals who meet the needs of social growth. The Auto-CAD network architecture design teaching system adopts a teaching mode based on the network architecture design of the teaching system. Ma et al. [7] combine the operational skills of Auto-CAD software and architectural design knowledge, aiming to provide students with comprehensive architectural design education and training. The teaching content of this system includes an introduction to the interface of Auto-CAD software, the use of drawing commands, and the drawing of building plans, elevations, and sections. In addition, the system also provides online experiments and case studies to help students better understand and master architectural design knowledge. In short, a teaching system designed based on network architecture is an advanced teaching mode that can provide flexibility and convenience for students' learning, promote the development and innovation of education. The Auto-CAD network architecture design teaching system combines the operating skills and architectural design knowledge of Auto-CAD software, providing comprehensive support and assistance for students' architectural design education and training. Under the influence of digital technology, visual transmission design has changed from static to dynamic, from the past 2D to all-round visual effects, realizing the innovative development of visual transmission design teaching is conducive to cultivating high-quality applied design talents. In the process of image generation and transmission by using CAD tools, external unfavorable factors will interfere with the image quality. At this time, it is needed to restore and enhance the image by using image processing technology to ensure the visual effect of the image. In view of the influence and requirements of the digital age on visual transmission design, combined with the current teaching situation of visual transmission design, this article discusses how to build a 3D CAD system in the digital age, make some innovations in visual transmission design teaching, and then promote the progress and development of visual transmission design field.

Graphic design has changed from paper design to computer information design, which has greatly improved the aesthetic effect and design efficiency of graphic design. In the process of graphic design, making full use of visual aesthetics can improve the artistic sense of works. Using computer platform to design and calculate graphic design works can produce more ingenious graphics and conformation, increase the visual aesthetics of graphic design and add luster to works. In the teaching of CAD course of visual transmission design major in universities, some teachers focus on the demonstration and verification of software, ignoring the cultivation of students' creative ability. Taking the innovation of visual transmission design teaching as the research object, this article puts forward the construction strategy of CAD system:

⊖ This article designs and implements image feature extraction and enhancement algorithms in 3D CAD systems, which better preserve the edge details of the image and ensure the contrast of the algorithm in low-pass sub-bands.

⊜ In order to reduce the complexity of solving optimization problems, regularization secondary processing and segmented filtering can effectively reduce image processing time while ensuring the quality of image reconstruction.

⊛ The system covers the design of planar visual elements, the rendering of visual processes, and the construction of scenes; From a planar dimension to a multidimensional space, relying on the latest CAD technology, we continuously expand the possibilities of dynamic experiments and strengthen the tension of visual effects.

The article first introduces the role and necessity of constructing CAD systems in visual transmission design teaching; Then summarize and analyze the relevant research on graphic design, and propose the improvement work done in this article; Implemented CAD system algorithms for visual transmission design teaching; And tested the feasibility of the algorithm; Finally, the research achievements and contributions were summarized.

2 RELATED WORKS

The enormous potential of digital manufacturing technology in the field of education. Through 3D printing technology, we can transform complex real specimens into highly reproducible physical models, providing a more intuitive, vivid, and convenient tool for teaching. With the progress of technology and the expansion of its application scope, we have reason to believe that digital manufacturing technology will play a more important role in the field of education. McMenamin et al. [8] achieved significant results in teaching the replication of human pathological specimens using 3D printing technology. Obtain three-dimensional data by high-resolution scanning of real specimens. This process can be accurately positioned and detailed adjusted through computer-aided design software to ensure that the printed specimen is as consistent as the real specimen in terms of shape, color, and texture as possible. An efficient CAD system for identifying ALL cells from microscopic blood images can help doctors diagnose ALL more accurately. Mohammed and Abdulla's [9] research works through the following steps. Firstly, it is necessary to obtain images of blood samples. This can be achieved by using a microscope and digital camera, placing blood samples under a microscope and capturing their images. Due to the fact that blood images typically contain a lot of noise and interference, preprocessing is necessary. The preprocessing steps include denoising, contrast enhancement, and segmentation (separating cells from the image). Next, a classifier needs to be designed to recognize ALL cells. This can be achieved by using machine learning algorithms, such as support vector machines (SVM), artificial neural networks (ANNs), or deep learning models. Train and test classifiers using known blood images. This can help adjust the parameters of the classifier and evaluate its performance. Enhancing shape and spatial learning through STEM integration using 3D computer-aided design (3D CAD) is a very interesting and challenging project. Ng and Chan [10] learned about available 3D CAD software, such as AutoCAD, SolidWorks, SketchUp, etc. This software have various functions and tools to help create and modify 3D models. Integrate STEM themes into your project. You can design a building and apply scientific, technological, engineering, and mathematical concepts to the design process, such as structural strength, material selection, cost estimation, etc. Share your project with others and listen to their feedback and suggestions. Discuss STEM topics and 3D CAD technology with other students and teachers to deepen your understanding and application of these two fields. By learning 3D CAD technology and applying STEM themes, you can enhance your learning of shapes and spaces, and cultivate valuable skills and interests.

Nyshchak et al. [11] achieved intelligent teaching through artificial intelligence technology. Future technology teachers can independently choose learning content and methods based on personal needs and learning progress, achieving personalized and differentiated teaching. Through augmented reality and virtual reality technology, abstract concepts and ideas can be transformed into concrete images and scenes, enabling a better understanding and mastery of graphic design skills. Through big data analysis technology, it can analyze the learning behavior and performance of future technology teachers, identify their learning characteristics and problems, and better adjust teaching strategies and provide personalized learning plans. Through mobile teaching applications, future technology teachers can learn anytime and anywhere, without being limited by time and location, improving learning efficiency and convenience. In short, CAD information and communication technology has broad application prospects in teaching machines for future technology teacher graphic training, which can improve teaching efficiency and quality, promote the development and innovation of education. With the development of technology, carbon nanostructures have broad application prospects in various fields such as electronic devices, sensors, and drug delivery due to their unique physical and chemical properties. However, the synthesis process is complex and has numerous influencing factors, requiring precise control to obtain the required structure and properties. Traditional experimental methods not only consume a lot of time and resources, but may also be difficult to accurately control certain complex synthesis conditions. Therefore, developing a computer-aided design system that can simulate and predict the synthesis process of carbon nanostructures is of great significance for improving synthesis efficiency and reducing experimental costs.

Petrov and Chistyakova [12] analyzed a virtual model computer-aided design system for controlling and training the synthesis process of carbon nanostructures. It belongs to the application of artificial intelligence in the field of chemical engineering design. In AEC (Building Engineering) education, using ground laser scanners can help students better understand geometric entities and spatial relationships. Ramonell and Chacón [13] drew geometric figures and building plans using CAD technology. Students can use LibreCAD to learn how to draw geometric shapes, measure and annotate them, and apply them to architectural engineering design. By applying these open-source tools to AEC classrooms, teachers can help students better understand geometric entities and spatial relationships, and cultivate their computer application skills. Ruberto et al. [14] digitize biomedical images for storage, transmission, and analysis. The preprocessing steps include image enhancement, denoising, contrast adjustment, etc. to improve image quality and facilitate subsequent image segmentation and feature extraction. Using CAD systems to segment biomedical images and distinguish target areas such as organs and lesions in the image. At the same time, extract the features of the image, including shape, texture, color, etc., for further diagnosis and analysis. By using a CAD system to perform 3D reconstruction of multiple 2D images, three-dimensional models of organs or lesions can be obtained, making it easier for doctors to observe and analyze from multiple perspectives. The reconstructed model can also be visualized, such as surface rendering, transparency, etc., to highlight the target area. In a CAD system, a model library can be established for different diseases, including typical image features of various diseases. When encountering new cases, doctors can be assisted in rapid and accurate diagnosis by comparing them with models in the model library. With the continuous development of technology, digital manufacturing technology is playing an increasingly important role in many fields. In order to equip future teachers with the ability to teach this technology, Song [15] aims to develop and evaluate a preparatory course on digital manufacturing technology for teachers. The main objective of this course is to teach teachers the concepts and practices of digital manufacturing technology, so that they can effectively impart these skills in future teaching. Through the method of case study, it investigated the impact of the course on teachers and the skills they learned in the course. Tuli and Cesarini [16] generate 3D tool paths based on clustering and segmentation results. This can be achieved by converting the tool path in 2D images back into

3D space. The generated 3D path can include information such as the shape, position, and motion trajectory of the tool. Optimize and validate the generated 3D tool path. This can be done by comparing, simulating, and testing with known tool paths. Optimization can involve adjusting the parameters of the path, such as speed, acceleration, and direction, to improve machining efficiency and quality. Verification can confirm whether the generated path is valid and reliable through actual machining testing. Through the above steps, stacked 2D image processing technology can be used to achieve automatic and unsupervised 3D tool path generation. This technology can help improve processing efficiency, reduce human error, and reduce costs, which is of great significance for fields such as industrial automation and intelligent manufacturing.

Wei and Han [17] created an interactive visual communication teaching system based on CAD technology. It can help teachers better teach visual communication design and improve students' learning outcomes. The system can adopt a B/S architecture, with the front-end using web technologies such as HTML, CSS, and JavaScript, and the back-end using server-side programming languages such as Python and Java. At the same time, it is necessary to use a database to store students' submitted works and other data. The user interface of the system should be concise, intuitive, and easy to use. The system should support the use of CAD software for artwork design. Students can use CAD software to create flat works such as posters, packaging, logos, etc., as well as three-dimensional works such as product models, building models, etc. CAD systems can be used to create three-dimensional models of mechanical components. This helps students understand the shape, size, assembly relationship, and other details of mechanical components. Through 3D modeling, students can better understand mechanical principles and design principles. Computer graphics can be used to simulate the motion of mechanical systems. Through motion simulation, students can observe the interaction and motion trajectory of mechanical components during the motion process. This helps students understand the performance, motion patterns, and design principles of mechanical systems. CAD systems and computer graphics can be used for finite element analysis. Finite element analysis is a numerical analysis method that can be used to predict the stress and deformation of mechanical components. Through finite element analysis, students can better understand the strength, stiffness, and stability of mechanical components [18]. Computer assisted human-computer interaction in visual communication refers to the use of computer-aided tools to enhance visual communication and interaction between humans and computers. This technology uses various input methods, such as images, speech, postures, and gestures, as well as various output methods, such as text, speech, and images, to improve the efficiency and quality of communication and interaction between humans and computers. Zhang [19] captures human facial and body postures through images or videos, thereby recognizing human emotions and intentions, and achieving more natural human-computer interaction. By capturing human hand movements and gestures, computers can recognize specific gesture commands, thereby achieving operation and control of the computer. Computers can recognize human language through speech recognition technology and convert computer information into human language through speech synthesis technology, thus achieving more natural human-computer interaction. Computer assisted human-computer interaction technology in visual communication can help humans interact with computers more efficiently and naturally, thereby improving work efficiency and user experience. Under single piece production and maintenance conditions, computer-aided design systems for the production process of component processing can help engineers design and process complex components more efficiently. Zhetessova et al. [20] developed various modules based on system functionality and architecture. For example, component design modules, machining simulation modules, etc. It conducted system testing, identified and fixed potential issues, and further optimized the performance and functionality of the system. Provide training for users to help them understand and use the system. Simultaneously write system usage documents and operation manuals.

In this article, the algorithm of image feature extraction and enhancement in 3D CAD system is designed and implemented. In order to reduce the complexity of solving optimization problems, regularization secondary processing and segmentation screening can effectively reduce the image processing time while ensuring the quality of image reconstruction. On the basis of compressive sensing theory, this article constructs the signal model of image reconstruction, deduces the equivalent optimization problem of image reconstruction, and proposes a compressive sensing algorithm based on retrospective piecewise regularization optimal matching.

3 IMPLEMENTATION OF CAD SYSTEM ALGORITHM FOR VISUAL TRANSMISSION DESIGN TEACHING

In the digital age, the teaching of visual transmission design should be reformed and optimized. Thus, students can form new design concepts and information display means in the process of learning professional knowledge. The application of 3D CAD system in the teaching of visual design has changed the teaching scene from static to dynamic, from the past 2D to all-round visual effects, and realized the innovative development of visual transmission design teaching, which is conducive to cultivating high-quality applied design talents. This section mainly describes the image feature extraction and enhancement algorithm in 3D CAD system.

3.1 Feature Extraction of 3D Image

The characteristics of objects contain abundant information. In the image of an object, the quantity of pixels of various features is much less than the total quantity of pixels in the image. Processing the pixels of these local features instead of the total quantity of pixels can greatly improve the calculation speed and make real-time processing possible. The most intuitive feature of dynamic design is that the image is constantly moving and changing, and the fundamental purpose is to show the "reality" of the image, not to restore the visual "authenticity". Traditional 2D visual elements often pay attention to the integrity of form and the continuity of expression, but the presentation of dynamic vision provides more possibilities for designing forms. In the process of graphic design and image processing, information loss and image distortion will inevitably occur due to the influence of noise. In order to denoise the image and reconstruct the graphic design image accurately, the compressed sensing method can be used to fill the distorted image.

High-density data provides the possibility of high-precision virtual simulation of the real world, but the computational overhead brought by modeling, processing and analyzing it increases the dependence on the performance of computing equipment. The quantity of points in the point set that constitutes the model is usually huge. In order to facilitate the subsequent spatial analysis, it is needed to simplify the grid that constitutes the model. The 3D image feature extraction model is shown in Figure 1.

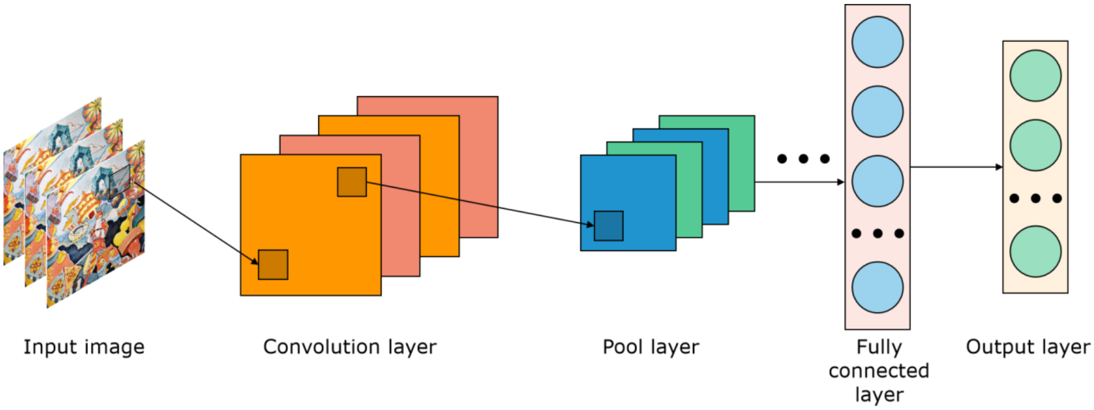

Figure 1: 3D image feature extraction model.

Feature point detection is the premise of camera calibration, and the extracted feature points will be input into the calibration program as known data, so the accuracy of feature point extraction directly affects the final result and accuracy of camera calibration. Image matrix is stored in the form of pixels, so the matrix is sparse. Using compressive sensing algorithm, the high-dimensional graphic matrix can be projected into the low-dimensional space, and the optimal solution can be obtained by matching the optimal algorithm. The original signal matrix is reconstructed by using the low-dimensional observation signal matrix, so as to realize the reconstruction of distorted images.

The error function is defined as:

$$\cos t(u,v) = \|u-v\| \times \max_{f \in T_u} \left\{ \min_{n \in T_{uv}} \left\{ (1 - f \cdot normal \cdot n \cdot normal) \div 2 \right\} \right\} \quad (1)$$

$\|u-v\|$ represents the distance between two u,v points, T_u represents all triangular surfaces adjacent to u point, and T_{uv} represents all triangular surfaces with uv as edges.

Let the plane P pass through the centroid P' of K nearest points, and the normal vector n satisfies $|n| = 1$. The eigenvector corresponding to the smallest eigenvalue of M can be regarded as the normal vector of point P_i:

$$M = \sum_{i=1}^{K} (P_i - P')(P_i - P')^T / K \quad (2)$$

Dynamic generation and simulation need to rely on a large quantity of computer programming languages to complete, so CAD system shows a large quantity of visual perceptual factors and modular orderly rational parameters coexist in the design pattern. Then, this 2D plane image is deconstructed again, so as to facilitate the local dynamics to drive the overall dynamics, and further improve the overall dynamics to match the appropriate expression of the theme concept. Using regularized secondary screening, small-scale orthogonal matching pursuit can be realized, which can not only ensure the approximation of the optimal matching reconstruction value, but also avoid excessive iterative complexity of dictionary atomic sequences. The basic matrix can be deduced from the epipolar geometry constraints outside the two views:

$$F = \alpha(e') \times KPK^{-1} \quad (3)$$

Thereby:

$$[e'] = \begin{bmatrix} 0 & -e_3 & e_2 \\ e_3 & 0 & -e_1 \\ -e_2 & e_1 & 0 \end{bmatrix} \quad (4)$$

e' is the pole on the second image.

Let $\mu = \alpha^2, C = KK^T$, the Kruppa equation can be obtained:

$$FCF^T = \mu(e')C(e')^T \quad (5)$$

Where μ is an unknown proportional factor, and matrix C is a positive definite matrix.

A corner point in an image refers to a point with high curvature in the image, which is formed by the place where the curvature of the edge of a scene object is large or the intersection of two or more edges. It is of great significance to take the corner of the target image as the geometric feature of the target because it has the geometric shape information of the target. For two adjacent images in the image sequence, the feature points will also change because of the change of geometric relationship, the change of lighting conditions and the change of viewpoint. Make the angle between the normal N_{new} of the triangle and the normal N_{ini} in the original mesh smaller than the threshold ε:

$$\arccos(N_{new} \cdot N_{ini}) \le \varepsilon \tag{6}$$

3.2 CAD 3D Image Enhancement

Three-dimensional digital image enhancement theory points out that the selection of initial nodes of resolution should be arbitrary, and in the actual imaging space, all elements can be regarded as initial points of estimation. In practical operation, in order to calculate the resolution value of 3D digital image simply and quickly, the processing method of enlarging a specific frame resolution image is usually adopted, and the physical frame node is defined as the reference frame of 3D digital image. In the subsequent visual processing, the reference frame can be used to construct 3D digital image with higher resolution level. In plane design, the images in the panoramic camera are simply spliced, and then the real shot images are spliced, and then merged with the plane images designed by CAD to form a plane panorama and output it.

According to the execution time of optimization, optimization can be divided into pre-modeling optimization, in-modeling optimization and post-modeling optimization. For optimization before modeling, such a designation is easy to bring about logical contradictions, because there can be no optimization without modeling. In fact, the optimization before modeling belongs to the category of data preprocessing, and the point set is sorted. According to the requirements of the specific modeling algorithm, the point group is sorted according to certain criteria. When the insertion growth is performed, the model is close to the real shape, and all that needs to be done is to optimize the local topology in modeling. Image data information base includes image data acquisition, image data information transmission and image data information reception. Image data acquisition can be realized by image acquisition and processing module in hardware. When image data acquisition, it is needed to classify the types of image data in order to improve the efficiency of acquisition and shorten the acquisition period. The technical process is shown in Figure 2.

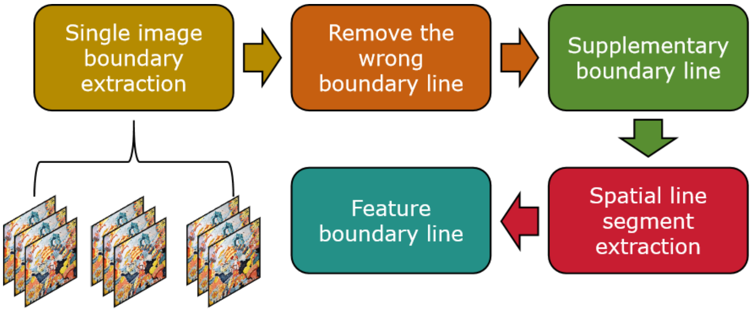

Figure 2: Process of feature boundary extraction algorithm.

Because every point on the surface of the object has a projected ray for the imaging plane, and every point on this straight line has the same 2D projection coordinates on the image. Therefore, it is impossible to determine which point on this projection line is the real object point by only one image. However, if two images obtained by shooting the same object from different angles are known, the projected rays of the object on these two imaging planes will intersect at one point in the air. Optimization in modeling and optimization after modeling are optimization in the traditional sense, and the patches that constitute the model are optimized and reconstructed.

Assuming that the quantity of images participating in visual design is n, and C_i is the internal participation and external parameter of the i-th image, m 3D space points are reconstructed, the coordinate of the j-th 3D space point is X_j, and the objective function optimized by the beam adjustment method is:

$$g(C,X)=\sum_{i=1}^{n}\sum_{j=1}^{m}w_{ij}\left\|q_{ij}-P\left(C_i,X_j\right)\right\|^2 \tag{7}$$

Where, w_{ij} is the indicator variable, which represents whether point j exists in image i. $P\left(C_i,X_j\right)$ is the coordinate of point j on image i after projection transformation, and q_{ij} is the actual image coordinate of point j on image i.

Iterative optimization for minimum reprojection error:

$$\Delta = -\left(J_f^T J_f+\lambda I\right)^{-1} J_f^T f \tag{8}$$

Where λ is the weight parameter.

Point is the basic element of an image, and its spatial position can be determined by two or more images. Moving all the discrete points whose distance from the plane is not more than a certain distance to the plane is actually changing the coordinate values of the discrete points in the axial direction. All the discrete points on the same plane have the same coordinate values in the axial direction. The 3D discrete point cloud of the main points of the object is obtained by calculating and processing most of the main points. Then these point clouds are imported into 3D software for corresponding processing, and the 3D model of the object can be obtained, thus completing the purpose of restoring the 3D model of the object from the image. The image resolution enhancement algorithm is shown in Figure 3.

If there are vectors $a_1,\cdots,a_n$, connecting them together can get $\left(a_1^T,\cdots,a_1^T\right)$, and the optimization problem for 3D reconstruction can be written as the following formula:

$$\min \sum_{k=1}^{m}\sum_{i=1}^{n}D\left(m_{ki},P_kM_i\right)^2 \tag{9}$$

In this formula, k represents the quantity of photos taken at different positions, with a total of m images; i represents the serial quantity of 3D points, with n 3D coordinate points in total;

P_k represents the projection matrix of the k-th image, M_i represents the coordinates of the i-th 3D point, P_kM_i represents the calculated 3D coordinates multiplied by the projection matrix and projected back into the image coordinate system, and m_{ki} represents the 2D coordinates of the i-th 3D point on the k images. The whole formula represents the sum of squares to minimize the projection error.

This description uses the difference of two kinds of Gaussian distributions to describe their proximity, and accurately describes the merging rules.

$$J_{merge}\left(i,j;\Theta^*\right)=\left(P_i\left(\Theta^*\right)-P_j\left(\Theta^*\right)\right)^T*\left(P_i\left(\Theta^*\right)-P_j\left(\Theta^*\right)\right) \tag{10}$$

Here, the smaller $J_{merge}\left(i,j;\Theta^*\right)$ is, the closer the two Gaussian distributions are, and they can be merged.

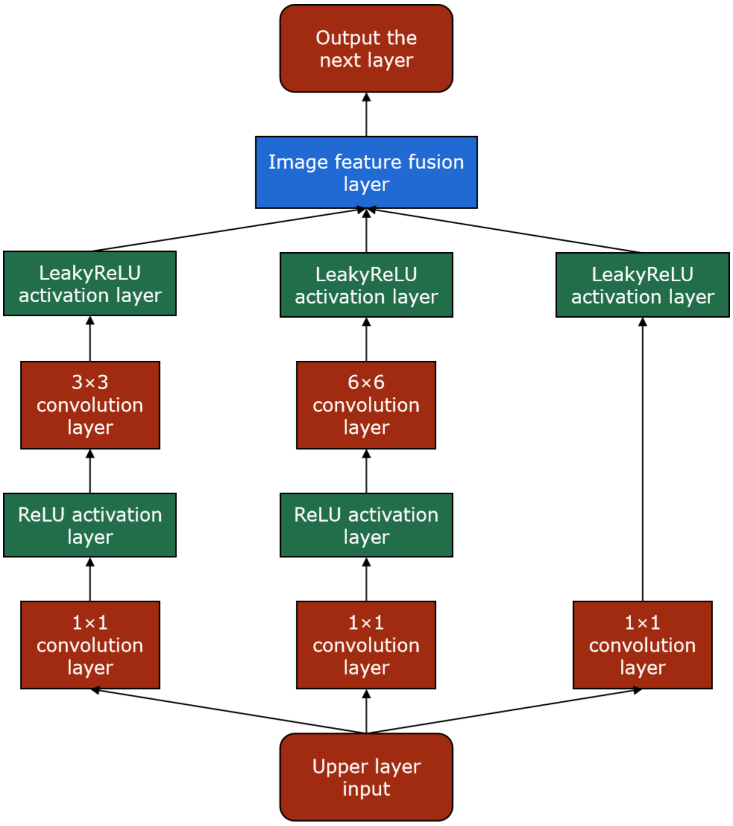

Figure 3: Image resolution enhancement.

The three vertices and three sides of all triangles in the triangulation are stored in counterclockwise order to ensure the consistency of the triangle normal in the triangulation. When triangulation is generated, the usage times of other edges are all 2, except that the usage times of several edges at the boundary are 1. In addition, each edge also stores triangles on its left and right sides to support the local optimization process if necessary.

4 MODEL TESTING AND ANALYSIS

In order to verify the effectiveness and practicability of the image resolution enhancement method of CAD system in this article, this section tests and analyzes the comprehensive performance of the algorithm. The experiment adopts MIT Scene Parsing Data set data set, which includes two parts: image resolution enhancement and image instance segmentation. Test the time required for image resolution enhancement under the condition of different numbers of pictures and different nodes, as shown in Figure 4.

From the whole to the details, the script is drawn from two angles: the way of dynamic design and the way of presentation, in which the form and times of dynamic alternate transformation between strokes should be considered. In order to avoid the visual fatigue of the audience, the dynamic visual process is quite inductive, and the whole display should be completed step by step from the local display. Figure 5 shows the image recognition accuracy test of the proposed method and the traditional DL model.

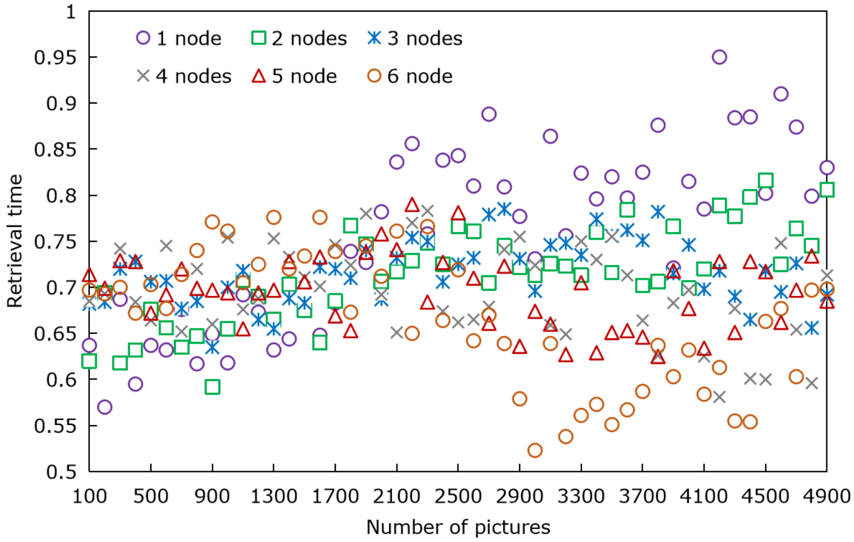

Figure 4: Image recognition consumes time.

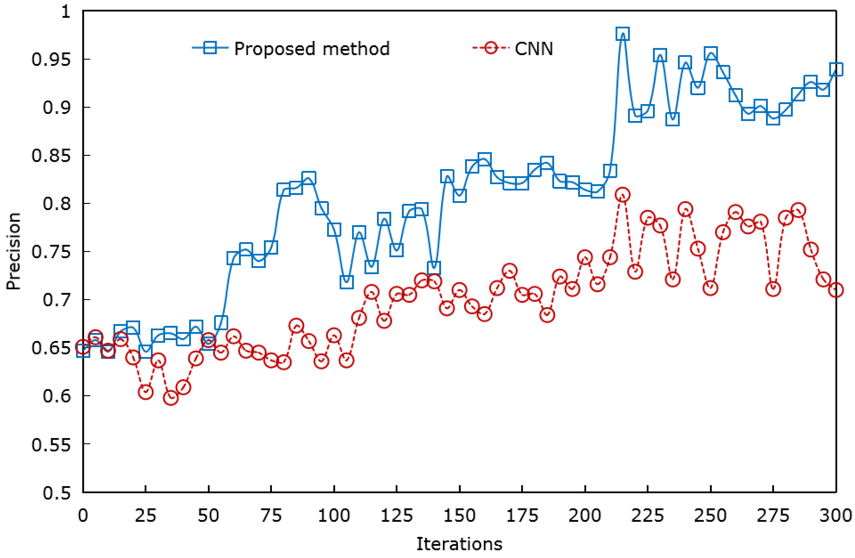

Figure 5: Accuracy results of different algorithms.

When a CAD work has obvious division position, you can directly draw the division line of a graphic design work by computer, calculate the ratio of the division line to the whole work, or calculate the ratio of the distance between the division line and the division line.

Regardless of the operations such as modeling and spatial analysis of spatial point sets, the final results are largely related to the local point groups in the total point set, and the calculation involving the whole is usually unnecessary. If the data set can be eliminated before the actual calculation, that is, irrelevant point groups can be excluded from the calculation, the required results can be calculated in real time. Compare the recall of visual design image enhancement by the algorithm, as shown in Figure 6.

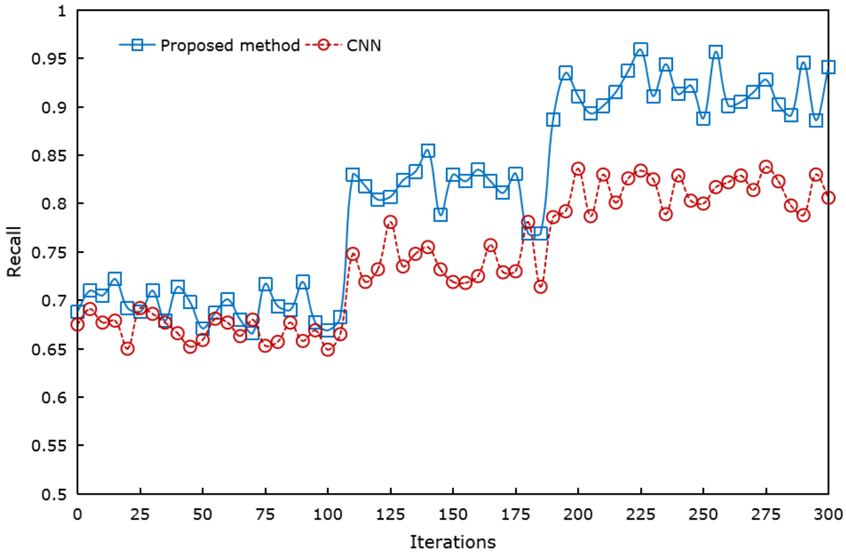

Figure 6: Comparison of recall for visual design image enhancement.

The recall of visual design image enhancement is improved by about 20%. Using the improved method to optimize the CAD modeling of visual transmission design instructional system can locate the edge contour of the design image relatively accurately on the premise of ensuring the clarity of the visual design image.

Dynamic rectangle is complex. Without dividing line, it is difficult for CAD works to judge the proportion of dividing line directly by manual work, and the use of dynamic rectangle method is also limited. However, the standard auxiliary line template of CAD based on visual aesthetics can help designers find the design proportion that is most in line with visual aesthetics. The search efficiency comparison of visual design image optimization algorithm is shown in Figure 7.

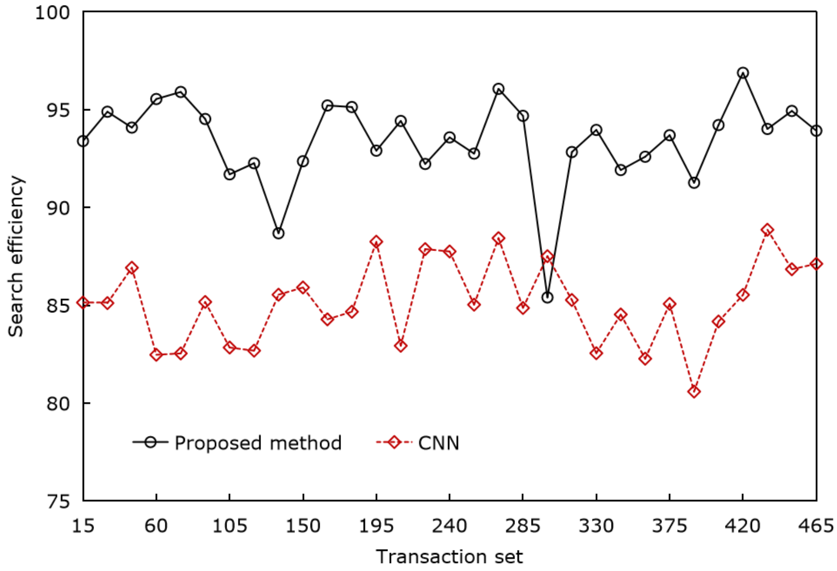

Figure 7: Comparison of search efficiency of algorithms.

Compared with the traditional DL model, the retrieval efficiency of this method is obviously improved. By hollowing out the convolution operation and pooling operation in CNN, it completely retains the computing structure of CNN, and in the process of calculation, it can keep the size of each layer of feature map in CNN consistent with the original map, so that the image resolution enhancement effect of the original map size can be directly obtained.

5 CONCLUSIONS

Graphic designers can achieve efficient visual aesthetic effects with the help of CAD. Improving the teaching method of visual transmission design can effectively improve the traditional teaching concept and realize the innovation of the teaching method of visual design. Aiming at the influence and requirements of the digital age on visual design, this article discusses how to build a 3D CAD system in the digital age, and designs and implements the image feature extraction and enhancement algorithm in the 3D CAD system. The results show that the accuracy of this algorithm is improved by more than 15% compared with traditional CNN, and the recall rate is improved by about 20%. Using the improved method to optimize the CAD modeling of visual transmission design instructional system can locate the edge contour of the design image relatively accurately on the premise of ensuring the clarity of the visual design image.

In the CAD teaching of visual transmission design specialty, every link must be closely combined with creative training, emphasizing creative inspiration and cultivation. Applying the algorithm in this article to the construction of 3D CAD system can innovate the teaching of visual transmission design. The next step will focus on real-time reconstruction of 3D scenes using images and image sequences.

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REFERENCES

[1] Anamova, R.-R.; Leonova, S.-A.; Nartova, L.-G.; Tereshchenko, V.-P.: Digital spatial models in technology as a development tool of the intellectual creative aspect within education, TEM Journal, 9(3), 2020, 1186-1193. https://doi.org/10.18421/TEM93-45

[2] Ge, M.; Tian, Y.; Ge, Y.: Optimization of computer aided design system for music automatic classification based on feature analysis, Computer-Aided Design and Applications, 19(S3), 2021, 153-163. https://doi.org/10.14733/cadaps.2022.S3.153-163

[3] Kiu, Z.: The Dynamic effect of visual communication in web design and its technical realization, Computer-Aided Design and Applications, 17(S2), 2020, 78-88. https://doi.org/10.14733/cadaps.2020.S2.78-88

[4] Lavicza, Z.; Weinhandl, R.; Prodromou, T.; Anđić, B.; Lieban, D.; Hohenwarter, M.; Diego, M.-J.-M.: Developing and evaluating educational innovations for STEAM education in rapidly changing digital technology environments, Sustainability, 14(12), 2022, 7237. https://doi.org/10.3390/su14127237

[5] Li, J.; Li, Y.: Research and application of computer aided design system for product innovation, Journal of Computational Methods in Sciences and Engineering, 19(51), 2019, 41-46. https://doi.org/10.3233/JCM-191006

[6] Lin, Q.; Man, Z.; Cao, Y.; Deng, T.; Han, C.; Cao, C.; Huang, X.: Classifying functional nuclear images with convolutional neural networks: a survey, IET Image Processing, 14(14), 2020, 3300-3313. https://doi.org/10.1049/iet-ipr.2019.1690

[7] Ma, K.; Mao, Z.; He, D.; Zhang, Y.: Design a network architectural teaching system by auto CAD, Computer-Aided Design and Applications, 17(S2), 2020, 1-10. https://doi.org/10.14733/cadaps.2020.S2.1-10

[8] McMenamin, P.-G.; Hussey, D.; Chin, D.; Alam, W.; Quayle, M.-R.; Coupland, S.-E.; Adams, J.-W.: The reproduction of human pathology specimens using three-dimensional (3D) printing technology for teaching purposes, Medical Teacher, 43(2), 2021, 189-197. https://doi.org/10.1080/0142159X.2020.1837357

[9] Mohammed, Z.-F.; Abdulla, A.-A.: An efficient CAD system for ALL cell identification from microscopic blood images, Multimedia Tools and Applications, 80(4), 2021, 6355-6368. https://doi.org/10.1007/s11042-020-10066-6

[10] Ng, O.-L.; Chan, T.: Learning as making: using 3D computer-aided design to enhance the learning of shape and space in STEM - integrated ways, British Journal of Educational Technology, 50(1), 2019, 294-308. https://doi.org/10.1111/bjet.12643

[11] Nyshchak, I.; Martynets, L.; Kurach, M.; Buchkivska, G.; Greskova, V.; Nosovets, N.: Didactic opportunities of information and communication technologies in graphic training of future technology teachers, BRAIN. Broad Research in Artificial Intelligence and Neuroscience, 11(2), 2020, 104-123. http://dx.doi.org/10.18662/brain/11.2/77

[12] Petrov, D.-N.; Chistyakova, T.-B.: A computer-aided design system for virtual models for training in control of the synthesis process of carbon nanostructures, Vestnik Tambovskogo gosudarstvennogo tehnicheskogo universiteta, 27(2), 2021, 212-230. https://doi.org/10.17277/vestnik.2021.02.pp.212-230

[13] Ramonell, C.; Chacón, R.: Open - source terrestrial laser scanner for the virtualization of geometrical entities in AEC classrooms, Computer Applications in Engineering Education, 30(4), 2022, 1009-1021. https://doi.org/10.1002/cae.22499

[14] Ruberto, C.; Loddo, A.; Putzu, L.: Special issue on image processing techniques for biomedical applications, Applied Sciences, 12(20), 2022, 10338. https://doi.org/10.3390/app122010338

[15] Song, M.-J.: The application of digital fabrication technologies to the art and design curriculum in a teacher preparation program: a case study, International Journal of Technology and Design Education, 30(4), 2020, 687-707. https://doi.org/10.1007/s10798-019-09524-6

[16] Tuli, T.-B.; Cesarini, A.: Automated unsupervised 3D tool-path generation using stacked 2D image processing technique, Journal of Manufacturing and Materials Processing, 3(4), 2019, 84. https://doi.org/10.3390/jmmp3040084

[17] Wei, X.; Han, Y.: Design and implementation of interactive visual communication teaching system based on CAD technology, Computer-Aided Design and Applications, 19(S7), 2022, 56-66. https://doi.org/10.14733/cadaps.2022.S7.56-66

[18] Zalilov, R.; Reshetnikova, E.; Savelyeva, I.; Svistunova, E.; Rebezov, M.; Goncharov, A.; Odinokova, E.: CAD systems and computer graphics in the training of specialists in the field of mechanical engineering, Journal of Critical Reviews, 7(2), 2020, 162. http://dx.doi.org/10.31838/jcr.07.02.30

[19] Zhang, Y.: Computer-assisted human-computer interaction in visual communication, Computer-Aided Design and Applications, 18(S1), 2020, 109-119. https://doi.org/10.14733/cadaps.2021.S1.109-119

[20] Zhetessova, G.; Yurchenko, V.; Nikonova, T.: The development of the computer-aided design system for production processes of component part machining for single-piece production and repair conditions, Journal of Applied Engineering Science, 17(4), 2019, 599-609. https://doi.org/10.5937/jaes17-21470