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3D Modeling and Design Effect Optimization of Ceramics Using Virtual Reality

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Abstract. 3D modeling is a core link in the design and production of ceramic products. The traditional 3D modeling method of ceramics is usually based on manual measurement and drawing, which not only has a large workload, but also needs to improve the accuracy and efficiency of modeling. Information technology tools such as computer aided design (CAD) and virtual reality (VR) are gradually applied in the field of ceramic manufacturing, which brings new possibilities for the design and production of ceramic products. This article will take ceramic products as the research object, and apply CAD technology, VR technology and convolutional neural network (CNN) to the 3D modeling and design effect optimization of ceramic products. CNN is used to identify the characteristics of ceramic images, so as to intelligently evaluate and optimize the design effect of ceramic products. In the ceramic design scene, the ceramic CAD modeling method proposed in this article improves the accuracy by more than 17%. MAE comparative experiments also show that CNN algorithm has significant advantages in virtual scene information feature recognition. The feature recognition method based on CNN can improve the classification accuracy and quality inspection accuracy of ceramic products, and provide strong support for the 3D modeling and design effect optimization of ceramic products.

Keywords: Computer Aided Design; Virtual Reality; Ceramic Design; 3D Modeling; Convolutional Neural Network
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1 INTRODUCTION

Ceramic is a kind of material with a wide range of applications, and its unique physical and chemical characteristics make it have important application value in many industries. However, the complexity and high cost of ceramic manufacturing make the design and production of ceramic products a challenging task. Detection and segmentation of ligand binding sites is one of the important issues in biomedical research. The traditional methods for detecting ligand binding sites mainly include computational mechanics-based algorithms and feature based algorithms. These methods typically require manual setting of features and parameters, and are often difficult to achieve ideal results for complex three-dimensional structures. 3D Convolutional Neural Networks (3D-CNN) have shown superior performance in processing biomedical image analysis with spatial information. Aggarwal et al. [1] explored the application of 3D-CNN is a neural network designed specifically for processing images with three-dimensional spatial information. It achieves accurate site detection and segmentation by convolving input data in three-dimensional space and extracting features related to ligand binding sites. Compared with traditional site detection methods, 3D-CNN does not require manual setting of features and parameters, and can automatically learn effective features from the data. In addition, 3D-CNN can directly process three-dimensional images without the need for two-dimensional slicing processing, so it does not lose the spatial information of the image. 3D modeling is a core link in the design and production of ceramic products. The traditional 3D modeling method of ceramics is usually based on manual measurement and drawing, which not only has a large workload, but also needs. With the development of technology, the demand for 3D models is increasing, especially in the construction industry. 3D building models can provide more comprehensive and accurate information, which helps with better conceptual design and planning. However, traditional 3D modeling methods have problems such as high workload, high cost, and long time. Therefore, studying how to restore a 3D building model from a single 2D image is of great significance. Alidoost et al. [2] adopts a series of technologies to improve the quality and accuracy of aerial images, including denoising, standardization, registration, and other steps. These steps can effectively reduce image noise and distortion, providing high-quality image data for subsequent processing. In the feature extraction stage, this article adopts an image feature extraction method based on convolutional neural networks. This method utilizes the powerful feature learning ability of convolutional neural networks to extract features related to buildings from preprocessed aerial images. These features can include the shape, size, color, etc. of buildings, providing important data support for subsequent 3D reconstruction. Identifying construction elements is a key step in reconstructing a 3D model. In architectural images, various constructions have their specific shape and texture features. By identifying these features, each pixel or region in the image can be assigned to the corresponding construction elements. Utilize known construction elements and rules from the knowledge base to construct a complete 3D building model. Information technology tools such as CAD and VR are gradually applied to the field of ceramic manufacturing, which brings new possibilities for the design and production of ceramic products. Through CAD software, designers can easily create, modify and optimize 3D models, which greatly improves the efficiency and accuracy of ceramic product design. The design and production of ceramic products is not only a problem of 3D modeling, but also needs to consider many factors such as the appearance, texture and luster of the products. In the process of traditional ceramic product design and production, these factors often need to be evaluated and adjusted by designers with experience. The emergence of VR technology provides a brand-new solution for the assessment and optimization of the design effect of ceramic products. Through VR technology, designers can simulate the real appearance and texture of ceramic products in the computer, so as to evaluate and optimize the design effect of products intuitively.

Benbarrad et al. [3] establishing an intelligent machine vision model, it is first necessary to obtain high-quality training and testing data. Feature selection is another key step in establishing an intelligent machine vision model. For defect product detection tasks, the texture, color, shape, and other features of images are often closely related to product defects. In addition, deep learning technology can be used to automatically learn image features, thereby better capturing the detailed information of product defects. In terms of algorithm selection, neural networks, especially convolutional neural networks (CNN), have become the mainstream algorithm. Model evaluation is another important step in establishing intelligent machine vision models. Common evaluation indicators include accuracy, recall, F1 value, etc. Accuracy and recall are typically visualized in two-dimensional tables (also known as confusion matrices) to gain a more intuitive understanding of the model's performance. In this table, the rows represent the actual categories, and the list shows the categories predicted by the model. Each cell in the table represents the performance of the model in each category. and F1 value is the harmonic average of accuracy and recall. These indicators can comprehensively evaluate the performance of the model and help us understand its advantages and disadvantages. The growth of deep learning and CNN provides powerful tools for image processing and recognition. Especially for the feature recognition of ceramic images, by training a specific CNN model, the features in ceramic images can be effectively extracted and classified, thus providing strong support for the 3D modeling and design effect optimization of ceramic products. Through CAD technology, efficient 3D modeling can be carried out, thus better meeting the needs of ceramic manufacturing; With the help of VR technology, the real appearance and texture of ceramic products can be simulated in the computer, so that the product design effect can be evaluated and optimized intuitively. This article will take ceramic products as the research object, and deeply apply CAD technology, VR technology and CNN to the 3D modeling and design effect optimization of ceramic products. Firstly, the 3D modeling of ceramic products is carried out by using CAD technology, and it is stored as a model file with general format. Then the 3D model is introduced into the virtual environment for realistic rendering and interactive display by VR technology, and the characteristics of ceramic images are identified by CNN, so as to intelligently evaluate and optimize the design effect of ceramic products. The purpose of this study is to explore a method of ceramic 3D modeling and design effect optimization based on CAD and VR.

It simulates human auditory and tactile senses, allowing users to immerse themselves in a highly realistic virtual environment. In the field of education, the application of immersive virtual reality has been quite extensive, such as virtual laboratories, virtual exhibition halls, virtual teaching aids, etc., providing learners with a highly realistic practical experience. In industrial design education, immersive virtual reality has unique advantages. Traditional teaching methods often focus on theoretical teaching and two-dimensional drawing teaching, while neglecting the exercise of practical operation and design thinking. Immersive virtual reality technology can introduce students into a highly simulated 3D design environment, allowing them to learn through practice and improve their design ability and innovation awareness. At the same time, this teaching method can effectively compensate for the shortcomings of traditional education. Bernardo and Duarte [4] improving students' interest in learning and practical abilities can also promote the cultivation of innovative thinking and environmental awareness. The research significance lies in that the combination of CAD technology and VR technology can greatly shorten the time period of ceramic product design and production, and improve the precision and quality of products. With the help of CAD technology and VR technology, the production process can be simulated and evaluated at the product design stage, thus reducing waste in production, improving product quality and reducing production cost. The research results can provide new ideas and methods for the innovation and growth of ceramic manufacturing field, and help to promote the application and growth of computer technology in ceramic manufacturing field.

During the research, the following innovations were made:

(1) By processing and fitting the original point cloud data, this article can quickly and accurately obtain a high-precision 3D model of ceramic products, which improves the accuracy and efficiency of modeling.

(2) This method obtains a virtual ceramic product image by rendering the 3D model, and analyzes the indicators of the virtual image, so as to evaluate and optimize the product design effect, making the assessment more objective and accurate.

(3) By training and learning a large quantity of ceramic images, this method obtains an efficient feature recognition model, so that new ceramic images can be classified and their features can be recognized, which provides a strong support for the 3D modeling of ceramic products and the optimization of design effects.

Firstly, this article introduces the significance and methods of CAD and VR in ceramic 3D modeling and design effect optimization. Then summarize the research contributions of scholars in this field; Then, a ceramic image feature recognition model based on CNN is constructed to assist the 3D modeling of product ceramics. Finally, the performance of the model is simulated, which proves the feasibility of the model.

2 RELATED WORK

Virtual reality (VR) technology provides a more intuitive and realistic simulation environment for industrial robot programming. In a VR environment, engineers can see the effect of programming robots in real-time without waiting for feedback from actual robots. This greatly improves programming efficiency and accuracy. Secondly, digital twin technology provides new possibilities for robot programming. Digital twin technology refers to creating a digital model that is identical to a physical robot in a virtual environment. Through this digital model, engineers can test and optimize the behavior of robots before actual programming, thereby improving programming quality and efficiency. Burghardt et al. [5] introduced how to program, and elaborated on their application background and significance. Connect actual industrial robots through digital twin software. Through digital twin software, robots can be calibrated to ensure consistency in their motion trajectory and simulation. After setting the parameters of digital twins, the modified parameters can be simulated and run through virtual reality software, and the running results can be observed and recorded. By creating virtual reality scenes, setting digital twin parameters, simulating operations, and practical operations, industrial robots can be effectively programmed and optimized. In practical applications, paying attention to safety, accuracy, maintainability refers to the ability of a system or component to be maintained and repaired during its lifecycle. For robot programming programs, maintainability means that the program should be designed to be easily modified, updated, repaired, and upgraded to adapt to constantly changing environments and needs. The program should be designed to be easy to read and understand. This way, when it is necessary to modify or update the program, engineers can more easily understand the structure and logic of the code, thereby reducing errors and maintenance time. Decomposing a program into independent and reusable modules can simplify the maintenance process. When a module needs to be modified, only the code of that module needs to be modified, without the need to modify the entire program. Virtual experiences are becoming increasingly close to physical reality. However, there is still a certain gap in achieving a completely immersive virtual experience. Fouad et al. [6] conducted in-depth research on factors related to the design of props using questionnaire surveys and field research methods. The results indicate that designing props can effectively enhance the immersion of virtual experiences and help users better understand and adapt to virtual environments. Although virtual reality has made significant progress, there is still a gap between it and physical reality. This gap may affect users' immersion and realism in virtual experiences.

The Monte Carlo method has advantages in dealing with the uncertainty of complex systems and can be used to predict the performance of molecular products and optimize process parameters. Frutiger et al. [7] through Monte Carlo simulation, a large number of possible problem instances can be generated and optimized on these instances. This can help understand the impact of uncertainty on optimization results and find the best process design. In each Monte Carlo simulation, optimization algorithms such as genetic algorithm, particle swarm optimization algorithm, simulated annealing algorithm, etc. need to be used to find the optimal solution. Through experimental verification, this strategy can effectively predict the performance of molecular products and optimize process parameters. Select representative molecular products from existing databases and collect corresponding process parameters. Use Monte Carlo simulation method for process simulation and calculate product performance indicators such as yield and purity. Based on the simulation results, analyze the impact of process parameters on product performance and determine. Through Monte Carlo simulation, we obtained the product performance indicators under various process parameters. Different process parameters on product performance. Among them, the reaction temperature yield, followed by the reaction time. By adjusting these two parameters, the optimal combination of process parameters can be obtained. There are certain shortcomings in the design of existing virtual reality visualization interfaces, such as complex operations and unsatisfactory visual effects. In order to improve user experience, Fu et al. [8] uses a questionnaire survey and experimental testing method to collect user feedback and evaluation on different virtual reality visualization interfaces. Among them, the questionnaire survey mainly collects users' cognition and preference information on various engineering image space designs. And experimental testing analyzes the impact of Kansas engineering image space on interface design by comparing the performance of different design schemes. In the specific design process, we first conducted research on the Kansas Engineering Image Space to identify the relationship between image features and user needs. Then, based on user needs and operating habits, determine the interface layout and element distribution. Finally, the optimal design scheme was determined through experimental verification. The study also optimized the interaction mode of interface elements. Through the study of Kansas Engineering Image Space, we have gained a deeper understanding of the relationship between image features and user needs, and based on this, we have optimized the design of visual interfaces. For example, when users interact with the interface, providing immediate feedback and dynamic effects enables users to understand the operation status and results. At the same time, we dynamically adjust and optimize interface elements iteratively based on user needs and feedback to meet the constantly changing needs of users.

Guan et al. [9] using computers to generate a three-dimensional environment, allowing users to interact with this environment in a natural way. In the field of ceramic production, VR technology can create a simulated ceramic production environment, where students can produce in a virtual environment through head-worn devices. He chose a ceramic production theme suitable for middle school students and collected relevant teaching materials and VR materials. Then, based on the learning characteristics and interests of middle school students, a series of interesting VR scenes and interactive links were designed. Finally, data on students' creativity and learning engagement during the production process were collected through experiments and questionnaire surveys. The experimental results indicate that the ceramic production method based on VR technology has a positive impact on the creativity and learning engagement of middle school students. In addition, students can create more freely in a virtual environment, thereby stimulating their creativity. Compared with traditional teaching methods, the ceramic production method based on VR technology has significant advantages in improving students' creativity and learning engagement. Hanssen [10] combined Oculus Rift and clay 3D printing technology to explore (VR) technology in the production of ceramic handicrafts. By applying VR technology to the throwing process of ceramic handicrafts, it can provide an immersive creative environment, assist designers in experimentation, improve production efficiency, and provide users with new experiences and learning opportunities. With the continuous progress of technology, it is handicrafts will become increasingly widespread, bringing more innovation and breakthroughs to traditional handicrafts. Throwing utensils are an important part of the production of ceramic handicrafts. Oculus Rift can be used to provide an immersive virtual environment, making users feel like they are in an actual pottery making scene. Through clay 3D printing technology, designs in virtual environments can be transformed into actual products. In addition, VR technology can also help potters simulate the shape, size, and structure of dishes. 5G wireless communication systems are driving the progress of global communication networks, providing higher data rates and lower latency. At the same time, ceramic materials have also received attention in multiple fields due to their unique physical properties and chemical stability. Hill et al. [11] explored the combination of 5G wireless communication systems and ceramic materials to achieve more efficient and stable communication devices. 5G is the fifth-generation mobile communication standard, which has higher data transmission rates, lower latency, and higher network capacity than 4G. It is the foundation of future wireless communication and will support the Internet of Things (IoT), autonomous vehicle, telemedicine and other advanced applications. Ceramic materials have high frequency stability and Q-value, making them suitable for manufacturing filters. A filter is a component used to select the required frequency, which is crucial for the normal operation of 5G wireless communication systems.

In today's design field, product form design is receiving increasing attention. Form design is not only an aesthetic issue, but also the key to user experience and functional implementation.

Sensory engineering and virtual reality technology provide new research methods and tools for product form design. Liu and Yang [12] explored how to study the methods and processes of product form design through perceptual engineering and virtual reality technology. By combining perceptual engineering with virtual reality technology, ceramic product design will place greater emphasis on user experience and user experience. This not only improves the practicality and attractiveness of products, but also helps enterprises better understand user needs and expectations, thereby providing more competitive products and services for future markets. In traditional mining image segmentation methods, most of them are based on pixel level segmentation, which is often affected by changes in lighting, color, and texture, making it difficult to achieve accurate segmentation. With the continuous development of image processing and machine learning technology, deep learning-based image segmentation methods have become a research hotspot. Ma et al. [13] proposes an image segmentation method based on multi-scale convolutional neural networks. This method adopts a multi-scale feature fusion strategy to fuse image features of different scales, thereby improving segmentation accuracy. To verify the effectiveness of the new method proposed in this article, we conducted experiments on public datasets and compared the results with current mainstream methods. The experimental results show that the method proposed in this article has higher accuracy and faster running speed when dealing with complex image segmentation tasks. In addition, we also analyzed several feature fusion strategies at different scales and found that using multi-scale feature fusion can improve segmentation accuracy. This method can automatically extract effective feature information from the original image by training the CNN model, avoiding the tedious process of manually designing features. This method adopts a U-Net structure and has the ability to fuse multi-level feature information, which can effectively improve segmentation accuracy. Marín et al. [14] explored how augmented reality technology can improve the perception of ceramic molds and analyzed the specific degree of improvement. Through headphones or other devices, virtual information can be overlaid with real-world objects, providing operators with richer visual information. By utilizing augmented reality technology, ceramic molds can be modeled in 3D and visualized in real time. This helps the operator to better understand the structure and shape of the mold for more precise operations. By using augmented reality technology, defects in ceramic molds can be detected. For example, the operator can identify small cracks, pores, and other defects on the surface of the mold through virtual markings in the head mounted display. Augmented reality technology can be used to simulate the production process of ceramic molds. This helps the operator to understand the status of the mold at different production stages, thereby better controlling the production process.

Ming et al. [15] explored the system and application of virtual reality technology for ancient ceramic restoration, and looked forward to its future development direction. As an emerging technology, ancient ceramic restoration virtual reality technology has broad application prospects in the field of cultural relic protection and restoration. It not only improves the efficiency and effectiveness of ceramic restoration, but also provides more scientific and accurate technical support for cultural relic protection work. The virtual reality technology for ancient ceramic restoration is mainly based on technologies such as virtual reality, computer graphics, and artificial intelligence. Its core is to scan damaged ceramic objects through a 3D scanner, obtain their 3D data, and then use 3D modeling software to virtual restore the damaged ceramic objects. Next, use a virtual reality editor to simulate the restoration of ceramic artifacts, and finally evaluate and optimize the restoration process through the ceramic restoration knowledge in the virtual restoration library. In the field of medical image analysis, accurate segmentation of target structures in three-dimensional images is of great significance for the diagnosis and treatment of diseases. However, due to the complexity and uncertainty of medical images, manual segmentation is very time-consuming and prone to errors. Therefore, automated medical image segmentation methods have become a research hotspot. Among them, deep convolutional neural networks, and are also widely used in medical image segmentation tasks such as automatic 3D salt segmentation. Shi et al. [16] introduced an method using deep convolutional neural networks and analyzed its advantages and disadvantages in practical applications. Through experiments, we found that the method networks have high accuracy and recall in medical image segmentation tasks, and can effectively segment the target structure. Compared with traditional segmentation methods, DCNN method has higher robustness and adaptability, and can handle various complex medical image data. In addition, the DCNN method can also process multimodal medical image data, such as fusing CT and MRI data to improve the accuracy of segmentation. Ceramic art has a long history and is a perfect combination of art and technology. Modern ceramic technology has been widely applied. Tao mainly studied the application of modern ceramic technology in art design, aiming to explore its potential value and contribution. Tao [17] aims to explore the application of modern ceramic technology in art design. Summarize the unique value and potential of modern ceramic technology through an overview of historical development and current research. The article introduces research methods and designs, and elaborates on sample selection, data collection, and analysis methods in detail. Modern ceramic technology combines advanced technological means, providing more possibilities for artistic design and improving the innovation of works. The characteristics of ceramic materials endow works using modern ceramic technology with unique texture and aesthetics, enhancing the expressive power of artistic design. Modern ceramic technology is not only widely applied in art design, but also involves fields such as architecture and installation art, promoting interdisciplinary communication and integration.

The traditional research method does not study the combination of ceramic materials and computer technology deeply enough, and lacks systematicness and completeness, so it is difficult to realize the wide ceramic manufacturing. In this article, an efficient feature recognition model is obtained by training and learning a large quantity of ceramic images, so that new ceramic images can be classified and their features can be recognized. The virtual ceramic product image is obtained by rendering the 3D model, and the indicators of the virtual image are analyzed, so as to evaluate and optimize the product design effect and make the assessment more objective and accurate.

3 METHODOLOGY

3.1 Feature Detection of Ceramic Image

With the rapid growth of computer vision and deep learning technology, feature detection has become one of the core tasks in image processing. Especially in ceramic image analysis, feature detection is of great significance for ceramic product classification, quality inspection and design optimization. This section will introduce a feature detection method of ceramic images based on CNN. The feature detection method based on CNN is an end-to-end solution, which can learn effective feature expression directly from the original image. Specifically, CNN can automatically learn various scales and multi-level features in images through multi-layer convolution and pooling operations. In the feature detection of ceramic images, CNN can learn effective feature expression by training a large quantity of ceramic image data, thus improving the classification accuracy and quality inspection accuracy of ceramic products. The CNN model of ceramic image feature detection is shown in Figure 1.

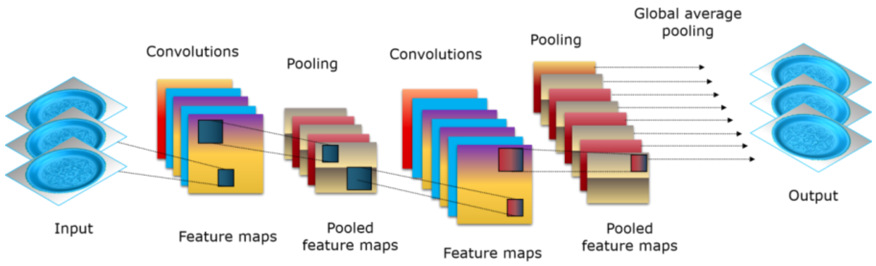

Figure 1: CNN model for feature detection of ceramic images.

CNN can learn effective feature expression by itself, avoiding the tedious process of designing features by hand, and can adapt to all kinds of complex and changeable ceramic images. CNN can capture the multi-scale features and nonlinear relationships in ceramic images, thus achieving better performance in ceramic product classification and quality inspection. The feature detection method based on CNN also has good generalization ability and can adapt to different types of ceramic products and application scenarios.

$$Y_i^k = f\left(X_i^k\right) \tag{1}$$

$$X_i^k = \sum_{j=1}^{n+1} W_{ij} Y_j^{k-1} \tag{2}$$

Generally, f is an asymmetric Sigmoid function:

$$f\left(x_i^k\right) = \frac{1}{1+\exp\left(-X_i^k\right)} \tag{3}$$

$$e = \frac{1}{2}\sum_i \left(Y_i^m - Y_i\right)^2 \tag{4}$$

In order to improve the generalization ability of the model, data enhancement technology is also used to randomly rotate, translate and scale the original image. Then, the trained CNN model is used for feature detection of ceramic images, and a set of representative feature vectors is obtained by inputting ceramic images into CNN model. These feature vectors can describe various key information such as texture, shape and color in ceramic images. The extracted feature vectors are used in the subsequent tasks of ceramic product 3D modeling and design effect optimization. By inputting the feature vectors into the 3D modeling algorithm, automatic modeling of ceramic products based on features can be realized. At the same time, these eigenvectors can also be used to evaluate the design effect and help designers optimize the appearance, texture and color of ceramic products.

The feature of the image is extracted by feature functions f_A and f_B, and the output feature vectors are u and v respectively. Then, in the part of pooling function P, bilinear CNN model adopts bilinear pooling to bilinear combine the output feature vectors:

$$bilinear\left(f_A, f_B\right) = f_A \otimes f_B = u^T v \tag{5}$$

$$\varphi\left(f_A, f_B\right) = \sum_{d=1}^{D} bilinear\left(f_A, f_B\right) = \sum_{d=1}^{D} u^T v \tag{6}$$

$$y = sign\left(\varphi\left(f_A, f_B\right)\right)\sqrt{\left|\varphi\left(f_A, f_B\right)\right|} \tag{7}$$

$$z = \frac{y}{\|y\|_2} \tag{8}$$

Finally, the obtained vector z is input into the classification function C for recognition and classification, and the classifier selects the Softmax function.

3.2 3D Modeling of Ceramic Products

In the previous section, we introduced how to use CNN to extract the features of ceramic images. This section will introduce how to carry out 3D modeling of ceramic products based on these extracted features. Before 3D modeling, it is needed to preprocess the ceramic image data. First, the original 2D image data needs to be converted into 3D model data. Before inputting the image data into the deep learning model, it is needed to denoise, enhance and normalize the image to improve the accuracy of the model.

Point Net is a deep learning model that specializes in point cloud data, and can learn effective feature expression directly from point cloud data. In the research, a Point Net model. The model can accept 2D ceramic images as input and output 3D ceramic model data. In the process of model training, we use random gradient descent (SGD) as the optimizer and set a suitable learning rate. The cross-entropy loss function is also used for optimization, and some regularization techniques are adopted to prevent over-fitting. The network structure of Point Net is shown in Figure 2.

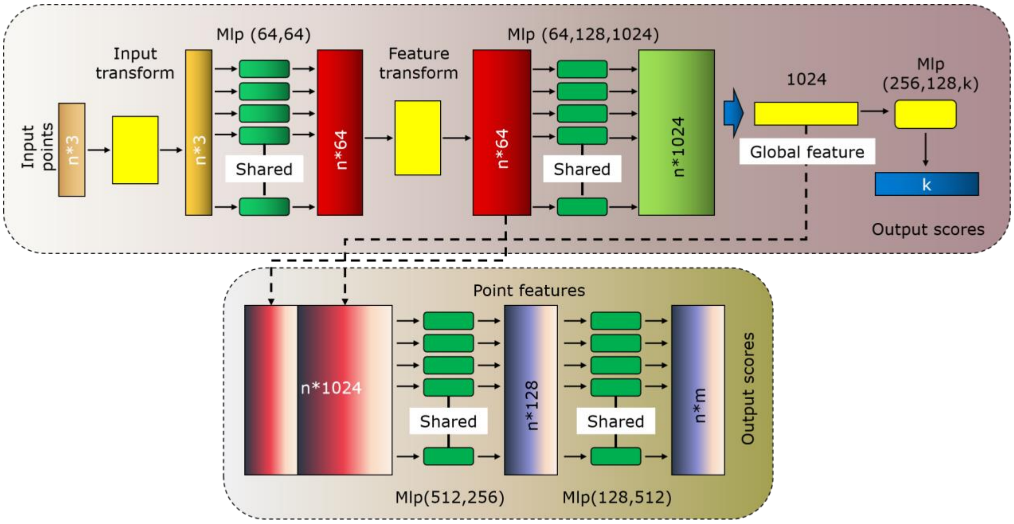

Figure 2: Network structure of pointnet.

In the 3D modeling stage, the extracted feature vector is used as input, and the 3D modeling of ceramic products is carried out with the network structure of Point Net. Point Net model can accept a series of 3D point cloud data as input, and automatically learn effective feature expression through multi-layer convolution and pooling operation. These characteristics can describe the shape, texture and structure of ceramic products.

Suppose that the projection of the image of the 3D space point $P(X,Y,Z)$ respectively. Superimpose the first camera on the world coordinate system, and the X coordinates of P point can be obtained as follows:

$$X_1 = \frac{x_1}{f}(Z_1 - f) \tag{9}$$

Where X_1 and Z_1 indicate that P point will also move with it while maintaining the relative geometric relationship. If you move the second camera to the origin of the world coordinate system, then:

$$X_2 = \frac{x_2}{f}(Z_2 - f) \tag{10}$$

Because the baseline length is L, and the Z coordinate of P point is the same for the two camera coordinate systems, there are:

$$X_2 = X_1 + L, Z_2 = Z_1 = Z \tag{11}$$

4 RESULT ANALYSIS AND DISCUSSION

In the experimental part, CNN model is trained and tested respectively, and applied to the task of feature detection of ceramic images. Compared with traditional feature detection methods, it is found that CNN method has obvious advantages in feature detection of ceramic images.

In the case of different quantity of photos and different quantity of nodes, the ceramic design scene is experimented, as shown in Figure 3. Multi-node strategy has higher efficiency when dealing with a large quantity of images. With the increase of the quantity of images, the advantages of multi-node strategy gradually appear. This is because multi-node strategy can process multiple retrieval tasks in parallel, while single-node strategy must process each retrieval task in turn at the same time. Therefore, when dealing with a large quantity of images, multi-node strategy can make more effective use of computing resources and improve retrieval efficiency.

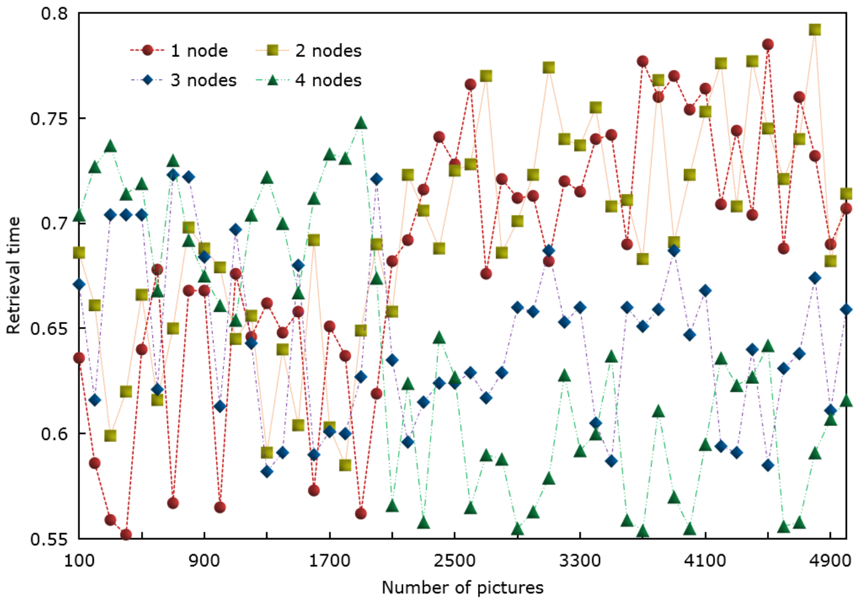

Figure 3: Image retrieval consumes time.

In the ceramic design scene, the image retrieval time increases with the increase of the quantity of network nodes, especially when the quantity of images is small. This is because in the case of fewer images, each node needs to deal with more retrieval tasks, which leads to an increase in retrieval time. However, by increasing the quantity of network nodes, the retrieval task can be shared more effectively, thus reducing the average retrieval time of each node. When the quantity of images is large, the multi-node strategy shows obvious advantages. This is because the multi-node strategy can handle multiple retrieval tasks at the same time, thus speeding up the overall retrieval speed. By assigning retrieval tasks to different nodes for processing, more abundant retrieval results can be obtained in a shorter time.

As can be seen from Figure 4, the ceramic CAD modeling method proposed in this article has improved the accuracy by more than 17% compared with the traditional SVM algorithm. This may be because the traditional SVM algorithm can not fully consider the complexity and variability of ceramic products when dealing with ceramic product modeling, which leads to limited modeling accuracy.

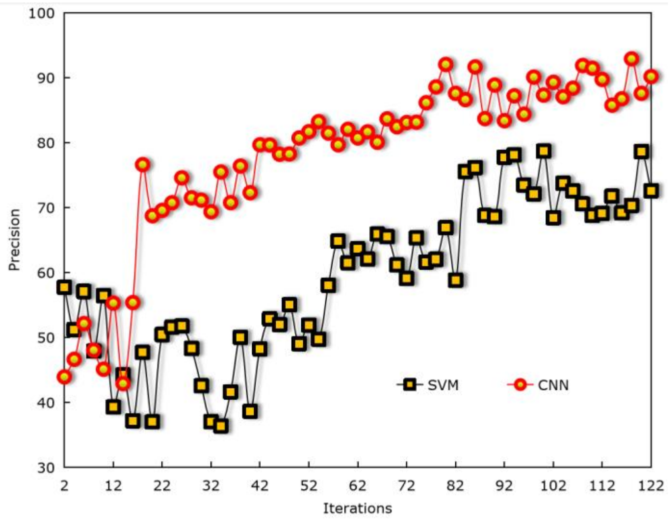

Figure 4: Accuracy results of different algorithms.

Ceramic CAD modeling method can learn and capture the characteristics of ceramic products more accurately by combining deep learning model and 3D point cloud data, thus improving the modeling accuracy. In addition, the ceramic CAD modeling method can also automatically complete the transformation from 2D images to 3D models, avoiding the tedious manual modeling process in the traditional SVM algorithm and further improving the modeling efficiency. By applying the deep learning model to the modeling of ceramic products, we can make full use of the powerful feature detection ability and pattern recognition ability of the deep learning model to automatically learn and identify various features and patterns of ceramic products.

Figure 5 shows that when comparing MAE values of different algorithms, algorithms with smaller MAE values typically perform better. Additionally, if an algorithm performs better on outliers or outliers, its MAE may be smaller than other algorithms, even if its prediction results are not entirely accurate. This is because MAE assigns equal weights to all prediction errors, regardless of their magnitude.

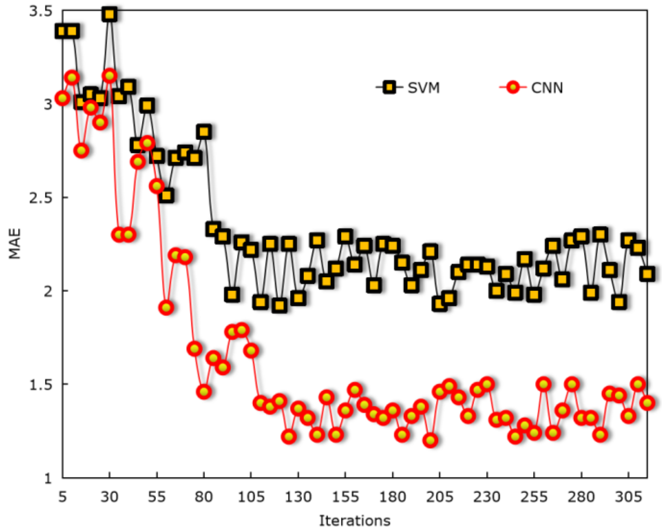

Figure 5: Virtual scene information feature recognition MAE.

In feature recognition of virtual scene information, CNN can effectively learn and extract useful features from data. In addition, CNN's parallel processing ability makes it more efficient when dealing with large-scale data. In contrast, SVM is a traditional machine learning algorithm, which is suitable for linearly separable data. However, feature recognition of virtual scene information is often nonlinear and involves complex spatial distribution and relationships, which may be one of the reasons why SVM is not as good as CNN.

Convolution operation can slide a small window (or filter) in the data and calculate the weighted sum of the data in the window. In this way, CNN can capture the local characteristics of the data. Then, these local features are used to generate global features, and finally used for classification or regression tasks. This hierarchical feature detection method of CNN makes it powerful in dealing with complex data. In the feature recognition of virtual scene information, CNN can effectively capture and utilize the complexity and variability of virtual scene information. In addition, the convolution operation of CNN can be executed in parallel, which makes it highly efficient in large-scale data processing.

As can be seen from Figure 6, as the quantity of pixel points of feature information increases, the processing time of different methods increases accordingly. This is because under the same conditions, more feature information means more computing resources are needed for processing.

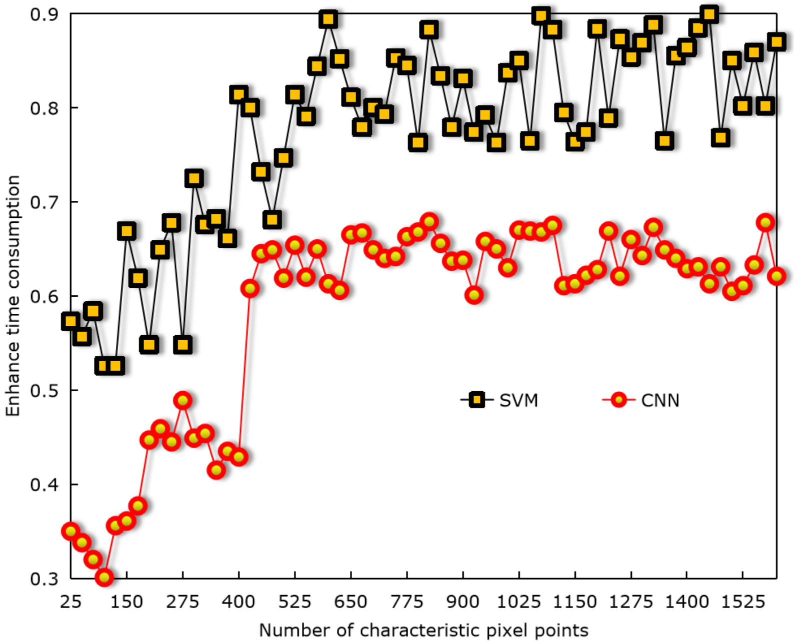

Figure 6: Enhanced image processing with different methods is time-consuming.

Comparing SVM with the VR image processing method proposed in this article, it can be clearly seen that the method in this article has significant advantages in processing time. Under all pixel counts, the VR image processing method proposed in this article is obviously faster than SVM. This is mainly due to the adoption of deep learning model in the VR image processing method proposed in this article, especially the feature detection of PointNet structure. PointNet is a deep learning model that specializes in processing point cloud data, and it can maintain high efficiency when processing large-scale point cloud data. In contrast, SVM may have an efficiency bottleneck when dealing with large-scale data.

Figure 7 shows the experience analysis results of the interactive experience display of the VR system in this article.

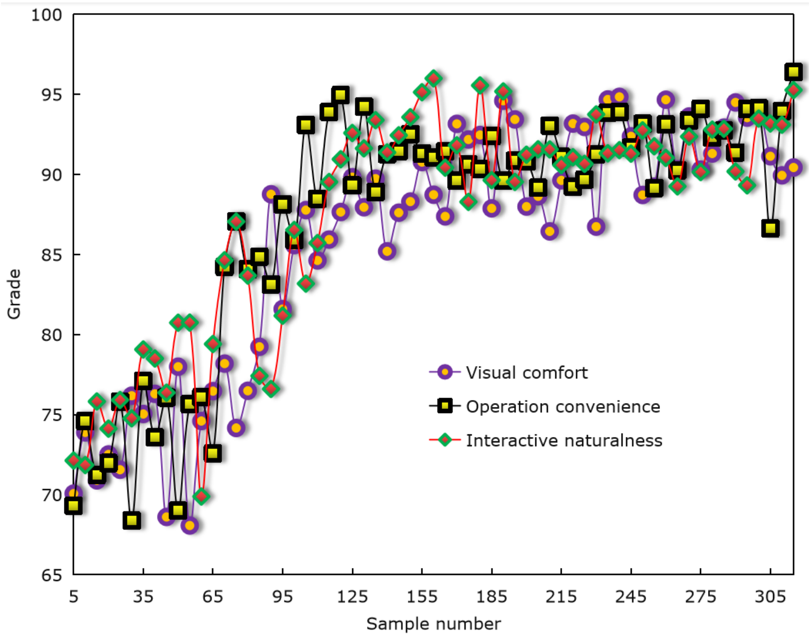

Figure 7: System interactivity score.

Visual comfort: Most subjects said that the visual effect of the VR display system is relatively comfortable, and there is no obvious dizziness, which is due to our emphasis on the balance between image rendering quality and visual comfort in system design. Convenient operation: the subjects generally think that the operation of the system is relatively simple and convenient, which benefits from our emphasis on user experience and optimization of operation process in system design. Interaction naturalness: Most subjects said that the interaction of the VR display system is natural and smooth, and it can simulate the interaction experience in the real world more truly, which is due to the advanced VR interaction technology adopted in the system design.

The feature detection method of ceramic image based on CNN is an effective solution, which can improve the classification accuracy and quality inspection accuracy of ceramic products, and provide strong support for 3D modeling and design effect optimization of ceramic products.

5 CONCLUSION

In the ceramic design scene, the accuracy of the ceramic CAD modeling method proposed in this article is improved by more than 17% compared with the traditional SVM algorithm. MAE comparative experiments also show that CNN algorithm has significant advantages in virtual scene information feature recognition. This shows that the VR image processing method proposed in this article has high accuracy and efficiency when dealing with complex and changeable ceramic design and virtual scene information. In the experiment of the constructed VR display system. The subjects generally think that the system has good visual comfort, convenient operation and natural interaction. To sum up, the ceramic CAD modeling method and VR display system proposed in this article have shown excellent performance in many experiments. Aiming at the complex and changeable tasks of ceramic design and virtual scene information processing, the proposed method has high accuracy and efficiency, and can meet the needs of practical application. In addition, the VR display system also shows excellent performance in interactive ability and user experience, which can provide useful reference for other related fields.

Although the ceramic CAD modeling method proposed in this article has shown excellent performance, we can still try to introduce new technologies or algorithms to further improve its performance and efficiency. At present, the VR display system is mainly aimed at the display of ceramic products. However, this technology can also be extended to other fields, such as architectural design and animation production.

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