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Computer-Aided Design AND APPLICATIONS

Optimization of Ceramic Design Integration With Visualization Instruction

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Abstract. In the traditional ceramic design process, designers usually need to spend a lot of time and effort on hand drawing, modification, and refinement, which is not only inefficient but also difficult to control every detail of the design accurately. The application of CAD technology enables designers to digitize their designs through computers, quickly generate accurate models, and greatly shorten the design cycle. Therefore, this paper constructs a ceramic design optimization model based on CAD technology; this article analyzes the quality of 3D animation using virtual technology and visual ceramic design methods. The visualization results of clustering analysis were constructed by analyzing the effectiveness of the model. calculate the contribution value of design elements, and effectively improve the smoothness and accuracy of ceramic design lines based on the results. Compared with other models, the model in this paper shows a higher optimization effect and stability. In addition, the results of the ceramic design satisfaction questionnaire show that the optimized ceramic design of this paper's model can be recognized by most people, and the degree of satisfaction is relatively high.

Keywords: CAD Technology; Ceramic Design; Design Optimization; Visualization Instruction
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1 INTRODUCTION

Ceramics, as a traditional craft material with a long history and unique skills, has developed and evolved over a long history and still occupies an irreplaceable and important position in modern design. It is a comprehensive field that covers several aspects, among which ceramic modeling design is an important part of ceramic art design, which involves several aspects such as the appearance, size, function, and practicality of the product. Bahraminasab [1] proposed and implemented a personalized tile design and manufacturing system for ceramic 3D printing. The user inputs a two-dimensional texture image through the system, and the system performs preprocessing operations such as denoising, grayscale, and grayscale clustering on the user's input image. Then, in order to solve the problem of large format printing, the system proposes to perform diversified segmentation operations on the preprocessed images, and users can choose diverse segmentation methods. The system directly generates corresponding geometric textures on the surface of ceramic tile models with selectable shape styles based on the G-code path level. In order to ensure the practicality and manufacturing friendliness of the system, the work proposed a lightweight design and local optimization for ceramic 3D printing. Simultaneously conducting single path planning and manufacturing adaptation, ensuring that the generated path meets printable constraints, the final output can be directly applied to ceramic 3D printing digital manufacturing. The system can generate batch-printed G-code series files to improve manufacturing efficiency. The system has designed and implemented the basic interaction interface, which enables two-dimensional visualization of input images and three-dimensional visualization of generated models and paths, facilitating user interaction and control. Designers in ceramic modelling design, need to take into account the requirements of the use of the product, the use of natural forms or the idea of linear, to create both practical and beautiful ceramic shapes. Baumer et al. [2] mainly provide a detailed introduction to personalized bone tissue engineering design and manufacturing for ceramic 3D printing. This article proposes a personalized bone tissue engineering and manufacturing system, which allows users to convert any input two-dimensional image into personalized bone tissue that can be 3D printed and manufactured. Based on the two-dimensional corresponding texture, the corresponding texture surface points are generated through diversified segmentation and sampling, followed by printability optimization for ceramic 3D printing, ultimately generating a single path. Generating textures at the G-code manufacturing level eliminates the need for intricate and complex 3D mesh structures and slice processing, thus meeting the requirements of interactive design and low spatial and temporal load. In addition, ceramic shape design, decorative design and colour design are interrelated and complementary. Styling design is the foundation, which determines the basic form and appearance of the product; the decorative design is to beautify the product and increase the beauty of the product through elements such as grain, pattern, pattern and so on; colour design makes the product more vivid and rich, and enhances the visual effect of the product.

China is a magnificent country with a long history and splendid civilization. The evolution of the times and the replacement of political power have to some extent promoted the continuous development of culture. Culture, as a comprehensive embodiment of a nation's humanistic spirit, is a symbol of a country's civilization. Ceramics, as a Chinese symbol, are outstanding in the development of Chinese culture and the most distinctive form of cultural expression. Cizhou Kiln and Yaozhou Kiln Ceramics are two major porcelain kilns in northern China that have formed their own systems, and both are now cultural heritage protection areas in China. However, with the rapid advancement of social modernization, traditional and single-text dissemination methods can no longer meet the needs of ceramic culture inheritance and market. In the rapidly developing modern society of information, based on the inherent artistic characteristics of ceramic culture, fully utilizing the means of dissemination relying on network technology is an effective way to better protect and promote traditional handicrafts and their national culture [3]. Design methods have gradually exposed their limitations. Limited by the precision and efficiency of handmade, traditional design methods often require a lot of time for ceramic modelling, patterns, glazes and other aspects of the effect, it is difficult to meet the modern market demand for personalization, diversification and efficiency. Tiles, originating from the intricate and diverse art of collage, are widely used in artistic home furnishings, architectural appearances, and other fields due to their beauty of artistic inspiration collision. Ceramic materials have unique physical properties and strength and have become one of the important materials in the fields of living decoration, architecture and aerospace, sparking exploration of ceramic tiling. In recent years, 3D printing has gained widespread development as a typical additive manufacturing technology. The precision and technology of 3D printing manufacturing are steadily improving, and the types and materials of manufacturing equipment are becoming increasingly diverse. The emergence and creative application of ceramic 3D printing-related technologies have also sparked new explorations in areas such as digital decoration and architectural art. Based on the advantages of customization and environmental friendliness of 3D printing, Feng et al. [4] empowered designers through computer-aided design. The tiles produced by ceramic 3D printing manufacturing can combine personalization and aesthetics.

Against this background, the introduction of CAD technology has revolutionized ceramic design. CAD technology has greatly improved the accuracy and efficiency of ceramic design with its precise and efficient features. Designers can quickly perform modelling, rendering and simulation through CAD software, and this reduces the cost of trial and error. Ceramic membranes are widely used in the pre-treatment process of reverse osmosis seawater desalination due to their excellent chemical stability, anti-microbial properties, and other characteristics. However, during its preparation and use, surface and internal defects often occur - incomplete ceramic membranes, which seriously affect their mechanical strength and material mechanical properties, thereby reducing the efficiency of seawater desalination and the service life of ceramic membranes. Therefore, how to achieve automated quality inspection of ceramic film products. Han et al. [5] aimed to achieve non-destructive testing of incomplete ceramic films and designed a system for non-destructive testing of incomplete ceramic films. At the same time, CAD technology also provides designers with a broader innovation space, which can help designers improve the smoothness and visual effect of ceramic modelling design, create more unique and novel ceramic works, and satisfy the market demand for personalization and differentiation. In computer graphics, textures include both surface colour textures and geometric textures that typically present patterns on the surface of an object. The 3D geometric texture is a complex and intricate geometric structure that is very common in real life. Its versatile visual effects and tactile experiences have attracted widespread attention and love from people. Therefore, as a means of enriching geometric patterns and details in the context of digital manufacturing, texture has been widely studied in various generation and manufacturing methods in recent years. Liu et al. [6] analyzed how CAD systems process input images and design multiple segmentation styles. Fine textured 3D structures, can be embedded into the surface of tiling tiles and generate a single path while meeting printability requirements. The ultimate integration of design and manufacturing can be achieved, and the output path files can be directly manufactured through 3D printing technology. At present, many excellent works have emerged in the fields of ceramic 3D printing and texture 3D printing. In addition, the combination of CAD technology and visualization teaching is more helpful in promoting the inheritance and development of ceramic design. Visualization teaching can use modern technology to present the complex ceramic design process to students intuitively, helping them to better understand and master design skills and methods. Starting from the requirement of non-destructive testing for incomplete ceramic films, Lv et al. [7] designed a hardware system for incomplete ceramic film testing that integrates ultrasound and machine vision, based on the research of current surface and internal defect detection technologies for ceramic films, combined with the characteristics of machine vision and ultrasonic detection technology. The system uses an EinScan-SE scanner and Phascan phased array platform to obtain surface images and internal data of incomplete ceramic films, respectively. Surface images can be used for the classification and characterization of surface defects in incomplete ceramic films based on machine vision. Internal data can be used for three-dimensional reconstruction and visualization analysis of internal defects in incomplete ceramic films based on ultrasonic testing. At the same time, through practical operational training, students can gain a deeper understanding of the application of CAD technology in ceramic design and improve their practical ability and innovative thinking.

Based on this paper combined CAD technology to build a ceramic design optimization model, using parametric design and morphological semantics to improve the visual effect of ceramic design, according to the parameter optimization to achieve the optimal purpose of obtaining shape design. This paper also combines CAD technology and VR technology to build a ceramic design visualization teaching system, in the teaching process can be achieved through three-dimensional animation technology and VR technology to three-dimensional ceramic modeling design display, enriching the teaching content and improving students' level of practical operation.

2 RELATED WORK

Tiles made through ceramic 3D printing technology have significant advantages in personalization, design diversity, standardization, and controllability. However, geometric textures are complex geometric structures, and generating textures using traditional modelling methods requires some design and modelling experience. If you want to express detailed 3D textures well, you need a fine mesh structure, which requires a lot of computation. At the same time, the requirements for storage space are also relatively high. Moreover, slicing the texture generated by modelling incurs significant time and storage overhead, and also requires high hardware requirements. Based on the material properties of ceramics themselves, it is still difficult to add support when printing complex geometric structures on ceramics, which poses higher requirements for manufacturing. In addition, ceramic 3D printing requires high requirements for printing paths. How to generate a single printing path and avoid the loss of printing accuracy caused by multiple printer movements is also a problem that needs to be solved. At the same time, in order to meet the practical application of ceramic tiles, it is necessary to solve problems such as lightweight design and manufacturing matching [8].

To achieve three-dimensional visualization and evaluation of internal defects in incomplete ceramic films, Mühlemann et al. [9] proposed a three-dimensional reconstruction method for internal defects in ceramic films that integrates triangular matrix synthetic aperture focusing. It obtained ceramic film ultrasound imaging based on the fusion triangle matrix synthetic aperture focusing algorithm, preprocessed the B-scan images and reconstructed them based on defect contours in 3D. This can achieve three-dimensional visualization of internal defects in ceramic films. This imaging algorithm reduces the amount of data acquisition and computation by nearly half, effectively improving detection efficiency. At the same time, it retains the high imaging resolution feature of the synthetic aperture focusing algorithm. Results show that the diameter measurement error range of internal hole-type defects is between 2.0% and 3.0%, and the diameter and length measurement errors of crack defects are between 2.0% and 4.0%. Reducing testing errors caused by subjective assumptions and fatigue of inspectors, and improving the drawbacks of existing incomplete ceramic film testing methods, has become an urgent task. Machine vision is crucial for detecting surface defects such as defects, debris, and dents in products to ensure their functionality and performance. It has been widely used in product defect detection and size detection in various industries. Pasco et al. [10] used machine vision to detect surface defects on ceramic films, and machine vision detection detected the surface of ceramic films through the following methods. Obtain surface images of ceramic films, process the images and obtain defect feature parameters to define the types of surface defects of ceramic films, and then obtain the characteristics of ceramics. The core user group of personalized design and manufacturing systems for ceramic 3D printing is pursuing artistic design. Users can import images with textures to be generated through a concise interactive interface and see the grayscale results of the imported images in the image visualization window. The system performs certain image processing and optimization on input texture images. Next, the user selects the desired segmentation method and inputs or selects the parameters of the ceramic 3D printer and generates relevant parameters for personalized tiling models in the interactive interface. Subsequently, the system maps the input to three-dimensional space and generates a geometric texture plane with texture protrusions. Then, construct the printing path points for each layer of the texture surface, and perform smoothing and local optimization of printable constraints on them [11].

Due to the characteristics of ceramic 3D printing materials that are prone to collapse, strict constraints such as self-supporting and single paths need to be met in the actual manufacturing process. Therefore, in the process of generating 3D textures based on certain mapping rules, a collapse detection algorithm is used to detect the printability of the 3D geometric textures generated by the input texture transformation, and local optimization is carried out on the areas prone to collapse to meet the printability requirements. Based on the characteristics of ceramic materials and 3D printing-related constraints, path optimization is carried out to generate a tile printing path that satisfies both manufacturing constraints and a single path, thereby improving the success rate of manufacturing. In order to ensure the practicality and manufacturing friendliness of the system, Sheikh et al. [12] added a manufacturing adaptation module to the system and added a patch number to the local area of the tile. Design a lightweight path for tiling and add corresponding support to increase the strength of the tiling. At the same time, the system can generate batch-printed G-code series files to improve manufacturing efficiency. Wu et al. [13] designed a visual detection system for incomplete ceramic films using BIM and parametric design. To characterize and classify the surface defects and internal defects of ceramic films through 3D reconstruction and defect visualization analysis. The hardware design mainly achieves the acquisition of surface images of ceramic films and cross-sectional images of ceramic films, as well as the probe driving during the process of cross-sectional image acquisition of ceramic films. The software design requires a reasonable structure, complete functionality, and the ability to characterize and classify surface defects of ceramic films, as well as perform three-dimensional reconstruction and visual analysis of internal defects in ceramic films.

Virtual reality technology provides strong support for the 3D modelling of ceramics with its unique immersive experience. Artists can use professional VR devices and software to construct intricate ceramic models in virtual spaces. Compared with traditional manual modelling, virtual reality technology has higher accuracy and efficiency, which can greatly shorten the modelling cycle and reduce production costs. In addition, virtual reality technology allows artists to make real-time adjustments and modifications during the modelling process. Wu and Song [14] freely rotate, scale, and move the model in a virtual environment, observing its shape and structure from various angles. This real-time feedback mechanism enables artists to promptly identify and correct design issues, ensuring the perfect presentation of the final work. Yang et al. [15] explored the fusion of machine learning models to predict the colour and corresponding minimum thickness of CAD-CAM ceramics in different clinical contexts. CAD-CAM technology provides the possibility for customized design of ceramic materials. Through precise digital modelling and manufacturing, ceramic restorations that meet the personalized needs of patients can be produced. However, the colour, shape, and clinical needs of teeth vary among different patients, which requires us to accurately predict and control the colour and thickness of ceramics in the design and manufacturing process. Machine learning is a powerful data analysis tool that can extract useful information and patterns from a large amount of data. In the field of ceramic design, we can use machine learning models to analyze patient clinical data, tooth images, and physical properties of ceramic materials, in order to predict the optimal ceramic colour and thickness.

In the field of teaching, the introduction of visual teaching methods has also brought about revolutionary changes in ceramic design education displaying the design process and effects. In contrast, the visual teaching method digitizes and visualizes the design process through CAD technology, enabling students to have a more intuitive understanding of every step and detail of the design. For example, in ceramic design courses, teachers can use CAD software to showcase the entire process of ceramic design, including the conceptualization of forms, material selection, and process production. Meanwhile, students can also use CAD software for practical operations, by manually adjusting parameters and simulating the production process, to gain a deeper understanding of the principles and techniques of ceramic design. They also organize students to participate in CAD design competitions and practical activities, enabling them to master the operational skills and design thinking of CAD technology in practice. This teaching method not only stimulates students' interest and creativity in learning but also improves their practical and problem-solving abilities.

In other fields, there are also some studies that focus on the application of CAD technology in ceramic art creation. Artists use CAD technology to design unique ceramic art shapes and create physical models through 3D printing technology. This technology provides artists with broader creative space and more precise production methods. Designers also use CAD technology to create 3-D renderings and product animations, allowing customers to improve their market competitiveness.

3 OPTIMIZATION MODEL

3.1 Optimization Model Construction

Ceramic modeling design is a combination of contemporary aesthetic elements of designers to show the specific carrier of self-aesthetic; ceramic modeling of every line, every pattern, and color are designers of the interpretation of beauty. Traditional ceramic design is based on the designer's experience and technology in the process of continuous practice to achieve the final result slowly.

Many traditional processes inherently have a high degree of complexity, such as the ceramic hollowing process requires the designer to carve the desired pattern on the ceramic embryo, and then after firing to see the final design effect. This process is not only long and low yield, designers need to repeat the production process in order to finally get the ceramic works in line with the design effect. Parametric ceramic modelling design is the combination of parametric modelling and ceramic design, through the adjustment of parameters to more accurately control the shape, structure and texture of ceramics, so as to create a rich variety of ceramic works. Designers can quickly generate a variety of design options by adjusting the parameters and optimizing the selection, thus greatly improving design efficiency. In addition, the combination of parametric design and morphological semantics can transform the designer's abstracted styling design concepts into operable design results. As shown in Figure 1, the optimization flow chart of ceramic modelling design is based on parametric design and morphology semantics.

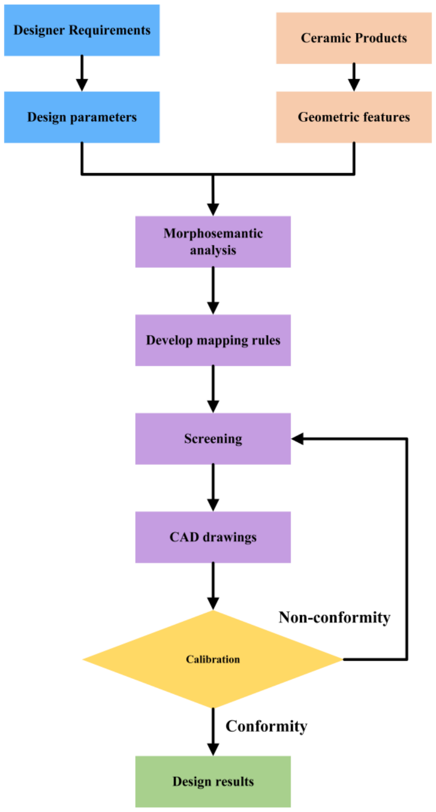

Figure 1: Flow chart of ceramic shape design optimization based on parametric design and morphological semantics.

Algorithmic generation of parametric design is essentially the power of algorithms to realize the simulation of ceramic art modelling on biomorphic forms or the self-generation of ceramics. At the level of design principles, algorithmic design mainly relies on the core principles of computer graphics, using computer program technology to solve specific design problems or generate visual images based on data. In practice, algorithmic design and parametric design often complement each other and work together. For example, random generation algorithms, topology optimization algorithms, genetic algorithms, etc. These mature algorithmic designs play a key role in parametric ceramic modelling design, helping designers to more accurately and efficiently realize creative ideas. Comprehensive consideration of practical needs, this paper chooses to use genetic algorithms for ceramic design optimization, as shown in Figure 2 for the process of optimizing ceramic parameters by genetic algorithms.

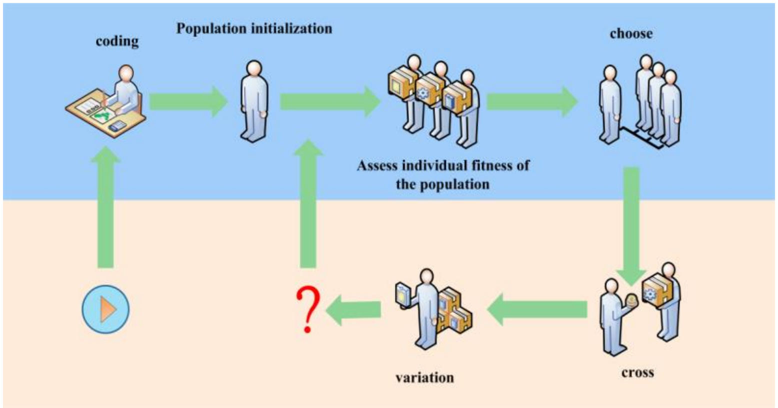

Figure 2: Genetic algorithm optimization process of ceramic parameters.

From the figure, it can be seen that the GA algorithm can complete the optimization of ceramic design parameters through six steps:

The first step is to encode the entire sample data, i.e., to record the individual characteristics possessed by different populations while transforming them into objects that can be recognized and manipulated by the GA algorithm.

The second is to initialize the weights, bias values, etc., contained in the population individuals, as well as to customize the population size.

The third is to assess the individual fitness of the population as shown in equation (1):

$$F = a[\sum_{m=1}^{M} abs(y_m - o_m)] \tag{1}$$

Where individual fitness is denoted as F, individual output value is denoted as y_m, ideal output value is denoted as o_m, a denotes the parameter and M denotes the number of outputs.

The fourth is individual random search by roulette selection method as shown in Eqs. (2) and (3):

$$f_m = k/F_m \tag{2}$$

$$p_m = \frac{f_m}{\sum_{m=1}^{M} f_m} \tag{3}$$

From the formula, it can be seen that the relationship between f_m and individual adaptation value F_m is a negative correlation; the relationship between f_m and individual selection probability p_m is a positive correlation.

The fifth is to introduce the best individuals from other populations into the new population so that they can cross each other and thus obtain better genes, as shown in equations (4) and (5):

$$y_{kn} = y_{kn}(1-b) + y_{\ln}b \tag{4}$$

$$y_{\ln} = y_{\ln}(1-b) + y_{kn}b \tag{5}$$

Where y_{kn} and $y_{\ln}$ denote individual superior genes and b is the parameter.

Finally, there is mutation, i.e., genetic variation that occurs in the evolution of organisms, as shown in equations (6) and (7)

$$y_{mn} = \begin{cases} y_{mn} + (y_{mn} - y_{\max}) \times f(g) & r > 0.5 \\ y_{mn} + (y_{\min} - y_{mn}) \times f(g) & r \leq 0.5 \end{cases} \tag{6}$$

$$f(g) = r(1 - g/G_{\max})^2 \tag{7}$$

Where r denotes a random number between 0 and 1, g denotes the current iteration number and $G_{\max}$ denotes the maximum iteration number.

Morphological semantics in ceramic design refers to the symbolic nature of ceramic product modelling in the context of use. This covers the physical and physiological functions of ceramic products, as well as psychological, social, and cultural meanings. Specifically, morphology, as the entity of design conception, is the medium of the visual language of ceramic products, which conveys the spiritual connotation of the product with its unique language form. In this paper, the words related to ceramic form design elements are sorted out by clustering algorithm and combined with GA-optimized parameters to realize the clustering analysis of ceramic modelling form semantics, as shown in Figure 3. The figure shows the spatial distribution map of ceramic design semantics clustering analysis, from which we can directly understand the correlation between different semantics, as well as the average score of each semantics itself in the whole semantic group clustering analysis, to help the designer better understand the value and importance of the semantics of the design elements in the whole design, so as to eliminate the redundant elements.

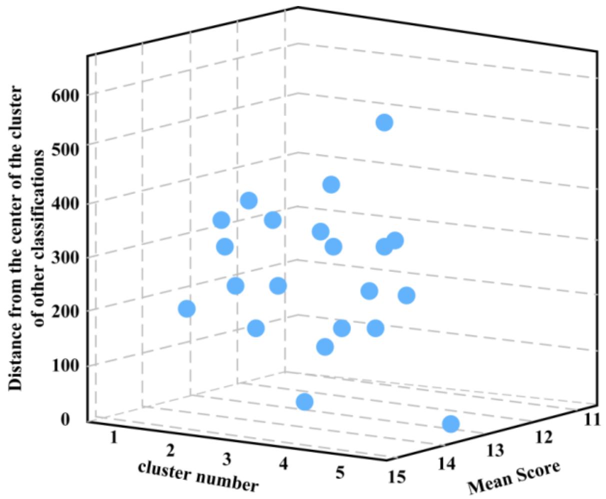

Figure 3: Spatial distribution map for semantic cluster analysis of ceramic design.

Based on the above analysis, it can be further constructed between the morphological semantics and ceramic modelling elements correlation model, set ceramic design elements qualitative variables recorded as X, perceptual evaluation of the value of the variable as Y, the number of design elements recorded as n, the sequence number of i design elements belonging to the category is expressed as P_i, the design of the number of sequences of h in the category of the sequence number of j samples of the corresponding response is expressed as $\lambda_j(i,h)$, as shown in (8):

$$X = \{\lambda_j(i,h)\} \tag{8}$$

In the formula, $j = 1,2,\ldots,m, i = 1,2,\ldots,n, h = 1,2,\ldots,p_i$.

If there is a linear relationship between the responses between Y and the different categories in the design elements, it is shown in (9):

$$y_j = \sum_{i=1}^{n}\sum_{h=1}^{p_i}\beta_{ih}\lambda_j(i,h) + \varepsilon_j \tag{9}$$

where the category coefficients of the design elements with sequence number i ordered as h are denoted as β_{ih} and the random errors are denoted as ε_j .

The degree of correlation between the design elements and perceptual evaluation can be obtained through the bias relationship coefficient to determine the contribution of the design elements, as shown in equation (10):

$$R_{yi} = \frac{-\beta_{iy}}{\sqrt{\beta_{ii}\beta_{yy}}} \tag{10}$$

Afterward, the quadratic curve rate entropy is used to realize the reconstruction optimization of the ceramic design curve, and the fixed points in the ceramic design are set to be denoted as G_1, G_2 respectively, and the points that can be regulated are labelled as $T_1 \sim T_7$ sequentially, and the radius of movement is defined as shown in (11), taking into consideration of the cross-over phenomenon that may occur in the process of the movement of the regulated points and the issue of the effect is not obvious:

$$\frac{1}{8}\min\{\overrightarrow{T_{l-1}T_l}, \overrightarrow{T_lT_{l+1}}\} \le R_i \le \frac{1}{2}\min\{\overrightarrow{T_{l-1}T_l}, \overrightarrow{T_lT_{l+1}}\} \tag{11}$$

Among others, $i = 2,3,\ldots,6$.

The weight factor of the NURBS curve is set to 1, then the curve interpolation formula is shown in (12):

$$p(u) = \sum_{i=0}^{m} k_i N_{i,3}(u) = \sum_{i=j-3}^{j} k_i N_{i,3}(u) \tag{12}$$

where $u \in [u_3, u_{n+1}], i = 3,4,\ldots,n+1$ the control vertex is denoted as k_i and the node vector is described as $U = [u_0, u_1, \ldots, u_n, u_{n+4}]$. The quadratic curvilinear rate entropy for the ceramic design curve reconstruction optimization process is shown in Figure 4.

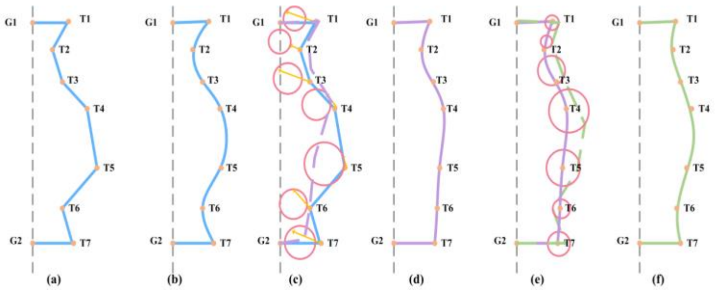

Figure 4: Quadratic curvilinear rate entropy on ceramic design curve reconstruction optimization process.

3.2 Three-Dimensional Animation Ceramic Design

Virtual reality technology provides new dimensions and possibilities for modelling animation scenes. In the process of modelling animation scenes based on virtual reality technology, we first focus on the virtual coordinates of the nodes in the 3D animation scene. These coordinates form the basic skeleton of the animation scene, providing accurate spatial positioning information for subsequent image generation. Through the application of virtual reality technology, we can accurately obtain the average value of each pixel in 3D animated images. This step is crucial as it ensures that the generated image achieves a high degree of realism and accuracy in terms of colour, brightness, and other aspects. By calculating the average value of these pixels, we can obtain the corresponding pixel data and form a complete image.

$$I(x,y) = avg\sum_{b}\alpha(m,h) \tag{13}$$

where the domain range of the image in the 3D animated scene is denoted as avg , and b is denoted as the image linear distortion parameter.

$\alpha(m,h)$ is the centre pixel of the animation scene.

Afterwards, on the basis of 3D animation geometric information and virtual reality technology node coordinate positions, the scene image point set is comprehensively searched to find the optimal transformation relationship between the point sets, and the corresponding depth information is obtained, as shown in Equation (14):

$$f = \frac{1}{N}\sum_{m} j\left\| y_m - (r+t) \right\| \tag{14}$$

The 3D animation modelling coordinates and world coordinate transformations are shown in Equation (15):

$$D = AX + BY + CZ \tag{15}$$

$$V = e_1 e_2 - \varepsilon e_1^2 \tag{16}$$

When constructing a source image fusion model for 3D animation scenes, we fully utilize the characteristics of the white highlight parameter. By finely fusing, matching, and recombining these parameters, we can establish an accurate and effective fusion model. The core of this model lies in its fusion error function, as shown in equation (15). In this function, both the white highlight parameter and the fusion error function are clearly represented, which together determine the quality and effectiveness of image fusion.

$$L = \nu - \nu_r \tag{17}$$

In order to further improve the realism and detail representation of animation scenes, we adopted the root mean square error estimation method and constructed a random probability distribution model for 3D animation scenes. This model combines the information entropy estimation method, which can more accurately describe the distribution and relationship of elements in the scene. Through this model, we get the joint probability density distribution result of the grey similarity feature distribution, as shown in Formula (16).

$$k^p(\lambda) = (\sum_{d=1}^{N} a_d^p)(\sum_{d=1}^{N} a_d^{p+1}) \tag{18}$$

These parameters include the total amount of 3D animation generated, the actual number of times generated, the random probability generated, and the joint probability density. They together form the foundation for constructing our virtual reality reconstruction model, enabling us to simulate and reconstruct animation scenes more accurately.

4 EXPERIMENTAL RESULTS

The ceramic design process has a large amount of parametric data, in order to verify the application effect of the ceramic design optimization model based on CAD technology, this paper randomly selected a kind of ceramic bottle modelling design design design experiment, the experiment is a randomly selected teaching class in the seven students to complete their own ceramic bottle design through the three-dimensional animation ceramic design system based on virtual reality technology, two of them will be through the model optimization based on parametric design and morphological semantics of the ceramic shape design optimization model. optimization model of ceramic shape design based on parametric design and morphological semantics for model optimization.

The first is to classify the data and information related to the design of ceramic bottles, this part of the experiment in this paper uses the visualization of classification results for model performance comparison, the results are shown in Figure 5. The results in the figure show that before the classification of data and information, there is an obvious cross range between the data after simple processing, i.e., the classification is not clear, and there is a certain range of overlapping data problems. After processing according to the morphological semantics and genetic algorithm, the data classification effect is obvious, which effectively reduces the complexity of data selection and processing of the model afterward, and improves the accuracy of the morphological description of the ceramic bottle design.

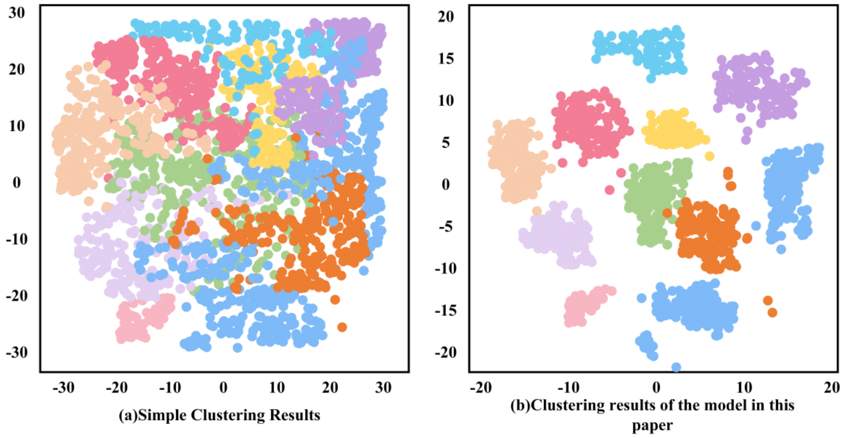

Figure 5: Visualization effect of categorization of data information related to the ceramic bottle design.

Based on the above data classification results for ceramic bottle design elements bias correlation coefficient calculation, that is, to determine the design elements of their respective contribution to the perceptual evaluation, to further optimize the design, the results are shown in Figure 6. In order to aspect the description in the application, this paper will ceramic bottle design elements were numbered labelling, in order of the bottle mouth, bottleneck, bottle shoulder, bottle belly and bottle foot. Calculation results show that the contribution of the bottleneck element is the highest among all elements, followed by the bottleneck foot. This indicates that the design of the neck and foot of the bottle is most capable of influencing its popularity in the market. Meanwhile, in the perceptual evaluation, the morphosyntax of the bottleneck is expressed as delicate-brutal, while the morphosyntax of the bottle foot is expressed as complex-simple. This indicates that the model can give the corresponding design direction suggestions for the corresponding ceramic design parts based on the results of the partial correlation coefficient calculation, which improves the aesthetics and efficiency of the design, and better meets the market and consumer needs.

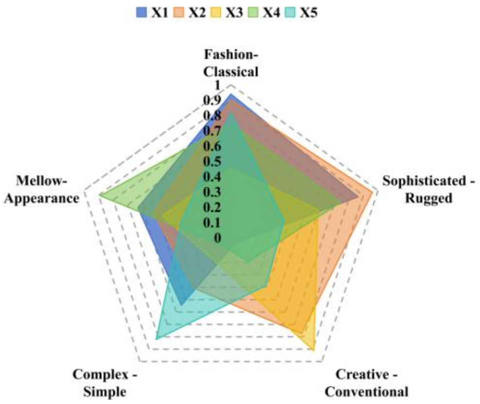

Figure 6: Calculation results of bias correlation coefficient of ceramic bottle design elements.

In order to verify the optimization performance of the models in this paper in ceramic design, three additional ceramic design optimization models were selected for comparison, and the results are shown in Figure 7. Figure 7(a) shows the curvature distribution of the contour line before the optimization of the ceramic bottle design, and the results after the optimization of the four models are (b)-(e), respectively. The results show that, although the smooth splicing algorithm in (b) effectively improves the local smooth rows of ceramic bottle contour curves, there are curvature anomalies, and there is a high degree of computational complexity, with a relatively narrow range of adaptation. (c) The overall optimization effect of the improved B-spline curve reconstruction algorithm in (c) is not good, and the curve rate after optimization has more fluctuation areas and lower line smoothness. (d) The wavelet framework reconstruction algorithm reduces the influence of noise data and improves the detailed effect of ceramic bottle line contour design. However, there are more fluctuations in the overall curve rate distribution, and a large number of data points need to be added in order to improve the effect of detail processing, and the reconstruction effect is not ideal. (e) in this paper, after the model optimization of the ceramic bottle line contour curvature change fluctuation is small, showing good smoothness, effectively improving the ceramic bottle design effect.

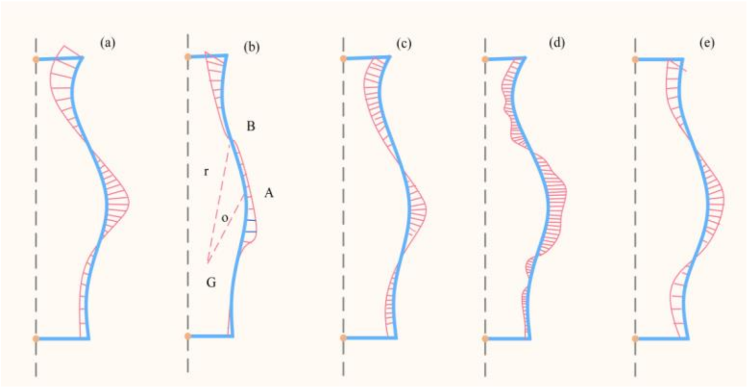

Figure 7: Four kinds of ceramic bottle design optimization model contour line optimization results.

As shown in Figure 8 for the final ceramic bottle design satisfaction questionnaire results for seven students, questionnaire satisfaction participants for other students in the class, in order to ensure the fairness and effectiveness of the questionnaire, but also invited another class of students for ceramic bottle design satisfaction questionnaire. The results show that among the seven ceramic bottle designs, the ceramic bottles optimized by the model in this paper received satisfaction scores ranked 1 and 3. This shows that the model-optimized ceramic bottles are recognized by most students and have a high level of satisfaction, which proves the validity and reliability of the model optimization performance.

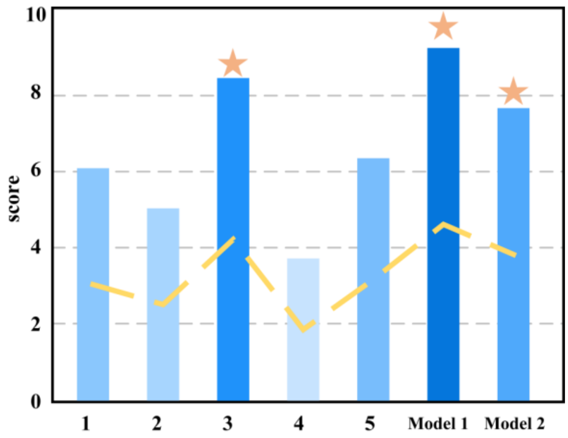

Figure 8: Ceramic bottle design satisfaction questionnaire results.

5 CONCLUSIONS

Based on the characteristics and problems of traditional ceramic design, this paper proposes research on the optimization of ceramic design based on CAD technology and its integration with visualization teaching and constructs a ceramic design optimization model by combining the genetic algorithm and morphological semantics in the parametric model. The experimental results show that the model can effectively classify the data related to ceramic design elements and calculate the corresponding contribution value of the elements, screen out the design elements and design directions that are more effective, more reasonable and more in line with the market demand, and improve the design efficiency. At the same time, the optimization comparison experiment results show that the model optimization effect of this paper is more, can effectively improve the smoothness of the ceramic bottle curve, and improve the reconstruction effect. Ceramic bottle design satisfaction questionnaire results show that this paper's model optimization of ceramic bottle design can get more people's recognition and higher satisfaction. Although the model optimization effect of this paper is better, there are still many problems that need to be further improved and perfected in the subsequent research should improve the model of ceramic pattern, color, and other aspects of feature extraction performance to achieve the optimization of pattern design and color matching.

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