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Modeling Design of Daily-use Ceramics Based on Multimedia Interactive Technology

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Abstract. To overcome the constraints inherent in traditional methods of designing everyday ceramics, this article proposes a novel approach utilizing 3D modeling grounded in Back Propagation Neural Networks (BPNN). Integrated with multimedia interactive technology, this methodology aims to elevate design efficiency, enhance user engagement, and bolster product competitiveness in the market. After thoroughly examining the perks of multimedia interactivity and aligning them with the practical necessities of ceramic design, a comprehensive 3D modeling framework rooted in BPNN is established. This innovative framework can produce ceramic shapes aligned with precise design specifications, all while facilitating seamless real-time interactions between users and the design tools via a multimedia-based interface. Simulations reveal that our BPNN-powered 3D modeling for daily-use ceramics consistently generates an array of shapes with precision and speed, all the while fostering a superior interactive experience for designers. In addition, compared with the machine learning design method, this method has obvious advantages in design efficiency, user participation, and innovation. The research in this article provides new ideas and methods for daily-use ceramic modeling design, which helps promote the innovation, development, transformation, and upgrading of the ceramic industry.

Keywords: Multimedia Interactive Technology; Household Ceramics; Modeling Design; Back Propagation Neural Network
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1 INTRODUCTION

Multimedia interaction technology refers to the technology of integrating and processing text, image, audio, video, and other media information through computer, network, communication, and other technical means to realize human-computer interaction. Traditional ceramic product defect detection methods often rely on manual visual inspection, which is not only inefficient but also susceptible to human factors, making it difficult to ensure consistency and accuracy in the detection. Therefore, Benbarad et al. [1] developed an intelligent vision model based on machine learning to detect defects in ceramic products automatically. The intelligent visual model for defect detection of ceramic products based on machine learning mainly utilizes computer vision technology and machine learning algorithms to automatically analyze and process images of ceramic products, thereby achieving accurate detection of product defects. This model learns the features and patterns of different defects by training a large amount of ceramic product image data. Then, in practical applications, real-time analysis of new product images is used to determine whether there are defects and provide corresponding detection results. It has the characteristics of diverse information forms, strong interactivity, and good real-time performance. In the process of designing ceramic molecular products, the uncertainty of material properties often poses challenges for designers. This uncertainty may arise from small differences in raw materials, variables during the processing, or fluctuations in environmental conditions. To address these uncertainties, Frutiger et al. [2] combined Monte Carlo methods to provide an effective optimization strategy for the process design analysis of ceramic molecular products. Computer-aided design technology plays a crucial role in the process design of ceramic molecular products. Through precise modeling and simulation, CAD technology can predict the performance of products under different process parameters. However, when there is uncertainty in material properties, a single simulation result often fails to accurately reflect the actual situation. At this point, the application of Monte Carlo methods becomes particularly important. It simulates uncertain factors through a large number of random samples and estimates the probability distribution of the target variable based on this. In the process design of ceramic molecular products, we can use Monte Carlo methods to simulate fluctuations in material properties and evaluate and optimize process design based on these simulation results. Through multimedia interactive technology, users can interact with computers more intuitively and conveniently, and obtain the required information and services. As an important component of the middle school art curriculum, traditional teaching methods of pottery making are often limited by factors such as materials, tools, and time, making it difficult to fully unleash students' creativity and learning participation. The ceramic production method based on virtual reality provides a new learning platform for middle school students, which has a positive impact on their creativity and learning engagement. In a virtual environment, Guan et al. [3] freely explored various ceramic materials and tools, trying different creative ideas and techniques. This unconstrained creative environment helps stimulate students' imagination and innovative thinking, enabling them to create more unique and creative works. At the same time, virtual reality technology can also provide real-time feedback and modification functions, allowing students to continuously adjust and improve their work during the creative process, further enhancing their creativity level.

As science and technology rapidly evolve, multimedia interactive technology has become increasingly prevalent in all facets of daily life, presenting fresh opportunities for the advancement of traditional industries. The combination of multimedia interaction technology and virtual reality (VR) technology has brought unprecedented changes to the field of ceramic production. The integration of this technology not only makes ceramic production more convenient and efficient but also provides a new interactive experience for creators and experiences. In the field of ceramic production, virtual reality technology can simulate the entire process of ceramic production, from the selection of raw materials, and design concepts, to various stages such as molding and firing, all of which can be simulated and experienced in a virtual environment. Through virtual reality technology, Hanssen [4] freely created in virtual space, without being limited by physical space. It can freely adjust the shape, size, color, and other properties of ceramics, and view the creative effect in real time. This creative approach not only improves creative efficiency but also reduces production costs, allowing more creators to participate in ceramic production. Daily-use ceramics, practical and often adorned with cultural and artistic significance, are ceramic items frequently utilized in our day-to-day routines. When multimedia interaction technology is integrated with ceramic material perspective technology, a new application scenario has emerged. Hill et al. [5] explored the perspective technology of ceramic materials in 5G wireless communication systems based on multimedia interaction technology. By utilizing the high-speed data transmission capability of 5G wireless communication systems, perspective images of ceramic materials can be transmitted in real time to remote terminal devices. At the same time, by combining multimedia interaction technology, users can zoom in, out, rotate, and other operations on perspective images on terminal devices, in order to observe the internal structure and defects of ceramic materials more clearly. These encompass a diverse range of products, including tableware, tea sets, coffee sets, wine sets, and sanitary ware, each with a myriad of shapes and specifications catering to various settings and uses. While the design of these ceramics has garnered significant attention, traditional design techniques often encounter limitations imposed by manual skills and material constraints, struggling to align with the diverse aesthetic and functional preferences of contemporary consumers. The daily art creation and design laboratory is gradually moving towards a brand new era. Machine learning not only provides powerful tools for artists and designers but also to some extent changes our understanding of art and design. Traditional daily art forms and design processes often rely on the designer's intuition and experience. Although this method can produce excellent work in some cases, it also has certain limitations. The thinking of designers may be constrained by personal experiences, cultural backgrounds, and trends of the times, making it difficult to break through inherent frameworks. Machine learning technology, on the other hand, can discover patterns and trends that are difficult for humans to perceive by analyzing large amounts of data and patterns, thereby providing designers with new creative inspiration [6].

Against this backdrop, our study aims to delve into the integration of multimedia interactive technology in the design process of daily-use ceramics. Our objective is to enhance both the design quality and market competitiveness of these products through innovative methodologies. Central to our research is an analysis of multimedia interactive technology's unique characteristics and its potential to revolutionize the design of daily-use ceramics. Furthermore, we aim to explore a design approach centered on multimedia interactivity and introduce a 3D modeling technique for daily-use ceramics, grounded in BPNN. The efficacy of this proposed method will be rigorously tested through simulation experiments.

The advancements are predominantly showcased in several ways: (1) Utilizing BPNN for the 3D modeling of everyday ceramics, thereby enhancing and refining conventional modeling techniques; integrating multimedia interactivity with classic ceramic craftsmanship to fashion daily ceramic items that embody contemporary scientific, technological, and aesthetic sensibilities; validating the proposed approach's efficacy and viability through simulation experiments and case studies.

Initially, this research examines the pertinent theories and progress related to multimedia interactive technology and daily ceramic design. Subsequently, it delves into the prospective uses and implementation patterns of multimedia interactivity within this design sphere. Lastly, experimental validation confirms the practicality and efficiency of the BPNN-based 3D modeling technique for daily ceramics.

2 RELATED WORK

The rapid ceramic industrial product design method based on a 3D CAD system not only improves design efficiency but also provides strong technical support for product innovation. Liu [7] discussed the rapid ceramic industrial product design method and its application based on a 3D CAD system. The 3D CAD system, with its powerful 3D modeling, analysis, and simulation functions, has brought many advantages to the design of ceramic industry products. Firstly, it can achieve precise modeling of products, visually displaying the appearance and structure of products through 3D models, which helps designers better understand and optimize design solutions. Secondly, 3D CAD systems can perform rapid modifications and iterations, allowing designers to quickly adjust model parameters according to requirements and view modification effects in real time, greatly shortening the design cycle. In addition, 3D CAD systems can also perform collision detection, mechanical analysis, etc., helping designers predict and solve potential problems, and improving product reliability. Liu and Yang [8] utilized Kansei engineering and virtual reality (VR) technology to study product form design. Through VR technology, designers can construct highly realistic virtual scenes, allowing users to experience various aspects of product form, materials, interaction, etc. This immersive experience helps designers more accurately capture user emotional responses, identify potential design issues, and make timely adjustments and optimizations. Combining Kansei engineering with virtual reality technology can further improve the quality and efficiency of product form design. Firstly, by collecting emotional data from users through VR technology, designers can gain a more comprehensive understanding of their expectations and preferences for product form. In the field of ceramic art, the design and production of molds is a crucial link. Traditional mold perception methods are often limited by physical entities, making it difficult for designers to understand the characteristics of molds. With the help of these tools and applications, Marín et al. [9] significantly improved their perception of ceramic molds, thereby enhancing the effectiveness of design and production. Augmented reality technology provides users with a richer and more intuitive perceptual experience by overlaying virtual information in the real world. Augmented reality technology can play a huge role in the perception of ceramic molds. Designers can use AR devices, such as AR glasses or AR helmets, to cover virtual ceramic molds in a real environment, enabling 3D observation, rotation, scaling, and other operations on the molds. This perception method not only breaks through the limitations of physical entities, but also enables designers to observe molds from multiple angles and all directions, discover potential design problems, and optimize space.

The application of multimedia interaction technology and virtual reality technology in the field of cultural heritage protection is becoming increasingly widespread. As a treasure of Chinese culture, the restoration and protection of ancient ceramics are particularly important. The virtual reality technology for ancient ceramic restoration based on multimedia interaction technology provides new possibilities and ideas for ceramic restoration. Ming et al. [10] reviewed the system composition, application advantages, challenges, and development trends of this technology. By using high-definition cameras, 3D scanners, and other devices, precise data collection is carried out on ancient ceramics. Subsequently, computer graphics technology was used to process the collected data and generate a highly realistic virtual ceramic model. Based on the processed data, construct a virtual repair environment that is highly consistent with the real environment. This environment can simulate the entire process of ceramic restoration, including fragment splicing, color restoration, texture restoration, etc. By designing an intuitive and user-friendly interface, users can easily interact with the virtual repair environment. Users can perform repair operations on virtual ceramics through gesture recognition, voice control, and other methods. High-quality product design not only affects the appearance and performance of the product but also directly affects the market competitiveness of the product. High-quality product design based on computer-aided design is of great significance for improving product quality, meeting consumer needs, and promoting industrial development. Saleh et al. [11] used CAD systems to gain a deeper understanding of consumer preferences and needs, thus fully considering these factors in product design. Designers can optimize the human-computer interaction design of products by simulating user behavior and usage scenarios. Predict product performance through simulation analysis to ensure that the product meets consumer expectations. This consumer-centered design concept helps to improve the user experience and satisfaction of the product.

In the field of ceramic art, the introduction of 3D shape segmentation technology not only improves production efficiency but also provides designers with richer creative means. Shi et al. [12] explore how to use deep convolutional neural networks (DCNN) to achieve automatic 3D ceramic shape segmentation and analyze its advantages and challenges. A deep convolutional neural network is a special neural network structure that extracts features from input data through convolutional layers, pooling layers, and other structures, thereby completing tasks such as classification and recognition. In 3D modeling segmentation, DCNN can effectively extract spatial features of 3D models and achieve precise segmentation results. Ceramic products often have complex shapes and details, and traditional manual segmentation methods are not only inefficient but also difficult to ensure the accuracy and consistency of segmentation. Therefore, achieving automatic 3D ceramic shape segmentation is of great significance for improving production efficiency and optimizing product design. Multimedia interaction technology, with its unique interactivity, real-time performance, and immersion, has brought new development opportunities for modern ceramic technology. Tao [13] discussed the application of modern ceramic technology based on multimedia interaction technology in art and design, analyzed its advantages and challenges, and proposed future development trends. Modern ceramic technology focuses on material innovation, process optimization, and design diversification. The integration of the two enables ceramic art design to no longer be limited to traditional creative techniques but to utilize multimedia interaction technology to achieve richer forms of expression and deeper user experiences. Through virtual reality (VR) and augmented reality (AR) technology, designers can create and showcase ceramic works in a virtual environment. This approach not only reduces creative costs but also provides users with an immersive viewing experience. Designers can adjust their design plans in real time based on user feedback, achieving seamless integration between design and users.

Ceramic art, as an important component of traditional Chinese culture, has a long and unique history of application in landscape design. Artificial intelligence provides strong technical support for the application of ceramic art in landscape design. Traditional ceramic art creation often requires deep skills and inspiration from artists, but with the assistance of artificial intelligence, designers can precisely control the performance, color, texture, and other aspects of ceramic materials through algorithms and data analysis, thereby achieving more precise and personalized design. Wang [14] used ceramic art elements more scientifically in landscape design by simulating and predicting the changes of ceramic materials in different environments. Through technologies such as machine learning and deep learning, artificial intelligence can analyze a large number of design cases and user feedback data, discover patterns and trends, and provide designers with new ideas and inspiration. Multimedia interaction technology is gradually penetrating into various fields of materials science, providing new research tools and methods for researchers. High entropy ceramics, as a new type of multi-component solid solution material, have attracted widespread attention in the field of materials science due to their unique structure and properties. Zhang and Reece [15] reviewed the design and synthesis of high-entropy ceramics based on multimedia interaction technology. The design of high entropy ceramics is a complex and delicate process that requires consideration of the interactions and synergistic effects between multiple components. Multimedia interaction technology provides designers with an intuitive and convenient design platform. Through virtual reality technology, designers can construct three-dimensional models of high entropy ceramics in computers and adjust and optimize them in real-time. In addition, using data analysis techniques, designers can also mine and analyze a large amount of experimental data to identify key factors affecting the performance of high entropy ceramics, thereby guiding material design.

As consumer demand for personalized and interactive daily-use ceramics grows and multimedia interactive technology continues to mature, research in this area is poised to become more diverse and in-depth.

3 THEORETICAL BASIS

3.1 Multimedia Interactive Technology

Multimedia interactive technology has found widespread application in various design fields, including advertising, product design, and architecture. This technology enables designers to present concepts more intuitively, simulate product effects, and facilitate user participation. For instance, advertising produces more vibrant and engaging works. In product design, it aids in prototyping and user testing. And in architecture, it's used to showcase models and discuss designs.

As a subset of product design, daily-use ceramic design can also leverage multimedia interactive technology. During the modeling phase, this technology facilitates 3D modeling and rendering, providing designers with a more intuitive understanding of the product's shape and impact. Functional design enables user participation and feedback, enhancing product practicality and user experience. Furthermore, in marketing, multimedia interactive technology can create more compelling promotional materials and product displays. Thus, the integration of multimedia interactive technology in daily-use ceramic design offers vast potential and application opportunities.

3.2 Daily Ceramic Styling Design

Modeling the design of daily-use ceramics is a complex and challenging process. In the modeling design of daily-use ceramics, certain principles and methods need to be followed. First of all, the design should follow the principle of "form follows function", that is, the form of the product should be determined according to its use function. For example, the design of tableware should take into account factors such as comfortable holding and easy cleaning. Secondly, the design should pay attention to the overall coordination and proportional relationship, so that all parts of the product can be harmonious and unified. In addition, innovation and individuality are also indispensable principles in the design of modern daily-use ceramics, which are helpful to enhance the market competitiveness and added value of products.

In terms of design methods, various methods can be used in the design of daily-use ceramics. Designers can express their design ideas quickly through hand-drawn sketches and use computer-aided design software for accurate 3D modeling and rendering; Through traditional crafts such as clay sculpture and blank drawing, the physical model is made to verify it. These methods have their own advantages and disadvantages, and designers should choose and use them flexibly according to the actual situation. Aesthetics and functionality are two important considerations in the design of daily-use ceramics, as shown in Table 1.

Consideration factor	*Subfactor*	*Realization mode*
Aesthetics	Morphological beauty	Through beautiful curves and harmonious proportional relations.
	Color beauty	Through clever color matching and decorative techniques.
	Material beauty	Through the selection of appropriate ceramic materials and surface treatment process.
Functionalism	Practicability	Ensure that the product meets the functional requirements, such as easy cleaning and storage.
	Comfort	The product can give people a pleasant experience during use, such as the ergonomic grip.

Table 1: Consideration factors of daily-use ceramic modeling design.

4 3D MODELING METHOD OF DAILY CERAMICS BASED ON BPNN

4.1 BPNN Basic Theory

BPNN, a multi-layer feedforward neural network, possesses the capability to acquire and retain numerous input-output pattern mappings through a training process utilizing the backpropagation algorithm. This is achieved without the need for predefined mathematical equations that describe these mappings. BPNN's learning mechanism relies on the steepest descent method, continually refining the network's weights and thresholds via reverse propagation in order to minimize the total squared network errors. A diagrammatic representation of the structural model featuring multiple input neurons is depicted in Figure 1.

In BPNN, the signal propagates forward, and the error propagates backward. Let the input vector by:

$$X = \left[x_1, \ldots, x_{n1}\right]^T \tag{1}$$

The expected output vector is:

$$T = \left[t_1, \ldots, t_{N3}\right]^T \tag{2}$$

Among them, k represents which training mode, that is, sample pair. The respective outputs of the hidden layer node h and the output layer node s are as follows:

$$y_h^k = f\left(\sum_{i=1}^{N1} w_{ih} x_i^k + \theta_h\right) \tag{3}$$

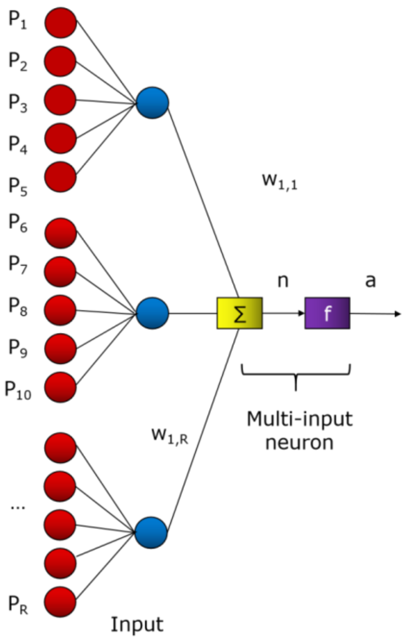

Figure 1: Multi-input neuron structure model.

$$o_s^k = g\left(\sum_{h=1}^{N2} w_{hs} y_h^k + \theta_s\right) \tag{4}$$

$$k = 1,2,3,\ldots,N \tag{5}$$

In the given context, k represents a sample from the set labeled as k. Meanwhile, θ_h denotes the threshold for the hidden layer node, while θ_s signifies the threshold for the output node. f and g, on the other hand, are transfer functions. The input signal undergoes sequential processing from the input layer to the output layer, with each layer of neurons influencing only the subsequent layer. If the output layer fails to produce the desired result, the process switches to backpropagation. This involves adjusting the network's weights and thresholds based on prediction errors, enabling the BPNN's predicted output to align with the expected output progressively.

4.2 Demand Analysis of Daily-Use Ceramics 3D Modeling

3D models of everyday ceramics entail a multifaceted endeavor, taking into account their form, composition, surface texture, and various other ceramic qualities. Traditional modeling techniques typically involve manual sculpting or the use of computer-aided design software; however, these approaches can be either time-consuming or challenging without advanced design expertise. Hence, the quest for an automated, streamlined method of 3D modeling for day-to-day ceramics arises.

Fortunately, a 3D modeling technique utilizing BPNN (Backpropagation Neural Networks) aptly fulfills this requirement. Through training neural networks to learn the distinct shapes and structural nuances of ceramics, this method can promptly craft 3D models in response to specified design inputs. Not only does this enhance modeling efficiency, but it also diminishes the necessity for advanced design proficiency, paving the way for more versatility and creativity in the realm of ceramic design for daily use.

4.3 3D Modeling Process Design of Daily-Use Ceramics Based on BPNN

The process of creating 3D models of daily-use ceramics with BPNN involves several stages. Initially, an extensive dataset of daily-use ceramics is gathered and organized. Following this, a BPNN model is constructed, with careful consideration given to the network architecture and parameter configuration. This model is then trained using the collected dataset, allowing it to grasp the intricacies of ceramic shapes and structures. Once trained, the model can be utilized to generate 3D models based on user-defined design parameters.

There are several crucial aspects to consider during this procedure. One such aspect is determining the optimal network structure and parameters to ensure both the model's performance and stability. Another is handling the input design parameters effectively so that they precisely depict the desired ceramic characteristics. Lastly, evaluating and refining the generated 3D models to align with practical application standards is essential. For illustrative purposes, Figure 2 outlines the BPNN model's structure in this context.

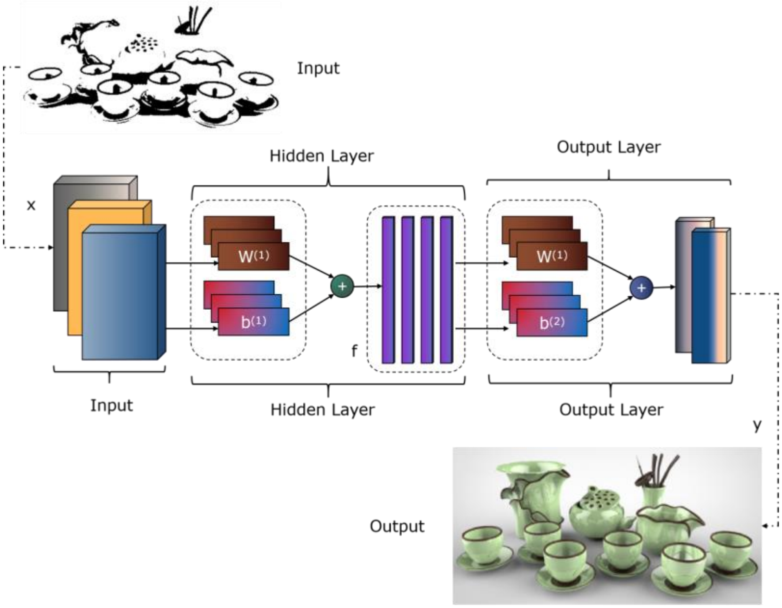

Figure 2: BPNN model structure diagram.

The weights of neurons are adjusted by δ learning rules, the purpose of which is to train the weights W to minimize the square of the output error of neurons for training samples (X, d). The formula is as follows:

$$J(W)=\frac{1}{2}(d-y)^2=\frac{1}{2}\left(d-f(W^T X)\right)^2 \tag{6}$$

Assume that the loss function is $\nabla J(W)$, where ∇J is the parameter vector of the model. For each parameter X, the gradient can be calculated by finding the partial derivative of the loss function with respect to this parameter:

$$\nabla J\ W\ =\ d-y\ f\ W^T X\ X \tag{7}$$

According to the input design parameters, it is the ultimate goal of the whole process to generate a 3D model from the trained model. The design parameters are passed to the model as inputs, and the corresponding 3D model output is obtained through the forward propagation calculation of the model. The output 3D model can be used for subsequent manufacturing and processing, or as a design reference and display. In this article, the following formula is used to illustrate the risk minimization function of the model structure:

$$\beta = \min \sum_{i=1} f\ x\ -y\ ^2 + \alpha \left\|\theta\right\|^2 \tag{8}$$

The linear transformation function expression formula of image input is as follows:

$$\partial = \sum_{i} \beta_i \omega\ x_i \tag{9}$$

Among them, the coefficient ω vector can be used to represent the weight ∂ value. In the task of target detection, the characteristic samples of image information are usually taken as input variables and processed by the correlation filtering function, and the kernel function involved can be expressed as:

$$\theta = \theta\ x_i, x_j \tag{10}$$

The input image is detected by the filter β generated after training, and the ceramic design image information response calculation is calculated and displayed:

$$f\ y\ = \sum \beta_i \theta\ y, x_i \tag{11}$$

After calculating the response value of ceramic design image features, in order to further improve the accuracy and efficiency of matching, the matched ceramic semantic features can be updated by filters. This process aims to optimize the feature extraction and matching algorithm to ensure that the system can identify and respond to different ceramic design elements more accurately. By constantly updating the filter, the sensitivity of ceramic design identification can be improved, thus providing users with more personalized and accurate design suggestions.

The configuration of parameters in a BPNN model plays a pivotal role in determining its performance and stability. These parameters encompass the network's layer count, the neuron count per layer, the learning rate, and the iteration count. Typically, the layer count and neuron count per layer are tailored to the intricacies of the problem and the data's scope. The learning rate must strike a balance between convergence rapidity and stability. The iteration count is determined by the model's convergence progress. Table 2 outlines the BPNN model's parameter configurations discussed in this article.

Parameter name	*Set value*	*Explain*
Network layer number	3	A simple three-tier structure is often used in many benchmark tasks.
Number of neurons in the input layer	10	Suppose there are 10 input features.
Number of neurons in the hidden layer	50	This value depends on the complexity of the problem and needs to be cross-verified to determine the best value.
Number of neurons in the output layer	1	Suppose it is a regression problem or a binary classification problem. For multi-classification problems, the number of neurons in the output layer will be equal to the number of categories.
Learning rate	0.001	A relatively small learning rate helps to ensure the stability of the

		model.
Iterations	1000	This value is usually determined according to the downward trend of training error. In practical application, the early stop method can be used to avoid over-fitting.

Table 2: Parameter setting of BPNN model.

5 SIMULATION EXPERIMENT AND ANALYSIS

5.1 Simulation Experiment

In order to verify the effectiveness of the 3D modeling method of daily-use ceramics based on BPNN, simulation experiments are needed. First of all, it is necessary to build a simulation experiment environment, including the appropriate hardware and software environment. Then it is necessary to prepare experimental data, including collecting and sorting out a large number of daily-use ceramic sample data and corresponding design parameters. In the process of preparing experimental data, this article pays attention to the diversity and representativeness of samples to ensure that the trained model can have good generalization ability. The simulation experiment process includes the training stage and the testing stage of the model. In the training stage, firstly, the BPNN model is trained by using the collected sample data, so that it can learn the shape and structural characteristics of ceramics. Then, in the testing stage, the trained model is used to predict the new design parameters and the corresponding 3D model is generated. By comparing the experimental results with the expected output or actual measurement data, the accuracy and performance of the 3D modeling method of daily-use ceramics based on BPNN can be evaluated. The analysis of experimental results includes error analysis, convergence analysis, and evaluation of model generalization ability. Convergence analysis can reflect the stability and efficiency of model training. The convergence of the algorithm is shown in Figure 3.

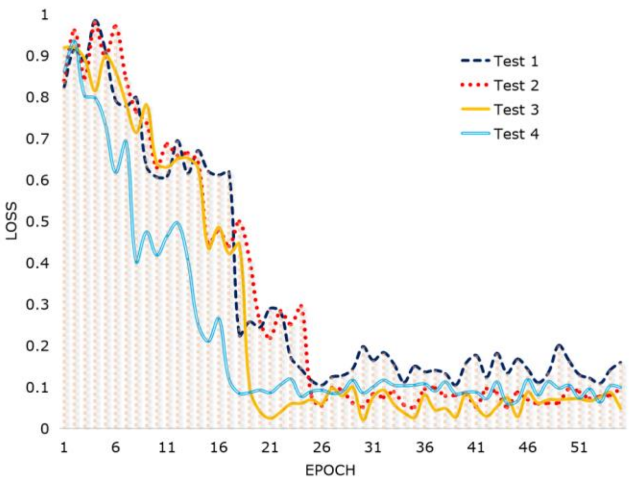

Figure 3: Convergence of algorithm.

Observing the convergence pattern depicted in Figure 3, it is evident that the BPNN progresses towards a stable condition throughout its training. This implies that as iterations accumulate, adjustments to network weights diminish, leading the algorithm to converge on an optimal solution.

Convergence quality is a key metric in assessing neural network performance. Notably, the algorithm demonstrates impressive training effectiveness within a reasonable iteration count.

Error analysis is critical in gauging how well a model's predictions align with actual outcomes. The algorithm's MAE is visualized in Figure 4, offering insight into prediction accuracy.

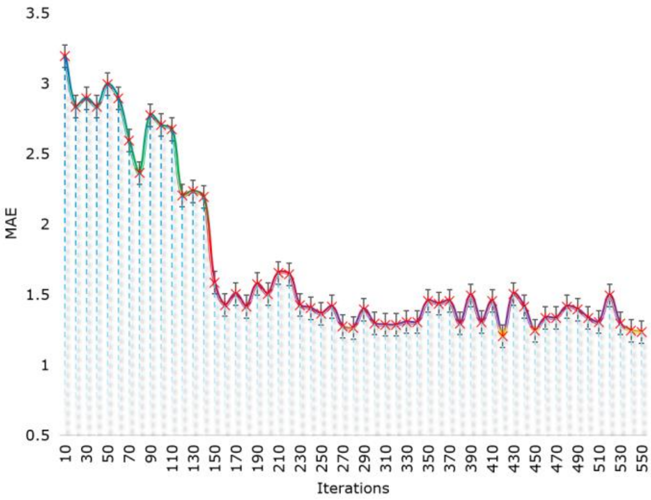

Figure 4: MAE.

MAE serves as a popular metric to assess the discrepancy between predicted and actual values, directly indicating an algorithm's predictive prowess. By juxtaposing MAE values across varying parameter configurations, one can appraise the algorithm's efficacy. In Figure 4, the MAE curve for BPNN exhibits a lower position, underscoring BPNN's superior predictive accuracy in modeling daily-use ceramics.

To gauge a model's predictive prowess on unfamiliar datasets, we evaluate its generalization capability. Figure 5 presents a comparative analysis between the algorithm's predicted and actual values, shedding light on its predictive reliability.

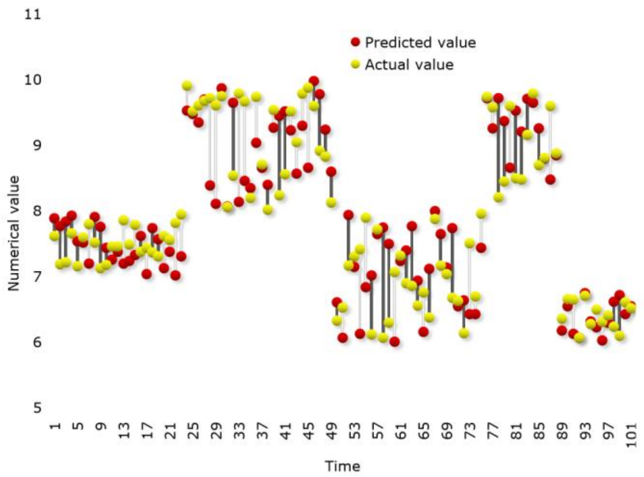

Figure 5: Comparison between the predicted value and the actual value of the algorithm.

Upon a direct comparative analysis of prediction outcomes with actual datasets, we gain a clear visualization of the algorithm's predictive efficacy at each sample point. The findings reveal that the predicted values align closely with actual values and follow a similar trend, highlighting the algorithm's commendable predictive performance.

In conclusion, a comprehensive analysis of experimental findings indicates that the 3D modeling technique for daily-use ceramics, grounded in BPNN, exhibits promising performance. It demonstrates notable strengths in terms of convergence, MAE comparison, and the correlation between predicted and actual values. This underscores BPNN's potential for effective implementation in the modeling and design of daily-use ceramics, empowering designers with enhanced efficiency, and precision, and driving innovation, transformation, and enhancement in the ceramic industry.

5.2 Comparison with Other Design Methods

Comparing the 3D modeling method of daily-use ceramics based on BPNN with the machine learning design method, we can evaluate the advantages and disadvantages of each method from multiple dimensions. Firstly, the differences between them in design efficiency, design quality, and design flexibility are compared. As shown in Table 3, the design flexibility and automation degree of the two methods are compared.

Method name	*Design flexibility*	*Degree of automation*
Machine learning design method	Flexibility score: 75/100 Can adapt to general design changes (80/100)	Automation coverage: 60% Partial automation of the design process (70/100)
	Need support in the face of complex situations (71/100)	Manual participation in creative conception, scheme review, etc. (50/100)
	Emergency needs guidance (69/100)	-
3D modeling method of daily ceramics based on BPNN	Flexibility score: 96/100	Automation coverage: 93%
	Can adapt to a variety of design requirements (94/100)	Highly automated design process (95/100)
	Strong innovation ability (90/100)	Reduce manual intervention and improve design efficiency (97/100)
	Strong adaptability (89/100)	Some cases may lack the accuracy of manual judgment (84/100)

Table 3: Comparison of design flexibility and automation degree between the two methods.

The design efficiency comparison of the two methods is shown in Figure 6. The method based on BPNN shows a high level of design efficiency. This is because BPNN can effectively adjust the network parameters through the backpropagation algorithm, so as to quickly converge to a better solution in the design process. In addition, BPNN has strong nonlinear mapping ability, which can deal with complex design problems and further improve design efficiency. In contrast, machine learning methods are limited in design efficiency. This is because this method lacks enough flexibility in dealing with complex problems, which leads to a long design process. The comparison of design quality between the two methods is shown in Figure 7.

Figure 7 shows that the method based on BPNN also has significant advantages in design quality. This is due to the strong learning and generalization ability of BPNN, which makes the designed scheme more in line with the actual needs and has high stability and reliability. At the same time, BPNN can continuously optimize the design results through the training of a large number of data, thus improving the design quality. However, because it is difficult for machine learning to fully consider the interaction and influence of various factors when dealing with complex problems, there is a certain deviation between the design results and the actual needs.

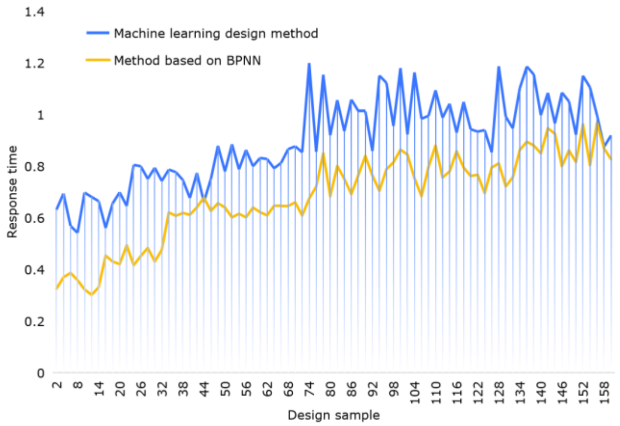

Figure 6: Comparison of design efficiency between two methods.

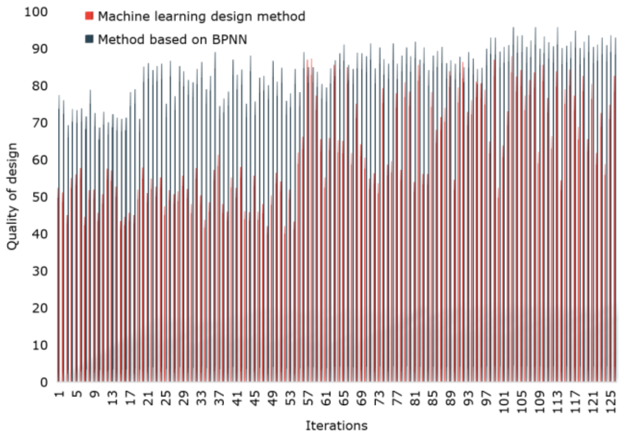

Figure 7: Comparison of design quality between two methods.

Through comparative analysis in this section, we can find that the method based on BPNN has obvious advantages in automation, design efficiency, and design flexibility. This comparative study helps understand the characteristics and application scenarios of the new method more comprehensively and provides useful references and guidance for practical application.

6 MULTIMEDIA INTERACTIVE REALIZATION OF DAILY-USE CERAMIC MODELING DESIGN

6.1 Application of Multimedia Interactive Design Principle in Daily-Use Ceramics

The principle of multimedia interactive design emphasizes effective communication and interaction between users and products. In the design of daily-use ceramics, the application of these principles means combining traditional ceramic art with modern science and technology to create works with both aesthetic value and practical function. Specifically, the application of multimedia interactive design principles in daily-use ceramics includes the following aspects:

(1) User friendliness is the key. Designers need to ensure that the design of ceramic products conforms to ergonomic principles and is convenient for users to operate and use. For example, the handle of a tea set should be designed to be beautiful and comfortable, so that users can hold it easily.

(2) The timeliness of information feedback is also an important principle of multimedia interaction design. In the design of daily-use ceramics, this can be achieved by embedding LED lights, display screens, and other elements. For example, a smart teacup can give out a prompt light when the tea temperature is suitable, thus enhancing the user's experience.

(3) Multimedia interaction design also emphasizes the customization and individuation of products. In the design of daily-use ceramics, this means that designers need to provide a variety of styles, colors, and patterns for users to choose from to meet the aesthetic needs of different users.

6.2 Concrete Implementation of Multimedia Interactive Technology in Daily-Use Ceramic Design

The concrete implementation of multimedia interactive technology in daily-use ceramic design includes hardware integration and software development. In terms of hardware, designers need to embed sensors, touch screens, and audio devices into ceramic products. These hardware components can detect the user's operation and provide corresponding feedback. For example, a ceramic dinner plate with a touch screen can display nutritional information and cooking suggestions. In terms of software, designers need to develop corresponding applications to control the work of hardware components. These programs can adjust the status of products and provide personalized services according to users' operations. For example, a smart ceramic vase can control lighting and sound effects through applications, creating different atmospheres for users.

7 CONCLUSIONS AND PROSPECTS

7.1 Summary of Research Work

This study primarily explores the utilization of BPNN in developing a 3D modeling technique for daily-use ceramics, alongside the integration of multimedia interactive design principles within this domain. Through a blend of theoretical examinations and simulation experiments, the study validates the efficacy and viability of the introduced methodology. Additionally, practical implementations and impacts of multimedia interactive design in daily-use ceramic creations are scrutinized through illustrative case studies.

The key accomplishments of this research encompass the following: The introduction of a BPNN-based 3D modeling approach for daily-use ceramics, facilitating an automated and streamlined modeling process. The incorporation of multimedia interactive design principles in daily-use ceramic designs, enhances user experience, real-time information feedback, and product customization. The demonstration of the practical implications and merits of the proposed methodology and design principles through detailed case analyses.

7.2 Research Deficiency and Future Work Prospect

Despite the accomplishments and advancements achieved in this study, there are certain limitations to acknowledge. One such limitation is the potential accuracy and efficiency challenges encountered by the BPNN-based 3D modeling method when handling intricate shapes and textures. Additionally, the integration of multimedia interactive design in daily-use ceramics remains in its infancy, necessitating further exploration and refinement.

Looking ahead, future endeavors could focus on refining the BPNN-based 3D modeling technique to enhance its capability in addressing complex geometries and textures. Furthermore, a more profound investigation into the application contexts and realization techniques of multimedia interactive design in daily-use ceramics would be beneficial, aiming to cater to a broader user base.

Lastly, exploring the feasibility of amalgamating other cutting-edge technologies with daily-use ceramic design presents an exciting opportunity for future research.

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