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Research Article

Modeling Design of Ceramic Products Based on Digital Image Processing Technology

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With the improvement of people's living standards, people's pursuit of art is also getting higher and higher. Ceramic products are artistic works whose meanings contain thousands of stories including mountains, waters, and rivers. Ceramic products include vases, tea sets, flower pots, plates, and rice bowls. A vase is a vessel, mostly made of ceramic or glass, with a beautiful and smooth appearance. The bottom of the vase usually holds water, which keeps the plants alive and beautiful. Tea utensils refer to tea-drinking utensils such as tea cups, teapots, tea bowls, tea cups, saucers, and tea trays in a narrow sense. There are many kinds of tea sets in China, with beautiful shapes. In addition to practical value, they also have high artistic value, so they are well known at home and abroad and are favored by tea lovers in all dynasties. Digital image processing is the use of computers to remove noise and enhance, restore, segment, and extract features from images. Discrete mathematics is a mathematical subject that studies the structure of discrete quantities and their interrelationships and is an important branch of modern mathematics. The meaning of discrete refers to different elements connected together, mainly to study the structure and mutual relationship based on discrete quantities. Its objects are generally limited or countable elements. With the continuous development of digital image processing technology, this technology has also been applied to the shape design of ceramic products. This paper mainly conducts in-depth research on the preprocessing algorithm of digital images, from the initial analysis of the historical culture of the process to the subsequent algorithm research. Then its accuracy is matched to make a comparison, and finally an estimate based on the ceramics studied in this paper will be made. In the experimental part, the public is first investigated and analyzed, and the conclusion shows that the results of the color investigation of ceramic products include the following aspects: There are about 103 people having more needs for light and elegant color feeling, which echoes the needs of modeling. There are around 97 people demanding that the color be combined with the shape to reflect the color difference between the interior and the exterior. Since the internal and external chromatic aberration and mixed colors will bring novelty to the appearance of ceramic products, there are also a large number of people in the demand for mixed colors, about 84 people. Then it is analyzed that the ink-and-wash ceramics in the landscape style are more popular, and then the detailed description is carried out. Finally, the finished product is displayed.

1. Introduction

Ceramics have a long history, created by human beings in the process of labor and production. Then they gradually developed. Today's society is changing with each passing day. The technology is developing rapidly, and computer technology is becoming more and more popular, indicating that electronic technology has penetrated into people's lives. Ancestors of China and the ancestors of some other countries and regions in the world, such as Egypt, India, Greece, Persia, and Southwest Asia, invented pottery in long-term practice. The production of pottery also has a history of nearly ten thousand years. Since human beings began to know how to make pottery, profound changes have taken place in all aspects. As Engels said, "the lowest stage of the barbarian age started with the application of pottery." On the basis of the continuous development and improvement of pottery-making technology, the Chinese invented porcelain. The invention of ceramics not only solves people's life problems, such as household utensils and building materials, but also provides artistic enjoyment! As a traditional art, ceramic design is constantly developing and improving with

the changes of the times. From manual to machine, to the intervention of today's digital technology, its unique virtual ceramic design is becoming more and more mature. The innovation and popularization of digital technology have completely abandoned the traditional ceramic industry and manufacturing methods. The advantages of being intuitive, efficient, and convenient have had a profound impact on the development of ceramic art design. Digital technology has replaced traditional ceramic art to a certain extent, breaking traditional design ideas and aesthetic concepts.

In the process of the development of porcelain, hundreds of types of porcelain have been formed. There are five famous porcelains in my country. In the Song Dynasty, there were five famous kilns: Ru, Guan, Ge, Jun, and Ding. Each kiln produced fine porcelain that has been passed down to later generations. Each kind of porcelain has its own unique style and characteristics and has become a collection in major museums around the world. The processing technology and production tools of porcelain are extremely complex, which reflects the natural concept of human beings. Porcelains are carved with dragons, phoenixes, and various patterns. The paintings with vitality appear on the porcelain, reflecting the humanistic thought of harmonious unity between man and nature, which are typical representatives of traditional Chinese culture. Ceramics are selected as the research object in this paper. It is because of our understanding of the culture of daily-use ceramics, and another reason is the representativeness of ceramic art itself, which is not only a representative of a culture but also a symbol of a culture. It is also a testimony to the splendid culture of China for thousands of years. Moreover, it will conduct in-depth analysis based on actual cases, with solid theoretical basis and personal experience. During the design and production of the case, I gradually gained a clear understanding of the previous confusion and a deeper understanding and motivation to learn, and I felt the guiding role of this institute more deeply. The research purpose of this paper is very clear, and it is also the important content of this paper. First of all, the application of digital technology in the design of daily-use ceramics is deeply discussed, and its theoretical research and application are deepened. Secondly, the technology application methods used in digital design are analyzed, and the interactive effects and advantages of each design software are compared. Thirdly, the level of regional design needs to be improved and the full application of digital technology in regional product design should be promoted. With the development of digital technology, if the daily ceramic industry wants to gain a foothold in the fiercely competitive market, it must change the traditional design and manufacturing concepts. In this way, digital technology can be effectively used to improve the efficiency of design and manufacturing, and the application of digital technology in daily-use ceramics can be further explored to meet the new demand for daily-use ceramics in the new era.

This paper mainly talks about the in-depth research on the preprocessing algorithm of digital images, from the analysis process to the algorithm as well as the accuracy of the matching algorithm. Then, combined with the research object of this paper, the ceramics are calculated. Finally, the experiments are carried out for research and analysis. First of all, the public is investigated, and then it is analyzed that landscape-style ceramics were more popular. Then detailed explanations are made. At last, the finished product is displayed. The innovation of this paper lies in the deeper research on the process and accuracy of the algorithm. Therefore, the conclusions drawn will be more accurate, and the experimental part is also the first to conduct market research on the research objects, which makes the results more realistic.

2. Related Work

Most people are creative, which makes them able to contribute to product design. However, differences in mindset can significantly impact the areas where art school designers can most contribute. Almamari focused on modern ceramic design, considering the artist's ideas about the ceramic industry and its functional and aesthetic impact [1]. A comprehensive investigation was carried out on the mineralogy and chemical composition and technical properties of clays from the Krupeiskii Sad deposit in Belarus. Popov et al. established the relationship between the formation characteristics of the structure and phase composition of heat-resistant ceramic materials obtained from polymineral clays and their physicochemical properties and operational characteristics [2]. Ceramic fiber insulation is used in numerous applications (such as aerospace, firefighting, and military) due to its stability and performance in extreme environments. The resulting uncertainty in material properties can complicate the design of systems using these materials. In this study, Headley et al. introduced a model to explain the variation of thermal conductivity with temperature, compression, and ambient gas. The model was adjusted according to the collected experimental data, and the results were compared [3]. With the development of image processing technology, the manufacturing process of ceramic handicrafts is becoming more and more diverse. The purpose of Matsubara et al. was to propose a set of constitutive functions for dry bodies to accurately predict the entire deformation process of ceramic products during firing. Correlation methods were presented to determine their coefficients from a series of respective thermomechanical analysis (TMA) tests [4].

Tile chromatic aberration refers to the color difference between one tile and another or the color difference between different parts of the same tile. Normally, in an area of about several square meters, under the appropriate uniform light, if color difference of a batch of products is not obvious, it can be regarded as no color difference. However, from the perspective of foreign consumption and domestic fashion trends, the phenomenon of chromatic aberration is gradually accepted by consumers who are seeking to return to nature, and the chromatic aberration of natural stone is particularly accepted by the public. All theoretically colorless waterproof products, when the surface is applied to porous surface ceramics, will produce a chromatic aberration in the color of the ceramic. Coronado Martín and García Santos explored the factors that influence the color change.

Ceramics were handcrafted, pressed, and extruded according to their type of manufacture, and they were characterized according to absorption coefficient, open porosity, absorptivity, surface treatment, and initial color parameters [5]. Tableware and bathroom ceramics are formed by grouting. The proliferation of bacterial and fungal microorganisms occurs during the storage of paper sheets and disturbs their properties, resulting in defects in the final product. Mata et al. designed to characterize the microbial efficiency of several fungicides and evaluate their impact on rheology and final product quality [6]. In the production process of PT, the quality is excellent. NJMX is a company engaged in the manufacture of ceramics, and consumers expect good ceramic surface quality without any defects. Nurcahyanie and Koesdijati aimed to study the use of the seven-piece method to identify the defects of ceramic products in the glaze process and to use the seven-piece method as an effective tool to improve the production efficiency and product quality of ceramic binary glazes [7]. They all explained the various modeling design factors and the various difficulties of ceramic craft products very well. However, it has not been combined with the current popular image processing technology to study. This paper aims to study the modeling design of ceramic products based on digital image processing technology.

3. Modeling Design Algorithm of Ceramic Products Based on Digital Image Processing Technology

3.1. Implementation of Image Preprocessing Algorithm. The pros and cons of the pretreatment method will be directly related to the subsequent printing quality inspection. How to choose the preprocessing method correctly is very important. Image processing with high flexibility can be roughly divided into three parts: image quality improvement, image analysis, and image reconstruction, each of which contains rich content. In principle, the optical processing of images can only perform linear operations, which greatly limits the goals that optical image processing can achieve. Digital image processing can complete not only linear operations but also nonlinear processing; that is, all operations that can be expressed by mathematical formulas or logical relationships can be implemented by digital image processing.

3.1.1. Purpose and Process of Preprocessing. The full name of CCD is charge-coupled element. It can be called CCD image sensor or image controller. CCD is a semiconductor device that can convert optical images into electrical signals. First, the printed image is captured with a CCD and then denoising processing is performed. Next, it searches in the upper right, upper left, and lower left corners. By positioning the three points, the numerical values of the positions of the three points in the area are obtained. Finally, the printed image is rotated with the center point of the image as a reference point, and the layout image is used as a template to match its corresponding parts to realize the position of the image.

3.1.2. Image Noise Analysis and Its Removal Algorithm. Ceramics are selected as the research object in this paper because of people's understanding of daily-use ceramics and our love for its culture and its own unique artistic charm [8].

Due to the blurring effect of the adjacent mean method on the image, the weighted mean method came into being. The weighted average method refers to a method of calculating the average unit cost of a material at the end of the month by taking the amount of a certain material at the beginning of the period and the amount of income in this month as weights. Specifically, this method is to divide the sum of the inventory amount at the beginning of the month and the amount purchased this month by the sum of the inventory amount at the beginning of the month and the purchase amount this month. The obtained monthly average unit price of this kind of material is taken as the unit price of the material cost issued this month. Compared with the neighborhood average method, the weighted average method is used to assign the weights of adjacent pixels. However, the closer the pixels of its neighboring points are, the greater the weight will be. On the contrary, the farther the distance is, the lower the weight will be. This is a good way to reduce the blur caused by smoothing. Therefore, by processing the image with the weighted average method, better edge details can be obtained.

The weighted average method reduces the blurring effect of the image through weights, but it still exists, making the edges and lines in the image blurred. Typically objects and backgrounds have nonuse statistical characteristics. Since these features (average and variance) have high edge information, local smoothing filtering method can be used to obtain better image details. The advantage of this method is that the edges and contours of the image are not blurred as much as possible.

In the case of comparing the shielding windows, filtering can be achieved and the image can be processed without affecting the image. In this method, grayscale changes are firstly performed on 9 existing masking windows, and then the smallest masking window is selected to perform average filtering to ensure the boundary information in the image.

From the above 9 types of templates, their respective averages and variations can be obtained.

The mean can be calculated as in the following formula:

$$N_j = \frac{\sum_{r=1}^{r=M} p(j,i)}{M}. \tag{1}$$

The variance can be calculated as in the following formula:

$$\chi_j = \sum_{r=1}^{r=M} \left(p^2(j,i) - N_j^2 \right). \tag{2}$$

In formulas (1) and (2), $r = 1, 2, 3, \ldots, M$. M is the number of pixels corresponding to each mask.

Through classifying the obtained results, the obtained result is the average grayscale of the mask corresponding to the minimum variance. Then a 5×5 window is used to slide across the entire screen, and a template operation is performed on any pixel, so that each pixel can be smoothed. The

Table 1: Window pixel arrangement.

	Column 0	Column 1	Column 2
Line 0	P_0	P_1	P_2
Line 1	P_3	P_4	P_5
Line 2	P_6	P_7	P_8

key of the selective mask smoothing method is to select the statistical features of the target and the background. According to the statistical features of the target and the background, the variance of different shading windows is used to select the most suitable template [9]. Therefore, it can not only achieve smooth filtering but also preserve the edge information in the image to the greatest extent and eliminate the blurriness of the image.

Median filtering is a typical filtering technique with strong nonlinear characteristics. Linear filtering (mean square filtering, mean filtering, etc.) will cause blurring of image details. Nonlinear filtering can solve this problem under certain circumstances, which has a good effect on filtering impulse interference and image scanning noise. In addition, in the program design, there is no need to perform feature statistics on the image, so it has a good application prospect. The one-dimensional standard median filter is as in the following formula:

$$b_r = \text{med}\{a_{r-M}, a_{r-M+1}, \ldots a_r, \ldots a_{r+M-1}, a_{r+M}\}. \quad (3)$$

As mentioned above, the traditional median filtering algorithm has problems such as large amount of calculation and being time-consuming. This paper proposes a fast median filtering algorithm to improve the filtering speed. This algorithm is based on a 3×3 template. Through clever arrangement, a large number of repeated pixel comparisons are avoided. The sorting of each window takes $O(M)$ time. For fast algorithm and implementation, in the $3 * 3$ window, each pixel is defined as $P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8$, and the pixel arrangement is shown in Table 1.

First, three groups of minimum, median, and maximum values are performed on each column of each window to obtain the minimum value group, the median value group, and the maximum value group. The calculation procedure is as follows: the maximum value group—$\text{Max}_0 = \max[P_0, P_3, P_6]$, $\text{Max}_1 = \max[P_1, P_4, P_7]$, and $\text{Max}_2 = \max[P_2, P_5, P_8]$; the median value group—$\text{Med}_0 = \text{med}[P_0, P_3, P_6]$, $\text{Med}_1 = \text{med}[P_1, P_4, P_7]$, and $\text{Med}_2 = \text{med}[P_2, P_5, P_8]$; and the minimum value group—$\text{Min}_0 = \min[P_0, P_3, P_6]$, $\text{Min}_1 = \min[P_1, P_4, P_7]$, and $\text{Min}_2 = \min[P_2, P_5, P_8]$.

In the formulas, "max" represents the maximum operation, "med" represents the intermediate operation, and "min" represents the minimum operation. The filtered pixel Winmed is the smallest median value. The expression for this calculation program is as in the following formulas:

$$\text{Max min} = \min[\text{Max}_0, \text{Max}_1, \text{Max}_2], \quad (4)$$

$$\text{Medmed} = \text{med}[\text{Med}_0, \text{Med}_1, \text{Med}_2], \quad (5)$$

$$\text{Minmax} = \max[\text{Min}_0, \text{Min}_1, \text{Min}_2], \quad (6)$$

$$\text{Winmed} = \text{med}[\text{Maxmin}, \text{Medmed}, \text{Minmax}]. \quad (7)$$

3.1.3. Image Rotation Algorithm. After the image is rotated, the corresponding pixels may not be found in the original image, so interpolation must be performed. When rotating an image, it is necessary to point out which point the image rotates around. The image rotation usually takes the center of the image as the origin and rotates an angle. When the image is rotated, a part of the image data will be moved out of the image display area. The image data can be intercepted or the display range of the image can be enlarged, so that the entire image can be presented [10].

As shown in Figure 1, the expression of point (a, b) in polar coordinates is as in the following formula:

$$\begin{aligned} a &= \phi \cos \alpha, \\ b &= \phi \sin \alpha. \end{aligned} \quad (8)$$

After rotating β angle around the coordinate origin (0, 0), the coordinate becomes $(a\prime b\prime)$, and the expression of $(a\prime b\prime)$ in polar coordinates is as in the following formula:

$$\begin{cases} a\prime = \phi \cos(\alpha - \beta) = \phi \cos \alpha \cos \beta + \phi \sin \alpha \sin \beta = a \cos \beta + b \sin \beta, \\ b\prime = \phi \sin(\alpha - \beta) = \phi \sin \alpha \cos \beta - \phi \cos \alpha \sin \beta = -a \sin \beta + b \cos \beta. \end{cases} \quad (9)$$

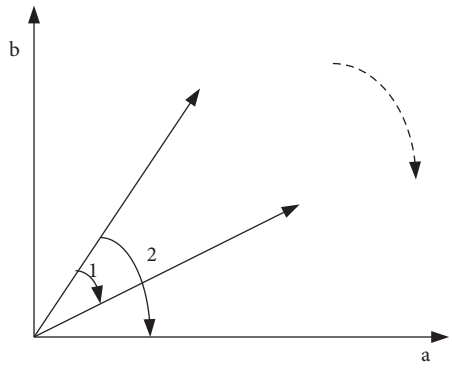
Formula (9) is written in matrix form as follows:

$$\begin{bmatrix} a\prime \\ b\prime \\ 1 \end{bmatrix} = \begin{bmatrix} \cos \beta & \sin \beta & 0 \\ -\sin \beta & \cos \beta & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} a \\ b \\ 1 \end{bmatrix}. \quad (10)$$

Its inverse operation is as follows:

$$\begin{bmatrix} a \\ b \\ 1 \end{bmatrix} = \begin{bmatrix} \cos \beta & -\sin \beta & 0 \\ \sin \beta & \cos \beta & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} a' \\ b' \\ 1 \end{bmatrix}. \quad (11)$$

The rotations described above are performed around the origin (0, 0) of the coordinate axis. To rotate around a specified point (a, b), first the coordinate system needs to be moved to that position and then rotated. It needs to be translated to the initial position. As can be seen from



$$\begin{cases} a = \varphi cos\alpha \\ b = \varphi \sin\alpha \end{cases} \quad (8)$$

Figure 1: Image rotation diagram.

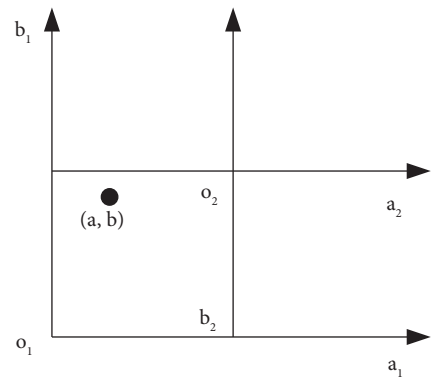


Figure 2: Schematic diagram of coordinate system translation.

Figure 2, the coordinate system is translated to the coordinate system in which the origin of the coordinate system is (a, b).

The coordinate transformation matrix expressions of the two coordinate systems are as follows:

$$\begin{bmatrix} a_2 \\ b_2 \\ 1 \end{bmatrix} = \begin{bmatrix} 1, 0 - x \\ 0, 1 - y \\ 0, 0, 1 \end{bmatrix} \begin{bmatrix} a_1 \\ b_1 \\ 1 \end{bmatrix}. \quad (12)$$

The inverse transformation matrix expressions are as follows:

$$\begin{bmatrix} a_1 \\ b_1 \\ 1 \end{bmatrix} = \begin{bmatrix} 1, 0, x \\ 0, 1, y \\ 0, 0, 1 \end{bmatrix} \begin{bmatrix} a_2 \\ b_2 \\ 1 \end{bmatrix}. \quad (13)$$

Assuming that the center coordinate of the image is (a, b) when it is not rotated and the center coordinate after rotation is (c, d), the rotation transformation matrix expression is as follows:

$$\begin{bmatrix} a' \\ b' \\ 1 \end{bmatrix} = \begin{bmatrix} 1, 0, c \\ 0, 1, d \\ 0, 0, 1 \end{bmatrix} \begin{bmatrix} a_2' \\ b_2' \\ 1 \end{bmatrix} = \begin{bmatrix} 1, 0, c \\ 0, 1, d \\ 0, 0, 1 \end{bmatrix} \begin{bmatrix} \cos\beta \ \sin\beta 0 \\ -\sin\beta \ \cos\beta 0 \\ 0, 0, 1 \end{bmatrix} \begin{bmatrix} a_1 \\ b_1 \\ 1 \end{bmatrix}$$

$$= \begin{bmatrix} 1, 0, c \\ 0, 1, d \\ 0, 0, 1 \end{bmatrix} \begin{bmatrix} \cos\beta \ \sin\beta 0 \\ -\sin\beta \ \cos\beta 0 \\ 0, 0, 1 \end{bmatrix} \begin{bmatrix} 1, 0 - x \\ 0, 1 - y \\ 0, 0, 1 \end{bmatrix} \begin{bmatrix} a \\ b \\ 1 \end{bmatrix}. \quad (14)$$

Its inverse transformation matrix expression is as follows:

$$\begin{bmatrix} a \\ b \\ 1 \end{bmatrix} = \begin{bmatrix} 1, 0, x \\ 0, 1, y \\ 0, 0, 1 \end{bmatrix} \begin{bmatrix} \cos\beta \ \sin\beta 0 \\ -\sin\beta \ \cos\beta 0 \\ 0, 0, 1 \end{bmatrix} \begin{bmatrix} 1, 0 - c \\ 0, 1 - d \\ 0, 0, 1 \end{bmatrix} \begin{bmatrix} a' \\ b' \\ 1 \end{bmatrix}. \quad (15)$$

Therefore, the following formula can be obtained:

$$\begin{cases} a = a' \cos\beta - b' \sin\beta - c \cos\beta + d \sin\beta + x, \\ b = a' \sin\beta + b' \cos\beta - c \sin\beta - d \cos\beta + y. \end{cases} \quad (16)$$

For the input image $f(a, b)$, the output image $p(a', b')$ is obtained after rotating angle φ. When calculating the mapping of point (a', b') on the origin through formula (16), (a, b) may fall somewhere between pixels. That is, (a, b) are the coordinates on the original image with decimal points [11]. Therefore, the image rotation formula can be rewritten in image form as follows:

$$\begin{cases} p(a', b'), \\ s = a' \cos\varphi - b' \sin\varphi + d \sin\varphi + x, \\ w = a' \sin\varphi + b' \cos\varphi - d \cos\varphi + y. \end{cases} \quad (17)$$

In formula (17), s and w are numbers with decimal points.

3.2. Implementation of Image Matching Algorithm

3.2.1. Image Matching Algorithm Analysis. Image registration is the optimal combination of two or more images in space. It can be summarized as follows:

(1) The selection of similarity metric is a critical step, which is determined by its final registration degree.

(2) In the retrieval space, finding the optimal matching point and matching strategy is the most important. In the search process, a big problem is to reduce the number of measurements.

Among them, the most commonly used method is the template matching method. It is a method based on grayscale correlation, and it is mainly used to study whether there is a known template image in a picture. The basic idea is to first select the original image as a template, and then the image is compared with the captured image. If it is found that there is a certain difference between the image content of the original image and the captured image, and image comparison can be performed. In regional comparison, there are many methods to measure similarity, including standardized cross-correlation, moment matching, and ABS.

Table 2: Research population and proportion of the number of people.

	Quantity	Proportion
Young artists	56	47
Pottery lover	32	27
Pursuit of individual youth	31	26

In short, in the template matching algorithm, the pixel value of the original image is used for matching. In this way, different objects can be separated from the picture. The disadvantage of template matching is that its anti-interference and antinoise ability is poor, and it is very sensitive to the nuances of the image. This algorithm has better matching effect for two images to be matched with the same external conditions. The disadvantage of template matching lies in its anti-interference, antinoise, and sensitivity to image details. On this basis, a new feature-based matching method is proposed, which can greatly reduce the number of pixels required for correlation operations and has better adaptability.

In this paper, Harris' corner extraction method is selected, and the singular value decomposition of corner points is carried out by using this method [12].

3.2.2. Harris Corner Detection Algorithm. A critical place in an image is the corners. The end of the image segment, the corner of the outline, and so forth can all be corner points. Corner features are especially suitable for dealing with occlusion and geometric deformation due to their large amount of information, easy measurement, easy expression, and adaptation to changes in ambient lighting. Therefore, it is second to none in many eigenvalues' matching. At a corner, there are two or more different gradients near the corner, and the Harris operator is given based on this situation. The formula of Harris operator only contains the first-order differential, that is, the first-order differential of each pixel point on the grayscale image, and then the product is obtained to obtain three new images. A grayscale image is a brightness level of 255. Channels are the basis for the entire Photoshop display image. The color change is actually an indirect adjustment to the channel grayscale image. The channel is the core part of Photoshop's processing of images, and all the color adjustment tools are used around this core. The value of interest for each point corresponding to the original image is as in the following formulas:

$$N = Q(\overline{d}) \otimes \begin{bmatrix} q_a, q_a q_b \\ q_a q_b, q_b \end{bmatrix}, \tag{18}$$

$$l = \det(N) - r d_k^2(N), \tag{19}$$

$$p(a', b') = \begin{cases} f(a, b), \\ a = a' - d_a, \\ b = b' - d_b. \end{cases} \tag{20}$$

Table 3: Crowd income statistics table.

	Number of people
Above 8000	4
5000–7999	24
3000–4999	59
1000–2999	30
Below 1000	3

In formulas (18)–(20), r is the weight coefficient, which is 0.04. q_a is the gradient in direction a; q_b is the gradient in direction b, and $Q(\overline{d})$ is the Gaussian template; "det" represents the determinant of the matrix, and rd is the trace of the matrix.

In the Harris operator, in the local area of the image, the maximum value of interest corresponds to the pixel point. Therefore, the interest value of each point is calculated, and the local maximum interest value in the original image is extracted.

3.3. Advantages of Image Preprocessing Algorithms

(1) The spectral analysis method is used to detect printing ghosting defects, which can not only detect ghosting but also detect the type of ghosting and the offset of ghosting. This makes it easier for the operator to adjust the printing press. It is a way of decomposing complex oscillations into frequency spectra. Any complex oscillating signal can be decomposed into many different amplitudes and different frequencies. The spectrum can be divided into discrete and continuous spectrum. Therefore, this method is widely used in acoustic, optical, and radio technology.

(2) In practical application, this method only needs to grayscale the image first. Then Fourier transform is performed, and the measured image and the standard atlas are used to add. Compared with the FSWM operator method, the SMD operator method, and other methods, this method has a smaller amount of computation and less processor requirements [13]. Fourier transform means that a function that satisfies certain conditions can be expressed as a trigonometric function (sine and/or cosine function) or a linear combination of their integrals. In different research fields, Fourier transform has many different variants, such as continuous Fourier transform and discrete Fourier transform. Fourier analysis was originally proposed as a tool for analytical analysis of thermal processes.

(3) The detection result is expressed by the subtraction curve of the spectrum of the measured image and the standard image. Compared with the difference image method, the obtained results are more intuitive, and it is easier to observe and determine whether there is a ghosting defect in the measured image.

Therefore, the preprocessing algorithm of digital image has become the mainstream algorithm of ceramic product modeling design.

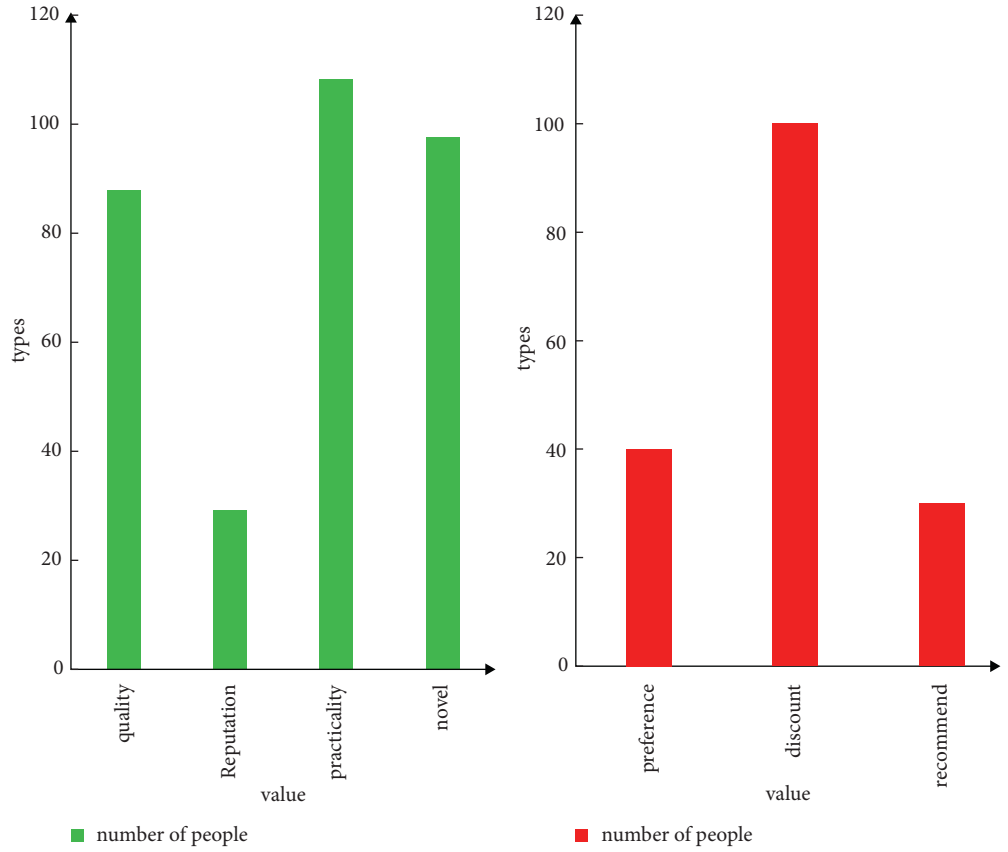


Figure 3: Information sources of buying ceramic products.

4. Experiment of Ceramic Product Design

4.1. Experimental Investigation

Investigation objects and locations: Because the preprocessing technology of digital images is suitable for the production of individualized and nonbatch products, it is very suitable for small groups of people, such as literary youth, pottery lovers, and people who pursue individuality. The research location was the ceramic table shop of China Art Library in Luodai, Chengdu. There were many ceramic lovers aged 30–50. In Chengdu Chunxi Road fashion stores, there were many people who pursued individuality, and the age group of them was 20–35 years; Memory Literature Street in the eastern suburbs of Chengdu was also one of the research sites. At the same time, after the questionnaires were distributed on the Internet, they were collected for statistical analysis.

Investigation content: It is necessary to conduct research not only on the monthly income of the crowd but also on various aspects of the product, such as functional research, modeling research, color research, size research, and element application, in order to lay the foundation for later design positioning and design implementation.

Investigation methods: Paper questionnaires and online questionnaires were used. The paper questionnaires were distributed and collected at fixed points, and network statistics were carried out. Then the network questionnaires were collected. Finally the overall statistics and analysis were carried out, and the analysis results were given.

The analysis of the survey results is as follows.

The survey population and the distribution of the number of people are shown in Table 2. The literary and artistic youth accounted for about 47%, with about 56 people. Pottery enthusiasts accounted for about 27%, with 32 people. Young people who pursued individuality accounted for about 26%, with 31 people. The number of literary and artistic young people surveyed was relatively large, and the numbers of pottery lovers and young people pursuing individuality were equal.

The monthly income survey and statistics of the target population were carried out. The survey results are shown in Table 3. There were 4 people whose monthly income was more than 8,000 yuan and 3 people whose monthly income was less than 1,000 yuan who were school students. There were 24 people with 5000–7999 yuan and 59 people with 3000–4999 yuan, which was a large number. There were 30 people with 1000–2999 yuan.

The results of the investigation on the information sources of purchasing ceramic products are shown in the bar chart in Figure 3. The sources of information for purchasing ceramic products include 30 people recommended by

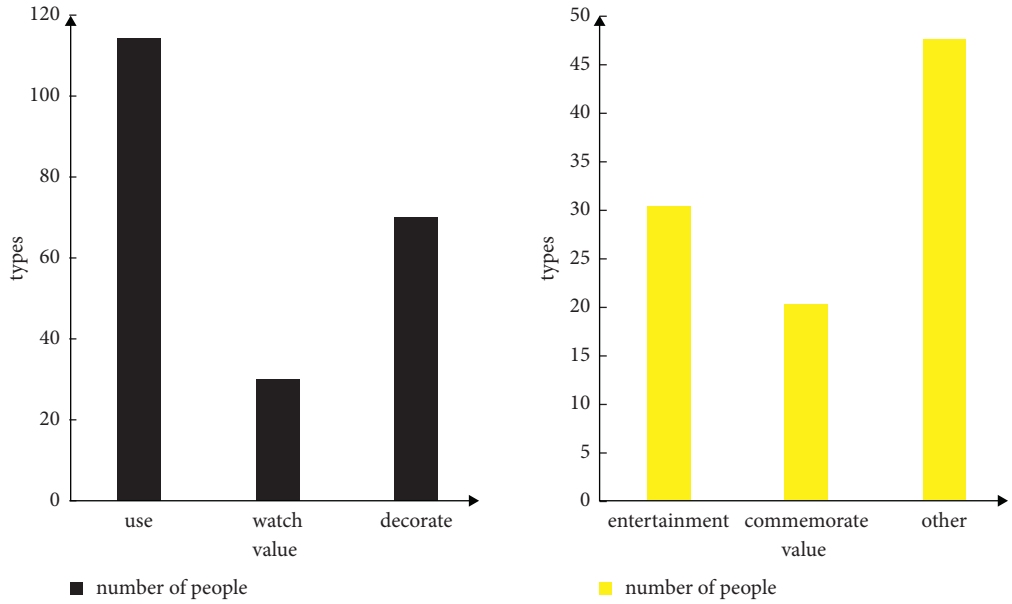


Figure 4: Functional requirements of ceramic products.

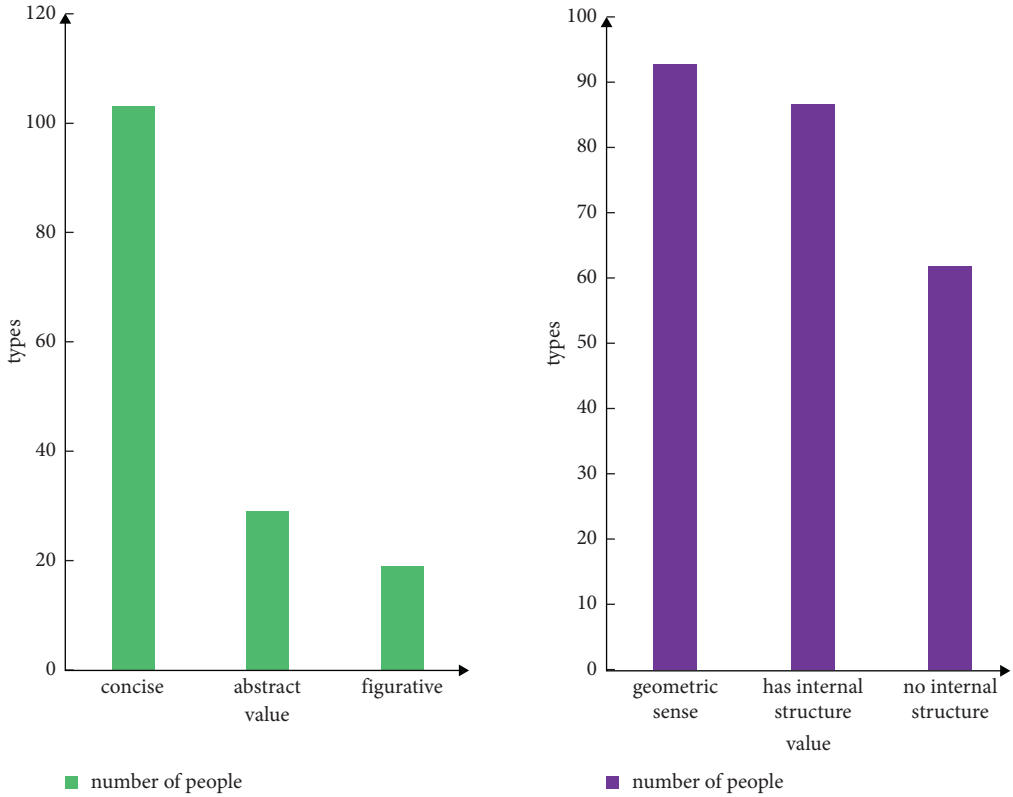


Figure 5: Ceramic product modeling needs.

friends, 100 people with discounted prices, 100 people with novel styles, 40 people with personal preferences, 111 people with practicality, 30 people with brand awareness, and 90 people with quality. From the statistical analysis results, it can be seen that the target group pays the highest attention to the practicality of the product, followed by the novelty of the style, the preferential price, and the quality [14]. Therefore, in the postproduct design positioning, it is necessary to focus on the practicality of ceramic products, and the shape should be different from the existing shape to bring a new visual sense. Meanwhile, the use process should not be complicated, and the cost of the product needs to be

controlled. In order to ensure the quality of the product, it is necessary to pay attention to the selection of ceramic materials and the firing process.

The results of the investigation on the functional requirements of ceramic products are shown in the bar chart in Figure 4. The target group has the largest demand for the use of ceramic products with 114 people. During the survey, it was found that, in addition to the relatively weak demand for ceramic products by ceramic art lovers and the increased concern about the performance of ornamental value, most people expressed their expectation that usability and decoration can be combined. There were about 30 people who had entertainment needs which were mainly reflected in some toys made of ceramic materials. There were about 20 people with commemorative needs which were mainly reflected in ceramic tourism products. There were also about 47 people who had other needs such as making precision instruments and medical applications. Therefore, in the later design positioning, the usability of the product should be reflected [15].

The results of the investigation on the modeling needs of ceramic products are shown in the bar chart in Figure 5. In terms of modeling needs, there were about 103 people who liked brief modeling, 90 people who liked geometric modeling, and about 84 people who wanted to have internal structure modeling. The demand for figurative and abstract shapes was mainly for pottery lovers, so the numbers of people were relatively small, which were about 29 and 19, respectively. The number of people without the need for internal structure modeling was about 60. Therefore, in the postproduct modeling design and positioning, it is necessary to reflect the geometric mechanical sense, the internal structure, and the overall shape to be concise. In the process selection, the process that can reflect the modeling characteristics needs to be selected, such as the preprocessing technology of digital images for production [4].

The results of the color investigation of ceramic products are shown in the bar chart in Figure 6. It can be seen from the bar chart that there were a large number of people who needed a sense of light and elegant colors, about 103 people, which echoed the needs of styling. There were also a large number of people who demanded that the color be combined with the shape to reflect the color difference between the interior and the exterior, about 97 people. Since both the internal and external chromatic aberration and mixed colors can bring novelty to the appearance of ceramic products, there were also a large number of people in the demand for mixed colors, about 84 people. The demand for monochrome, transparent texture, and bright color was similar, about 50 people, 50 people, and 42 people, respectively. Therefore, in the color positioning of ceramic products in the later stage, attention needs to be paid to the embodiment of mixed color and internal and external color difference.

Design positioning was given after market research and combined with the production process. In terms of crowd positioning, there were niche crowds such as literary youth, pottery lovers, and crowds pursuing individuality. This group of people had a strong ability to accept new things and is willing to challenge new things. Product positioning was also given: functions were positioned as being practical and beautiful. Not only is the product practical in the home, but also it can decorate the interior [16]. Modeling structure positioning was given: On the one hand, it needs to be in line with modern aesthetics and the aesthetic needs of the research crowd, and it should be simple and generous. On the other hand, it should reflect the characteristics of ceramic product modeling design under the preprocessing technology of digital images, including features internal structure, geometric mechanics, and layered textures. Color positioning was given: for example, the survey results were mainly fresh and elegant, such as transparent, white, and light blue, followed by some colors such as red, dark green, and dark yellow. On the one hand, it can be placed at home to add color but it is not obtrusive. On the other hand, it can show the texture of the shape under the craft. Size positioning was given: the size was mainly affected by the craft [17]. Because the size range that can be printed by the current layered 3D clay printer is $200 * 300$ mm, taking into account the shrinkage of ceramic biscuit and glaze firing, on the one hand, the size design should not exceed the printing range, and, on the other hand, it should not be too small; otherwise, it will be too small after firing.

4.2. Landscape Element Ceramic Vase Design with Evenly Layered Textured Shape

4.2.1. Reasons to Design Ceramic Vases with Landscape Elements. The reason for designing the ceramic vase with landscape elements is that the craftsmanship can print the graceful texture, which can be well applied to the surface texture modeling of the vase. Then, according to the printing process, the lines are shaped like rivers. If the shaped body is shaped from top to bottom, it looks like a river on a mountain after regular flow. Therefore, it stimulates creative thinking about whether it is possible to use the preprocessing technology of digital images to produce ceramic works that reflect Chinese landscape culture, and the design of ceramic vase with landscape elements is carried out.

4.2.2. Landscape Element Ceramic Vase Design Method. The design method of landscape element ceramic vase applies the direct forming method and loft forming method in the previous computer-aided design method, as well as the design and application of the basic element body and line element of the modeling. By extracting the elements of landscape, the mountains and peaks, the shape of high and low, and the shape elements such as the ripples of water and the trend of water flow can be extracted. Using the body forming method, each model object is directly regarded as a body. The height of the body is used to express the height of the mountain, and the changes of lines and texture changes such as vertical broken lines and vertical arcs are used to express water patterns [18].

4.2.3. Landscape Element Extraction. The overall design idea is that the ceramic products designed and produced by the

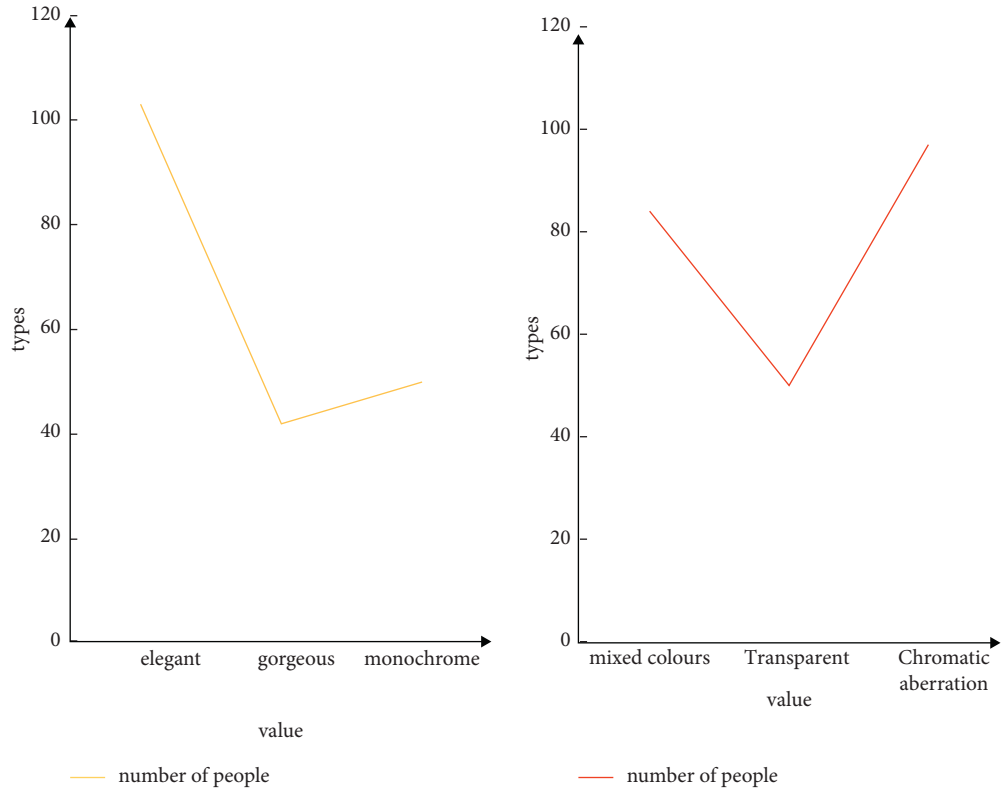


Figure 6: Color requirements for ceramic products.

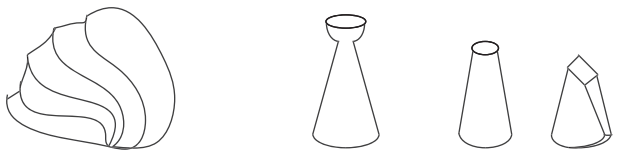


Figure 7: Landscape sketch plan.

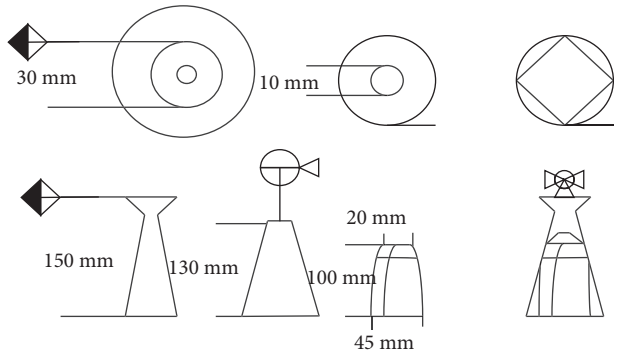


Figure 8: Mountain element ceramic vase dimensions.

preprocessing technology of digital images have a layered and orderly texture, and the vertical texture elements are used to extract relevant elements. The vertical pattern is used because the vertical pattern on the surface is stronger in the modeling expression during the surface texture experiment, and the texture of the stacked ranks is more prominent. Therefore, one of the design elements is vertical stripes. Schematic design is carried out by using the overlapping and staggering of elements, and then the 3D model is established. In this design, the source of the design of the first series of landscape vases is the shape of the landscape. In the extraction of the modeling elements, the shape of the mountain—the protrusions of different heights, the shape of the water—the flowing ripples, and the folds of the water are extracted, respectively, to design and create [19].

4.2.4. Use of Body Elements and the Deliberation of Plans. Through the above extraction of landscape elements, two methods are adopted in the design of mountain elements. One of the methods is that the stacking of mountains is expressed in one form. The highest peak on the left in Figure 7 is designed for the bottle mouth. The connection between the peaks of different heights adopts a graceful arc, adding elements of softness to the tough mountain. Another method is to express the stacking of mountains with separate shapes as shown on the right in Figure 7, and the

Table 4: Bitmap color table structure definition.

Field name	Field size	Field content
rgbBlue	1	Blue component
rgbGreen	1	Green component
rgbRed	1	Red component
rgbReserved	1	Reserve

(a) (b)

Figure 9: Difference between glazed and unglazed.

(a) (b) (c) (d) (e)

(f)

Figure 10: Finished product display.

lowest shape is used to express the lowest peak of the climb. The shape of the bottle mouth is a square, which symbolizes the toughness of the mountain, as well as the ups and downs and doubts of people in the road of life. The bottle body is arced to soften the tough shape. The middle-height vase is designed to be round at the bottle mouth, which is used to express that with the height of climbing and the progress of life, the level is getting higher and higher, and the doubts in the heart are slowly being resolved. The tallest vase is designed with a prominent round shape at the mouth of the bottle, which is used to express the ultimate breakthrough of the bottleneck to reach the peak. The overall use of three shapes with different heights not only reflects the level of the mountain but also shows the metaphor of the mountain.

4.2.5. Human-Machine Dimension Analysis of Landscape Element Ceramic Vase. The size of the mountain element vase is shown in Figure 8. The minimum vase height is 110 mm, and the size of the bottle mouth is 20 mm ∗ 200 mm. The height of the bottle and the size of the bottle mouth are different, implying a breakthrough in life. The diameter of the middle bottleneck is 10 mm, and the diameter should not be too small. The printing will fail if the slope is too large. The diameters of the bottoms of the three bottles are 45 mm, 50 mm, and 60 mm, respectively, implying that the accumulation of life is more and more.

4.2.6. Color Analysis of Ceramic Vase with Landscape Elements. The true color bitmap does not need a color table, while other bitmaps need a color table. The biBitCount component in the bitmap information structure determines the length of the color table, as shown in Table 4.

There are many kinds of glazes made of quartz, feldspar, borax, clay, and so forth. They are coated on the surface of porcelain and pottery and fired into a vitreous luster, which

can be divided into crystalline glaze, crack glaze, and so on. A layer of vitreous glaze is coated on the fired blank, mainly for protection and decoration. In terms of color selection of landscape element ceramic vases, there are two groups. A group of landscapes are not glazed as shown in Figure 9. Only the color of the clay itself is used to express the sense of simplicity and make the user closer to nature when using it. Another group of works with landscape elements are glazed, and the vase with mountain elements is in shadow cyan. On the one hand, this is a long-term representation in painting. On the other hand, it can also be used to represent the blue sky. The water element vases are all eastern green as green mountains and green waters. During the coloring process, the glaze should not be too thick to drown the layered texture.

4.2.7. Display of Finished Ceramic Vases with Landscape Elements. The finished product display is shown in Figure 10.

5. Conclusions

Through digital image preprocessing technology, the shape design of ceramic products can be different from the traditional forming process, with internal structure, internal filling, geometric mechanical sense, and evenly layered shape, thus enriching the appearance style of ceramic products. It brings new visual enjoyment to the appearance design of ceramic products and provides a reference for the ceramic products industry to apply digital image preprocessing technology for modeling design. However, not all sculptures are amenable to digital image preprocessing techniques. On the one hand, since the conveying method of the digital image preprocessing technology machine adopts air pressure push, although a stirring wheel device is installed at the needle head, that is, the material ejection port to remove the air, the stability of the air pressure cannot be kept constant all the time. Therefore, sometimes a certain layer will protrude, destroying the beauty of the overall shape, and sometimes it will even cause the body to explode and damage the work. On the other hand, at present, the preprocessing technology of digital images has just started. Especially in China, the accuracy of the printer still needs to be improved, especially the research and improvement of layer thickness. Because the mud strip is in a wet state during the printing process, it is difficult to achieve a shape with a relatively large arc. The thicker the layer is, the easier it will collapse. The author only studies the new ceramic molding process, that is, the shape design of ceramic products under the laminated 3D printing process, but little research on the hidden worry that the new process will weaken the traditional manual experience is explored. There are different views on the impact of the new process on the traditional molding process. Therefore, the combination of layered 3D printing process and traditional handicraft can be studied, including what new shapes will be brought about by the combination of the two and whether the combination of the two can weaken the direct impact on the inheritance of traditional hand molding.

Data Availability

The data that support the findings of this study can be obtained from the corresponding author upon reasonable request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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