Research on Machining Design of Ceramic Products Based on CAD Software

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Abstract. Machinable ceramics with its excellent electromagnetic, mechanical, high temperature resistance and environmental corrosion resistance and other comprehensive properties, in national defense, aerospace, precision instruments and other fields have been widely used. The standardization and science of CAD drawing provides a standardized design scheme for ceramic product design, thus improving the success rate and efficiency of the design. In order to promote the ceramic industry to adopt CAD/CAM technology to play a role in attracting jade. To solve the problem of piecing each block image obtained by CAD image scanning, combining with the data characteristics of scanned image, firstly, an improved SIFT (Scale Invariant Feature Transform) algorithm is used to obtain and match feature points, and RANSAC (Random) is used Sampling Consensus algorithm selects the matching point pairs to obtain the transformation matrix, and then the fabric scanning images to be stitched are mapped to the reference space through the transformation matrix. Finally, the linear transition method is used to achieve seamless stitching between images. The experimental results show that this method is not only effective and fast selection, Moreover, it maintains good stability for translation, rotation, brightness difference and deformation to a certain extent between scanned images of fabric, and can be well adapted to the automatic Mosaic of images in converging and weaving CAD. This method is based on particle swarm optimization algorithm to search the global optimal solution to obtain the optimal threshold of the image to be segmented.

Keywords: CAD Software; Ceramic Products; Process Design
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1 INTRODUCTION

Computer Aided Design (CAD) technology is an emerging technology formed by the combination of computer science and engineering design. CAD system is a complex information processing system for engineering applications composed of computer-dominated hardware and software. Ceramic dyeability refers to the effect that AlMawash et al. [1] present different colors on the surface of ceramic materials by adding dyes during the firing process. Dyeability has a significant impact on the performance of ceramic materials, as it can alter the surface properties of ceramic materials, thereby affecting their performance and application. On the one hand, dyeability can alter the surface characteristics of ceramic materials. For example, adding dyes can make the surface of ceramic materials present various colors and patterns, thereby changing the appearance of ceramic materials. This change can affect the coefficient of thermal expansion, electrical conductivity and mechanical strength of ceramic materials. On the other hand, dyeability can affect the application of ceramic materials. For example, some ceramic materials can be used to manufacture high-temperature structural materials, such as high-temperature furnaces, burners, heat exchangers, etc. These materials usually need to have high temperature, wear resistance, corrosion resistance, and other properties, and adding dyes can make the surface of ceramic materials present different colors and patterns, thereby changing the surface properties of ceramic materials. This change can improve the service temperature and lifespan of ceramic materials, thus making ceramic materials have good application prospects in the field of high-temperature structural materials. In summary, the dyeability of CAD/CAM ceramics is an important ceramic performance parameter that has a significant impact on the performance and application of ceramic materials. Dyeability can alter the surface properties of ceramic materials, thereby affecting their performance and application. Dartora et al. [2] analyzed the process of computer-aided design and manufacturing of ceramics using computer technology. Computer assisted ceramics can be divided into two stages: pre-processing stage and post processing stage. The pre-treatment stage mainly includes steps such as raw material processing, preparation of billets, and sintering. At this stage, computer technology can be used to design the composition and structure of ceramics. And generate corresponding design drawings. For example, using computer-aided design software, the optimal composition combination and billet preparation plan can be automatically calculated based on the material information and composition requirements provided by users. The post-processing stage mainly includes steps such as forming, processing, and surface treatment. At this stage, computer technology can be used to process and surface treat ceramics to generate the final product. For example, using computer-aided manufacturing software, ceramics can be automatically formed and processed based on design drawings provided by users, generating the final product. Computer assisted ceramic technology can greatly improve the efficiency and quality of ceramic manufacturing, while also reducing manufacturing costs. With the continuous development and popularization of computer technology, computer-aided ceramic technology will be more widely applied.

With the improvement of living standards, ceramic products used in hotels and units have entered thousands of households. People not only require sanitary products to be durable, but also require it to be beautiful and elegant, advanced function. In order to meet the needs of the market, many ceramic manufacturers have introduced advanced ceramic production equipment, the production of advanced functions, beautiful appearance, excellent quality of high-grade ceramic products. However, it must be seen that in the vast majority of ceramic manufacturers, the design work is still at a rather backward level or even no ability to design and develop new products. De Almeida et al. [3] conducted three-dimensional modeling of ceramics. Modeling software provides rich modeling tools and methods that can be customized and modified according to user needs, thereby quickly and accurately constructing a three-dimensional model of ceramics. In the CAD modeling process, material parameters of ceramics, such as density, thermal conductivity, hardness, etc., can be preset for reference and control in subsequent manufacturing and processing processes. Through computer simulation software, the performance and behavior of ceramics can be simulated and analyzed to optimize the design and manufacturing process. The virtual model of CAD ceramics can simulate the reaction and deformation of ceramics at different temperatures, pressures, and times, as well as the mechanical properties under different loading conditions. Hampe et al. [4] optimized the structure, composition, and performance of ceramics through virtual models of CAD ceramics. Virtual models can assist designers in material selection and optimization, thereby improving product performance and quality. It is often used to purchase foreign advanced product production mold and production equipment method to produce more high-grade ceramic products.

There are three problems caused by this method: first, the investment required to buy the production of molds is quite large, and the service life of each mold is quite limited, so it increases the cost of the product and weakens the competitiveness of the product in the market; Second, the purchase of a set of molds can only produce a product, cannot develop new products, so it is not conducive to product competition in the market; Third, long-term use of foreign equipment and product design, easy to form dependence on foreign manufacturers, is not conducive to the localization of ceramic products, more conducive to the development of national industry. Heck et al [5] In this way, the imitation of a new product has to go through a long process of product function/structure analysis, product model manufacturing, lofting manufacturing master mold, manufacturing mold pouring, billet drying, glazing, sintering and so on before it can find out whether the original design is reasonable. Kanat [6] calculate color changes using ANOVA(ΔE) And conduct statistical analysis, and then use the 2007 Number Cruncher statistical system for post hoc testing of Bonferroni correction ($\alpha < 0.05$). Because the raw material formula used by each manufacturer (mainly mud formula) is not the same, the production process is not the same, this process for each manufacturer is not able to borrow from each other. As a result, the time to copy a new product is often several months or even more than a year. Obviously, such a design process increases the cost of products, and such speed and efficiency cannot meet the requirements of market competition. In addition, in this way of design, there is another big drawback, is the reliance on experienced stylist. We see in many manufacturers, in the imitation design, completely rely on the experience of the stylist to analyze the product, with their long-term work experience to make product models, working models. In this case, the designed products cannot be tested effectively to ensure that all products have the same quality, and the product library cannot be established in the manufacturer's house. At the same time, the loss of a good stylist often means that the manufacturer's products do not have any secrets, but also the loss of the ability to develop new products. In short, it is also a design method of low labor productivity. Kermanshah et al. [7] evaluated the protective effect of fluoride mouthwash on the surface microhardness of two CAD/CAM ceramics after exposure to acidic solutions. Immersion in different solutions reduces microhardness. In both types of ceramics, the microhardness loss of the G FAA and G FGA groups is significantly affected.

2 RELATED CONCEPTS

The application and development of CAD technology in ceramic enterprises is relatively backward compared with other industries, such as machinery, electronics, aviation and so on. In foreign countries, the research is mainly engaged in the production enterprises, due to commercial competition, few papers published. In China, according to the situation of enterprise research and published papers, the research and development of CAD in ceramic enterprises in China is mainly concentrated in the following three aspects: computer aided design of ceramic products; Mourouzis et al. [8] modified ceramics with resin to improve their performance and application range. CAD resin modified ceramics refer to the use of computer-aided design software such as AutoCAD, SolidWorks, etc. Resin modified ceramics can change the performance and surface characteristics of ceramics by adding different types and quantities of resins. The advantages of CAD resin modified ceramics include the ability to quickly and accurately design and manufacture, the ability to simulate and analyze to optimize design and manufacturing processes, and the ability to perform CNC machining to optimize processing efficiency and quality. However, the manufacturing cost of resin modified ceramics is relatively high, and in some cases, the added resin may affect the chemical stability and mechanical properties of ceramics. Saravi et al. [9] incorporated some CAD resin modified ceramics. The performance and application range of ceramics are improved, but the manufacturing cost is relatively high. In some cases, the added resin may affect the chemical stability and mechanical properties of ceramics. Silva et al. [10] Mixed ceramics refer to the addition of different types and quantities of ceramic particles or powders to ceramic materials, thereby altering the performance and surface characteristics of ceramics. When processing mixed ceramics in CAD/CAM, grinding equipment such as ball mills are usually used to grind ceramic particles or powders to evenly disperse them in the ceramic material. When conducting CAD/CAM processing, it is usually necessary to use a high-energy ball mill to pre-treat the mixed ceramics to break the ceramic particles or powders and make them evenly dispersed in the ceramic material. Then, various CAD/CAM software such as SolidWorks, AutoCAD, MASTERCAM, etc. can be used to design and manufacture hybrid ceramics, including steps such as 3D modeling, material parameter presetting, visual simulation, and optimization design. Skorulska et al. [11] found that factors such as the size, distribution, and morphology of ceramic particles or powders can affect the performance and application range of ceramic materials in the CAD/CAM treatment of mixed ceramics. Therefore, when conducting CAD/CAM processing, it is necessary to select appropriate grinding equipment and software according to the specific situation, and conduct experiments and optimization to obtain the best processing effect. The materials suitable for this technology are continuously tested, evaluated, and improved. The paper discusses the computer-aided design of symmetrical rotating ceramic product modeling, which uses B-spline method in NURBS to construct curves to generate ceramic product modeling. They studied the B-spline surface modeling design of the non-rotating body, and obtained the three-dimensional modeling of ceramic products through the reasonable use of points, lines and surfaces, the splicing of the surface body, perspective and blanking. After the three-dimensional modeling is obtained, the cutting and dimensioning of each part can be carried out, and then the computer-aided design of the ceramic product mold can be carried out according to the thickness of each part of the modeling, the characteristics of mud material and the water absorption characteristics of Shiyin paste material. Vasiliu et al. [12] analyzed that CAD hot pressed glass ceramics refer to the process of designing and manufacturing hot pressed glass and ceramic materials in CAD software. Hot pressed glass and ceramic materials have good mechanical properties and chemical stability, so they have broad application prospects in many applications. In CAD software, various modeling tools and methods can be used, such as stretching, rotating, scanning, etc., to perform 3D modeling of hot-pressed glass and ceramic materials. Modeling software can also provide material parameter preset functions for reference and control in subsequent manufacturing and processing processes [13]. Vasiliu et al. [14] used various simulation tools and methods, such as thermodynamic simulation and dynamic strain analysis, to conduct thermodynamic performance and dynamic strain analysis on hot-pressed glass and ceramic materials to optimize design and manufacturing processes. Venturini et al [15] evaluated the fatigue failure load of adhesive materials with different microstructures (glass, hybrid, and resin ceramic) used for manufacturing CAD/CAM integrated restorations. It analyzes the number of cycles before failure and the probability of survival. When designing and manufacturing CAD hot pressed glass ceramics, it is necessary to select appropriate modeling and simulation tools based on the specific situation, and conduct experiments and optimization to obtain the best design and manufacturing results. In summary, CAD hot pressed glass ceramics is an important ceramic manufacturing technology that can improve the performance and application range of ceramic materials, but it needs to be designed and manufactured according to specific circumstances to achieve the best processing effect.

3 METHODS

3.1 Ceramic Block Image Acquisition and Stitching Algorithm

The ceramic block image is obtained by scanning a bmp bitmap with a size of 1755×1275 and a bit depth of 24, and a certain degree of overlapping sampling is maintained between adjacent blocks (more than 10%, and there are detailed features in the overlapping area, that is, no single texture). For the scanned image, the precision has met the requirements, the large ceramic style can be collected completely through the block. However, limited to the characteristics of the scanner and the ceramic itself, there are inevitably differences between each block image, mainly translation and rotation, as well as some brightness changes and deformation. Among the images to be stitched obtained by scanning in this paper, there are a large number of horizontal or vertical correlated images to be stitched in reality. Here, two horizontal scanned images are taken as examples. The whole algorithm process is shown in Figure 1.

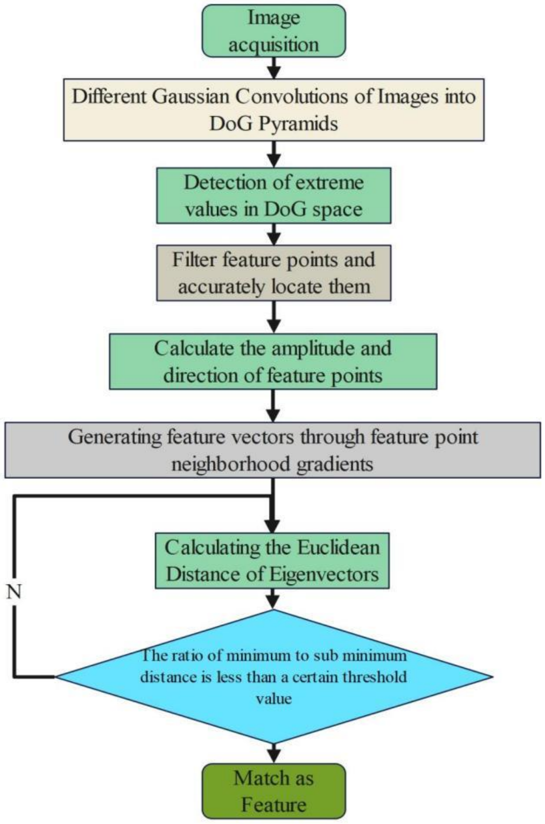

Figure 1: Flow chart of SLFT algorithm.

Due to the high computational complexity of SIFT algorithm itself, a lot of uncertain parameters, they determine the quality and quantity of detection feature points, need to determine the approximate range of the best parameters by experiment, at the same time in order to reduce the time of the algorithm, this paper has made partial improvements to its feature extraction and feature matching.

$$octave = \log(\min(x_{\max}, y_{\max})) / \log 2 - 1 \tag{1}$$

Although the improved SIFT algorithm is weakened in the amount of information contained, but for the ceramic scanning image, the experiment proved that the feature points are still enough and effective, and the complexity of the algorithm and the amount of computation has decreased significantly.

In SIFT algorithm, it is assumed that two images L. The number of feature points of and L: are N1 and Nz, respectively. Use L for feature matching. The feature vectors of one of the feature points in L: are compared with the feature vectors of all the feature points in L:, and the features are calculated. Euclidean distance between vectors, N2 Euclidean distance, where the minimum distance and the subminimum distance are D. And D:. If D. The value of/D2 is less than a certain threshold, which is 0.5 in this paper, then L is considered. In the feature point and L. Is matched by the feature points that produce the minimum distance.

3.2 Ceramic CAD Image Segmentation Method Based on Particle Cluster Clustering Algorithm

PSO method is originally derived from a simulation of the collective foraging behavior of birds, and is inspired from this process and applied to solve different optimization problems. Its basic principle is described as follows:

The fitness value of each particle's position in the search space is measured by a pre-determined evaluation function. In addition, in different PSO improvement methods, the neighbor of the particle can be preset as the particle in the adjacent region of the population. In this case, the global extreme value comes from the local extreme value in the adjacent region of all the particles. During the flight of particles in the search space, each particle has certain information exchange with the particle population, sharing their collected information about the area where the potential solution is located. This "tacit understanding" between particles will ensure that the vast majority of the particle population will eventually fly to the location of the optimal solution or its adjacent area. In every flight of particles (diaad), Each particle follows the global optimization model proposed by YuShi and Hui Russell Eberhart. That is:

$$v_{k+1} = \omega v_k + c_1 \times r_1 \times (pbest_k - x_k) + c_2 \times r_2 \times (pbest_k - x_k) \tag{2}$$

$$x_{k+1} = x_k + v_{k+1} \tag{3}$$

Where, k represents the number of overlapping times (i.e., flight time), vk is the velocity vector of a single particle in the search space, xk represents the current flight position of a particle in the search space, and pbestk represents the optimal flight position of a single particle found after k flights in the search space, which is the temporary optimal solution obtained by solving the problem of a single particle. pgbestk represents the optimal flight position found by the particle population after k flights, which corresponds to the current optimal solution of the particle population. vk+1 is the sum of vectors vk, pbestk-xk, and pgbest-xk. Here, in order to prevent the speed of particles from being too fast or too slow during the flight, the speed of particles per dimension is usually limited within a reasonable range [vmin, vmax]. If the speed of a certain dimension is not within the specified speed range after the flight, the speed of the dimension will be reset in the following way. That is:

if $v_k > v_{\max}$

$$v_k = v_{\max} \tag{4}$$

if $v_k < v_{\max}$

$$v_k < v_{\max} \tag{5}$$

In other cases

$$v_k = v_k \tag{6}$$

In addition, the parameters involved in the execution of PSO method also include inertia weight ω. Two accelerating constants called learning factors c1 and c2. Two random constants r1 and r2.

The application of K-clustering in pattern recognition in CAD image segmentation is based on the following principles: the goal is to maintain the maximum similarity between pattern samples (i.e., pixels) within a class and the maximum distance between different types. The optimal threshold of image segmentation is obtained by using the adada rule. The steps are:

㊀ In the case of a single threshold, the image is divided into target c1 and background c2 by randomly setting a threshold t1. The probabilities of the two categories are as follows:

$$p_1 = n_{c1} / N_{image} \tag{7}$$

$$p_2 = n_{c2} / N_{image} \tag{8}$$

Where, nc1 is the number of pixels of ci class (i= 1,2), and Nimage is the total pixels in the image. The central gray mean μi and variance of the two categories are:

$$u_i = \frac{1}{n_{ci}} \sum_{(x,y)\in ci} f(x,y) \tag{9}$$

$$\sigma_i^2 = \sum_{(x,y)\in ci} (f(x,y) - u_i)^2 \tag{10}$$

record

$$h(t_1) = p_1\sigma_1^2 + p_2\sigma_2^2 \tag{11}$$

⊜Each pixel in the image is classified. The way is as follows:

$$(x,y) \in \begin{cases} c_1, if \mid f(x,y) - u_1 \mid \le \mid f(x,y) - u_2 \mid \\ c_2, else \end{cases} \tag{12}$$

③After classification processing, all pixels in the target and background need to recalculate the center gray mean u_i^{new} , $\sigma_i^{2(new)}$, record

$$h(t_2) = \sum_{i=1}^{2} p_i^{new} \sigma_i^{2(new)} \tag{13}$$

$$t^* = \arg\min h(t) \tag{14}$$

Similarly, in the case of multiple thresholds (take the case of double thresholds as an example), after each classification, if the following formula is met, then the threshold is determined; otherwise, the pixel is re-allocated and then compared in the following way.

$$h(t^{old}) = p_1^{old}\sigma_1^{2(old)} + p_2^{old}\sigma_2^{2(old)} + p_3^{old}\sigma_3^{2(old)} \tag{15}$$

Using the optimization ability of particle swarm, image segmentation can be regarded as the particle swarm optimization problem in the process of PSO execution. When different particles continue to learn from each other and exchange information without interruption, most of the particles will finally find the optimal position or its adjacent area, so as to determine the optimal threshold of image segmentation. Since the gray level of pixels in image processing is 256, here, the initial position and speed of particles in the experimental test as well as the position and speed of particles in each overlapping are limited to [0,255]. Figure 2 describes the implementation flow of the particle swarm clustering algorithm, and the corresponding particle swarm clustering algorithm is described as follows.

4 RESULTS AND ANALYSIS

4.1 Experimental Verification

Experimental environment for: Intel Pentium4, CPU2.26 GHZ, Windows xp, Matlab7.0, VisualC++ 6.0 and OpenCV, images used for scanning the CAD drawing of ceramic images. In the experiment, the proposed particle cluster clustering algorithm is referred to as ISPSO method for short, and the proposed particle cluster clustering algorithm is applied to the edge segmentation of two ceramic images to identify the fine crack details in CAD ceramic images, and then compared with OTSU, the maximum inter-class variance method commonly used internationally. Test CAD image bowl and title size :243×300,512×512.

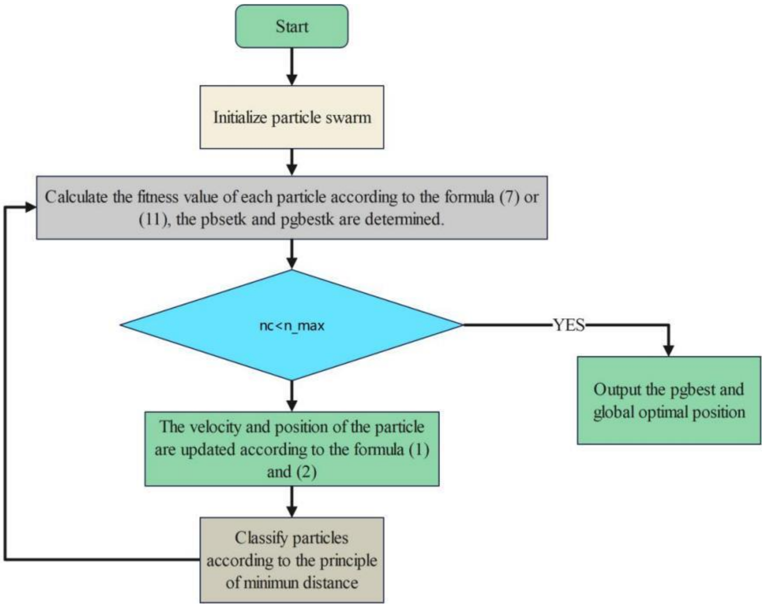

Figure 2: Flow chart of particle swarm clustering algorithm.

4.2 Result Analysis

In the experiment by scale space factor. Feature points of contrast ID (X) | and the adjustment of the parameters such as ring main curvature ratio value can be suitable for the stability of the current image splicing effect, These parameters are different with the image size, reason, etc. In this paper will be set to 2,D(X) set to 008, the main curvature ratio net value set to 3 Other parameters as shown in this paper, respectively, the SIFT algorithm parameters for default Settings and improved SIFT algorithm to compare the situation that the former is 8 octave, feature vector 128 dimension of the latter is 2 The feature vector was 32 dimensional and the comparison number of BBF algorithm was set dynamically. Moreover, the interior points were optimized by RANSAC algorithm to remove the outpoints. The experimental results were obtained. Four groups of jacquard ceramic scanning images were splicted, and the feature matching pairs obtained by BBF algorithm and the matching pairs determined as interior points by RANSAC algorithm were recorded. The interior points were determined according to the error within 2 pixels after the optimal transformation matrix. At the same time, the difference of time spent on image Mosaic before and after the algorithm improvement is calculated. SIFT method before and after the ceramic scanning image with translation, rotation, brightness difference and a certain degree of deformation can get enough and accurate matching pair the original algorithm based on 128 dimensional vector space matching in obtaining the initial feature matching pair and the correct matching logarithm calculated and the improved algorithm obtained useful information is similar, but the time is obviously too much and the improved algorithm The algorithm greatly improves the speed of operation without affecting the precision of stitching. Since the image itself is large and the algorithm complexity is relatively high, the stitching time still stays at the second level, so as to exchange the quality of the image stitching. As shown in Figure 3. Figure 4 shows the experimental results of the recall1-precision curve corresponding to the figure. The results showed that Surf-Rbrief hardware implementation scheme performed slightly better than OpenCVSURF and OpenCVSURF-BRIEF under the UBC test set, but slightly worse than ORB. The SURF-rBRIEF hardware implementation scheme studied in this paper has good robustness to image blur and illumination changes, and is better than ORB algorithm to a certain extent, achieving the expected research objectives.

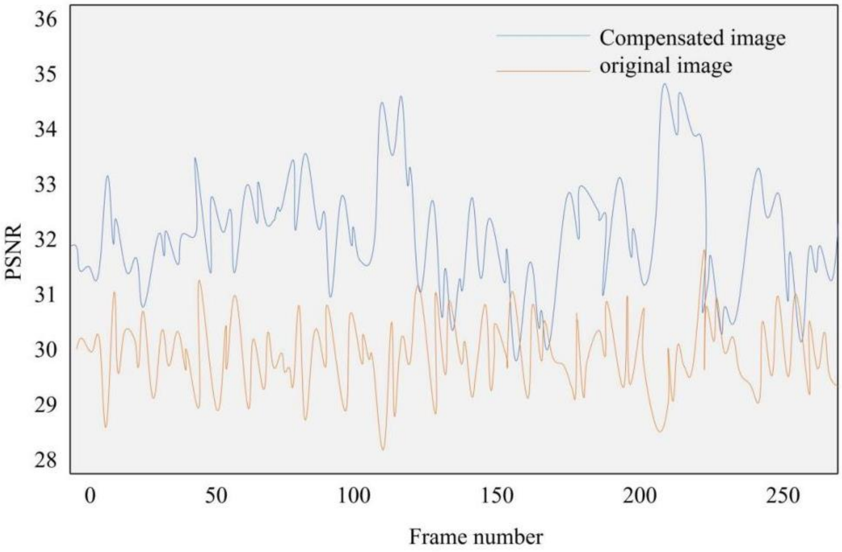

Figure 3: Comparison of PSNR between initial image and compensated image.

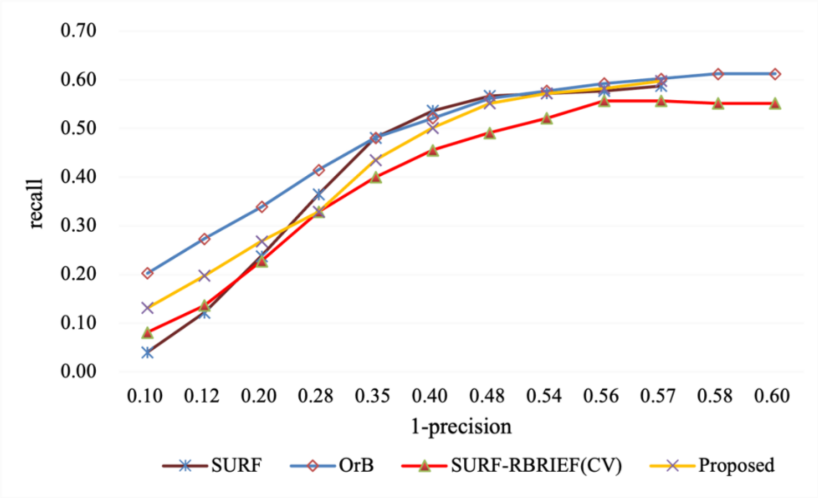

Figure 4: Recall & 1 - precision curve evaluation results.

Figure 5 presents the experimental results of this test method, in which light gray represents the number of matching point pairs obtained by OpenSURF-rBRIEFRANSAC, blue represents Nproposed, and black represents NC. In this experiment, the detection threshold of hardware SURF feature points was set at 150, and the Hamming distance matching threshold was set at 42. The purpose of this setting was to detect more feature points and control the matching results within a certain number range, thus ensuring the matching accuracy. Since the matching result of Open SURF-rBRIEF-RANSAC will be used as the reference sample, its threshold should be set loosely to obtain more matching point pairs consistent with the results of the hardware implementation scheme in this paper. As can be seen from Figure 5, this design still has a good performance in practical application scenarios, with the relative matching accuracy of the test results of the two pairs of images reaching more than 90%, and the relative matching accuracy of the test of the actual scene with large rotation reaching more than 85%, realizing the expected design goal of making the feature point extraction and matching screening system with rotation invariance.

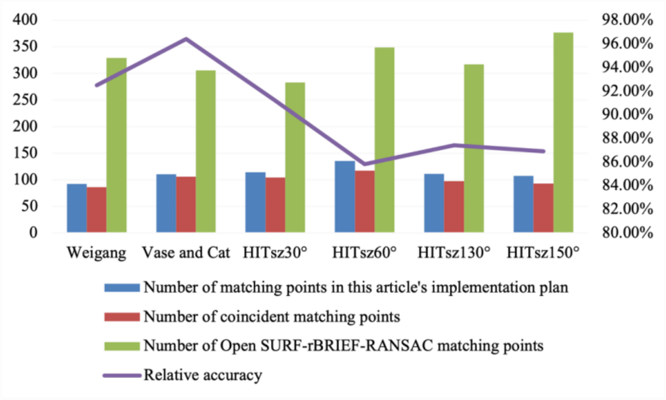

Figure 5: Test the relative matching accuracy of pictures.

In the process design, not only the image stitching is involved, but also the image segmentation, which is another technology to promote the progress of ceramic product processing. Therefore, we further study the CAD ceramic image segmentation technology. The number of particles used is set as np=20; The inertia factor w decreases linearly from 0.9 to 0.3. Overlap number nmax=200. The acceleration constant c1=1.5 and c2=1.6. Clustering of particles

10 independent experiments were conducted on the algorithm. Figure 6 and Figure 7 are the effect histograms of image segmentation by OTSU method. In the test in this paper, the optimal threshold of OTSU after segmentation of bowl and tile images is 175.0065 and 196.9875, respectively. For the ISPSO proposed in this paper, we run this method 10 times, and the optimal threshold values after bowl and tile images are 178.5 and 204.27 respectively, and the 10 times of obtaining threshold values are relatively close. In addition, the time of obtaining optimal threshold values is also within the acceptable range. By comparing the segmentation results of the two methods, it can be seen that the proposed ISPSO method can effectively extract the crack details and effectively separate the crack region from the surrounding background.

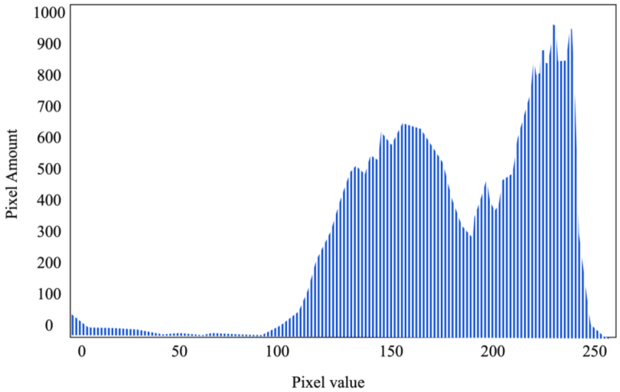

Figure 6: Histogram corresponding to normal ceramic image.

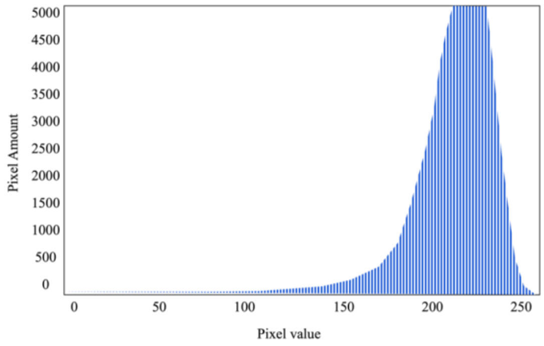

Figure 7: Histogram corresponding to cracked ceramic image.

Based on the analysis of the above experimental results, it can be seen that the running time of image segmentation method based on particle clustering is short, so the corresponding computational amount is not large, and the optimal position can be found relatively quickly. Therefore, the particle clustering effect of PSO in this paper is relatively ideal. While maintaining the stability of the optimal result, the time of searching the threshold value in the experiment does not fluctuate too much. This fully shows that the proposed method PSO can achieve a reasonable compromise in terms of search accuracy, threshold stability and speed. The experimental results show that the particle swarm clustering algorithm proposed in this paper is more effective for a specific application range.

5 CONCLUSION

In this paper, an automatic image Mosaic algorithm in ceramic CAD is proposed. Improved SIFT algorithm, BBFRANSAC algorithm and other algorithms can be used to Mosaic ceramic scanning images quickly and effectively. Moreover, it has good stability for displacement, rotation, brightness difference and certain deformation caused by scanning. It also further optimizes the contradiction between stitching speed and stitching quality, which is common in image stitching. Compared with the original algorithm, it has better real-time performance without damaging stitching quality. This is especially suitable for the subsequent large-scale panoramic Mosaic of jacquard ceramics. From the perspective of multiple different scanning Mosaic, automatic Mosaic of ceramic images can be applied in practice, so as to improve the design and application level of ceramic CAD to meet the development needs of the industry. In addition, an improved particle swarm optimization method is proposed based on the requirements of ceramic image segmentation, and it is applied to the segmentation of ceramic CAD images. From the experimental test results, it can be seen that the improved PSO method can better realize the segmentation and extraction of figures and target areas in the image. The determination of segmentation time further shows that the improved PSO method has certain effectiveness. The subsequent work of this paper will continue to deeply study the influence mechanism of different parameters of the improved PSO method on the image segmentation effect, and quantitatively analyze its influence degree.

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