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Retraction

Retracted: Application of CAD/CAM Technology in Electrochemical Relief Design and Processing of Ceramic Art

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] H. Li, "Application of CAD/CAM Technology in Electrochemical Relief Design and Processing of Ceramic Art," *Journal of Chemistry*, vol. 2022, Article ID 8190143, 6 pages, 2022.

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Research Article

Application of CAD/CAM Technology in Electrochemical Relief Design and Processing of Ceramic Art

Hongyan Li

Office of Educational Administration, Chongqing City Vocational College, Yongchuan, Chongqing 402160, China

Correspondence should be addressed to Hongyan Li; 20160197@ayit.edu.cn

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Ceramic relief modeling design and CNC machining programming have a wide range of applications in industrial production and daily life. In view of the actual needs of enterprises, this research studies the CAD simulation technology of ceramic relief and achieves the modeling of other pieces of relief based on the geometric outline of the plane breakthrough. According to geometric relief modeling, bitmap relief modeling, tool path selection, and relief simulation processing, the establishment of a ceramic relief model is realized. Finally, the simulation processing is carried out on the ArtCAM software platform, and reasonable processing parameters are obtained to realize the CNC engraving processing of ceramic relief. The experimental results show that the machining efficiency of the ceramic relief model established in this study is improved by 11.3% and 42.8%, respectively, compared with the two traditional methods, which verifies the correctness and superiority of the designed model.

1. Introduction

Ceramic carving is one of the most important traditional ceramic art decoration techniques. It has a long history in China. Its development process embodies the wisdom and hard work of potters of all dynasties. Aesthetic development track [1]. In recent years, people's living standards have been continuously improved, and the real estate industry has developed rapidly, which has brought about an increase in the demand for ceramic art. Interior decoration crafts, mainly lamps and carved vases, are more and more popular among people. At present, the traditional ceramic engraving method is still in the manual processing stage, and the patterns that can be engraved are relatively simple, which is far from meeting the deep needs of the market [2]. Based on market demand and production needs, the introduction of CAD/CAM technology into ceramic engraving processing and the use of CNC engraving processing technology to replace traditional manual engraving processing methods will greatly improve production efficiency and product quality. Figure 1 shows a typical case designed and manufactured by the CAD/CAM platform [3].

2. Literature Review

Geometric relief is to model a three-dimensional relief surface for a given two-dimensional contour area. This method is widely used in relief design, but there is no certain formula to specify the height value of each point in the contour area. Generate geometric relief for a given graphic, and different engraving softwares have different effects. For example, the relief effect of ArtCAM is smoother than that of Type 3. But the basic principle is to define the point in the area as the ordinate according to a certain rule from the boundary to the center and determine the height value of the point by giving the section line, so as to shape the three-dimensional surface relief model.

At present, a 3D modeling technology based on hand-drawn sketches has been developed in the design field [4, 5], which has a strong reference value for the improvement of geometric relief functions. It is a conceptual design-based modeling approach that models hand-drawn sketches directly. The process is that the user draws a free curve on the screen, and then, the system closes it and quickly calculates a three-dimensional model with this contour line. Some advanced algorithms also support cross-section shape

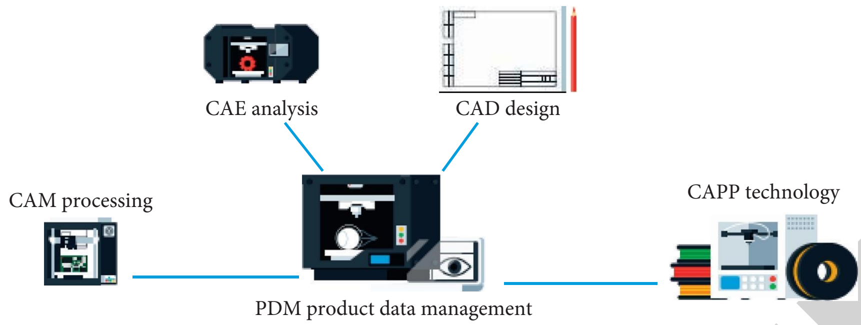

Figure 1: Typical case of CAD/CAM platform design and manufacturing.

modeling, that is, one curve is used as the outline and the other is the cross-section shape for fast 3D modeling. It can be seen that the hand-drawn sketch modeling technology is very similar to the geometric relief technology in principle, but it is more free and open than the geometric relief.

Bitmap relief is also called picture relief or grayscale relief. Its purpose is to obtain a three-dimensional relief model through the three-dimensional information reflected in the picture [6]. Since a picture cannot reflect the complete three-dimensional information, the picture relief is actually based on the picture data, relying on the artistic level of the designer to create a relief model that is artistically expressive but not necessarily accurate in the engineering sense. At present, popular relief software such as TYPE3 and ArtCAM do not provide processing of pictures but only extract grayscale information from pictures, convert them into heights according to the grayscale mapping relationship, and finally generate a 3D model [7]. Bitmap relief designers use the image processing software to process images into grayscale images that reflect three-dimensional shapes, that is, grayscale art images. The relief CAD software directly shapes relief from grayscale art images without making any changes to the three-dimensional information reflected in the grayscale art images. The JDpaint engraving CAD/CAM software developed by Beijing Jingdiao Technology Co., Ltd. is aware of its shortcomings and provides some functions of relief editing, but due to its simple technology, it still cannot change the current bitmap relief design. It is completed on the image processing software for the embarrassing situation [8].

The purpose of relief CNC machining programming is to generate a noninterference tool processing path according to different tool types and according to the cutting strategy proposed by the user and generate processing instructions after postprocessing to control the CNC engraving machine for processing. To realize the relief NC machining programming, the following problems need to be solved [9]: how to represent the relief model in the computer; how to generate the relief model according to the designer's intention; and how to generate an accurate and efficient CNC machining tool path according to the relief model. There is no essential difference between relief CNC machining programming and general CNC machining programming, so there are a lot of literature for reference. Chengdu University of Electronic Science and Technology takes the relief of the furniture [10] industry as the research object and carries out relief design and processing from the two-dimensional outline. The software is implemented based on the secondary development of AutoCAD and can only generate line-cutting and circular-cutting tool paths for 2D area milling. In the research, it was found that the commercial engraving CAD/CAM software at home and abroad mostly uses discrete facets to represent the relief model. The projection of the vertices of these facets on the *XY* plane is a regular lattice, so the NC machining programming of the relief can be considered. Drawing on the existing research results, tool path generation technology is based on a discrete point cloud or STL model [11]. British scholar RJ. Cripps [12] analyzed and compared the difference between discrete CAD/CAM systems and analytical CAD/CAM systems and used the inverse tool offset (ITO) method to generate the finishing tool path of discrete point data. Taiwanese scholars AC. Lin [13] and others first established the Z-map representation of the starting point cloud and then carried out rough and fine path planning according to the Z-map model. In order to improve efficiency, the algorithm does not calculate the discrete set of tool position points but adopts some special processing for ball-end tools to avoid overcutting.

On the background of the topic selection, this study refers to a company in Nanjing that has been engaged in the development and sales of engraving machines for a long time [14]. In order to expand the business scale and expand the market, the company hopes to have engraved CAD/CAM software with independent intellectual property rights, so it has established a cooperative relationship with the CAD/CAM Engineering Research Center of Nanjing University of Aeronautics and Astronautics to jointly develop the software. This study participated in this project in the CAD/CAM Engineering Research Center of Nanjing University of Aeronautics and Astronautics and undertook the research of relief CAD/CAM technology and the development of related modules. The software conducts demand analysis and function analysis through detailed demonstration in the system design process. During the development process, experienced senior engineers from the factory were hired as guidance to refine the software functions and make the software conform to the operating habits of the engineers [15]. After the software function module is completed, the software quality is tested in cooperation with the factory technicians, and the actual processing is carried out on the factory-produced engraving machine using the processing path generated by the software, which verifies the correctness of the algorithm and the practicability of the software.

3. Research Methods

The traditional ceramic carving process, from conception and design to final glazing and firing, is generally completed independently by a single worker. Before engraving, it is necessary to outline a hard pen sketch according to the design requirements, so the pattern can only be relatively simple [16]. The engraving process requires workers and masters to have high manual skills, which will have two impacts: first, the processing process is too affected by human factors, and the product quality is difficult to unify; second, there is a certain degree of inherited personal carving skills. The difficulty of changing the workers will make some products unsustainable. In the whole production process, the two links of engraving and engraving need to take a long time, and ceramic products are easily damaged during the engraving process, which leads to low production efficiency [17].

With the development of engraving CAD/CAM software, relief CAD/CAM technology is generally integrated as an important functional module. Currently, the relief models involved are mainly built through bitmap relief modeling and geometric relief modeling obtained using the modulo technique. The geometric relief modeling studied in this study is the relief surface modeling technology based on plane geometry. The bitmap relief modeling is the relief surface modeling technology based on geometric information and grayscale information, and the modeling of bitmap relief generally uses images first. The processing software preprocesses the picture and then uses the relief CAD software for editing, in order to obtain the perfect relief effect [18].

3.1. Geometric Relief Modeling. Geometric relief modeling refers to the process of constructing a three-dimensional relief from flat geometric figures. A three-dimensional relief model with complex details is often formed by the fusion of several small curved patches, which are called relief surfaces. The relief surface is jointly determined by a two-dimensional region and a cross-section function [19]. Taking the offset t of the equidistant ring as the independent variable and the height value h of the contour line as the function value, there are countless function mapping relationships, and each mapping relationship corresponds to a section function. The algorithm currently supports two types of section functions: linear functions and circular functions. As shown in the figure, the linear function is defined by the abscissa of the transition point and the inclination angle of the straight line in Figure 2; the circular function is defined by the abscissa of the transition point and the central angle of the arc segment, as shown in Figure 3. When the two-dimensional area of the relief surface intersects, the overlapping area can be defined by surface fusion. There are currently eight fusion methods:

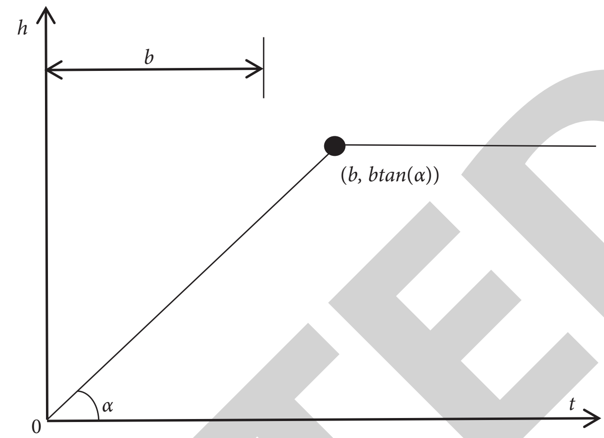

Figure 2: Schematic diagram of cross-section function (linear function).

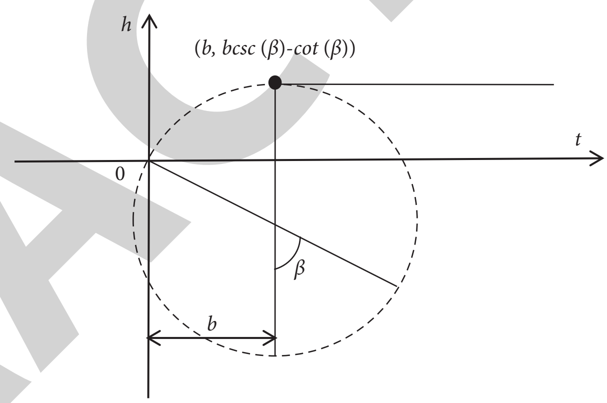

Figure 3: Schematic diagram of cross-section function (circular function).

negative substitution fusion, subtractive fusion, additive fusion, positive substitution fusion, highest fusion, lowest fusion, vector external zero fusion, and zero fusion [20].

By defining the section function and changing the surface blending method, the 3D relief model can be constructed from the plane outline.

3.2. Bitmap Relief Modeling. Bitmap relief modeling refers to reconstructing 3D relief models from bitmap images through a series of special processing. Through various digital image processing techniques (such as grayscale, embossing, filtering, and denoising), ordinary RGB photos are processed into grayscale art images, so that the grayscale information of each pixel in the RGB photo can be converted. For the height information of the relief, the relief model is finally obtained [21].

The empirical formula can make the conversion of a color bitmap to a grayscale image:

$$H_{ij} = 0.299R_{ij} + 0.578G_{ij} + 0.114B_{ij}. \quad (1)$$

Among them, H_{ij} represents the grayscale value of the converted grayscale image; R_{ij}, G_{ij}, and B_{ij} represent the red, green, and blue color components of the pixel in the i^{th} row and the j^{th} column of the color bitmap; bitmap relief modeling also supports eight fusion functions. Through the fusion of relief surfaces, it is convenient to combine the functions of bitmap relief modeling and geometric relief modeling in the same relief model, thus greatly enriching relief design methods.

4. Result Analysis

4.1. Toolpath Selection. There are two commonly used cutting methods in engraving processing: one is the line-cutting method, that is, the tool is processed along the straight line and the other is the circular cutting method, which is the sequential processing of the tool along the contour [22, 23]. In the process of circular-cutting, since the processing method of the engraving tool is always the same, that is, the cutting state of down milling has been maintained or the cutting state of upcut milling has been maintained, so the engraving processing accuracy of the blank is high, but this algorithm is quite complicated. When the tool path file is generated, it will waste a lot of time; in the process of back and forth cutting, the machining process will alternately show down milling and up milling. Although the processing quality of this processing method is not as good as that of circular cutting, it is not suitable for most parts. Material removal and row cutting have high cutting efficiency, and to a certain extent, this algorithm is very simple. In the CNC engraving of ceramic blanks, the ring cutting method is generally used in the relief engraving of flat ceramic plates; the line cutting method is generally selected in the CNC engraving of ceramic revolving workpieces. If the ring cutting method is used, the processing time is long and the yield is low.

4.2. Embossing Simulation Processing. With the completion of the relief design and the selection of the machining path, the tool path needs to be simulated. The ultimate purpose of machining simulation is to debug a satisfactory and efficient tool path file and finally generate standard machining instruction code [24]. In this study, ArtCAM, which is widely used by the British company Delcam, is used as the embossing simulation software [25]. Before simulation processing, the material setting of the workpiece to be processed is first required, that is, the X, Y, and Z values of the workpiece blank to be processed are set. It should be noted that the X and Y values of the blank must be the same as the size of the established 3D model, and the Z value is set according to the model parameters. In addition, it is necessary to set the Z-axis zero point of the material. The material Z-axis zero point is also called the machining origin, which can be set at the bottom or top of the material blank.

The thickness of the blank chosen in this study is 5 mm, and the Z-axis zero point of the material is at the top. Set the processing parameters; the area to be processed is the set selected vector area; the processing strategy selects parallel processing; the tool is selected as a flat-bottomed tip; the spindle speed is 20000 r/min, the feed rate is 2000 mm/min,

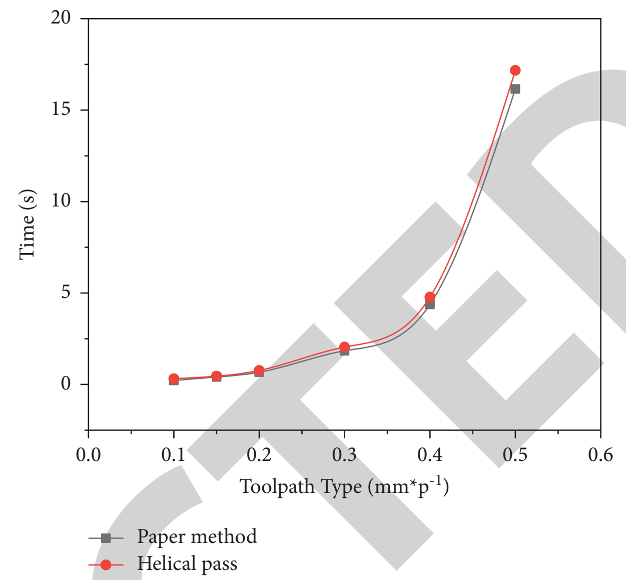

Figure 4: Comparison of processing path calculation efficiency (helical pass).

and the cutting speed is 600 mm/min; the model size is set to 100×1002 mm, and the resolution is 0.5 mm/pixel. The toolpath spacing is to go to 50% coverage. In this experiment, the calculation efficiency of machining paths was observed according to different path types of different tools. The experimental results are shown in Figures 4 and 5.

From the experimental results, the ceramic relief model established in this study is 11.3% and 42.8% higher than the two traditional methods in terms of machining path efficiency. The analysis is as follows: in theory, the calculation of different tool paths is mainly the generation of tool location datasets, so the calculation speed will not have much difference. It can be seen from the test results that the speed variation rules generated by the three machining paths are consistent, and the difference is limited, which is consistent with the theoretical prediction. For the last set of data, the data calculation time can be considered to have exceeded the user's tolerance. As the radius of the flat bottom of the tool increases, in order to avoid overcutting, the embossed details gradually disappear on the tool surface, and with the increase of the machining step, the tool marks on the embossed surface also increase significantly. Therefore, in the processing process, the tool radius should be selected as small as possible, and the step distance should be as small as possible.

For a given relief model, the reciprocating machining path is used to test, and different tools are used, and the calculation efficiency is given in Table 1.

It can be seen from the table that the computational efficiency of the algorithm decreases as the tool diameter increases. One of the main features of this algorithm is that the calculation speed has nothing to do with the complexity of the surface nor with the complexity of the tool shape. Most of the relief surfaces are free and complex surfaces. The diameter of the tools used for relief processing is small, and the shapes of the tools are many shapes with engraving characteristics. Therefore, the relief processing

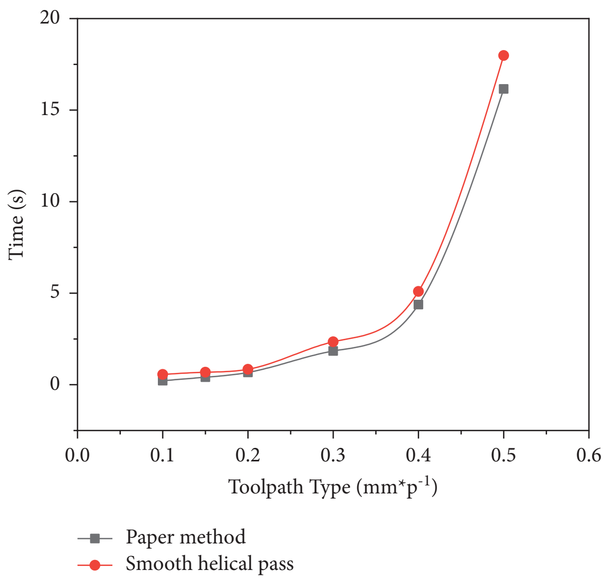

Figure 5: Comparison of processing path calculation efficiency (smooth helical pass).

Table 1: The relationship between calculation efficiency and tool diameter change.

Tool diameter	1 mm	2 mm	4 mm	8 mm	12 mm	16 mm
N_R	2	4	8	16	24	32
Operation time (s)	0.219	0.234	0.453	1.344	2.829	4.969

N_R is the number of points covered by the tool diameter.

programming module introduced in this article is suitable for relief finishing.

5. Conclusion

This study introduces relief CAD/CAM technology into ceramic engraving, which not only improves the efficiency and quality of engraving to a certain extent but also greatly expands the ceramic relief library. Finally, the feasibility of this technology is proved through example processing. The application of this technology fundamentally gets rid of the status quo of the manual engraving operation of ceramic engraving and relieves people from heavy manual labor. At the same time, ceramic engraving products have also been widely promoted.

The rapid development of relief art puts forward higher requirements for relief CAD/CAM software, and the continuous improvement of relief CAD/CAM software can better promote the development of the relief industry. Therefore, combined with the experience in relief research in this study, some work prospects are put forward: (1) learn from the hand-drawn sketch modeling technology and study the geometric relief modeling technology based on free-form curves. Improve the algorithm of smooth relief and improve its computational efficiency. (2) Expand the editing function of relief, such as adding functions, surface transition, and free-form surface fitting for the local modeling technology of relief surfaces. (3) Combined with the current development characteristics of GPU, further study the hardware acceleration technology of inverted tool based on the *Z*-Map data model and study the application of programmable GPU in relief modeling, display, and lighting.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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