Personalized Product Creation With Auspicious Totems

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Abstract—**Auspicious totems are an important form of expression of traditional craft aesthetics among various ethnic groups. They not only show the profundity and ingenuity of folk art skills, but also present the individuality and characteristics of various ethnic cultures in humanities and artistic aesthetics. In order to give these auspicious totems a new presentation form, many scholars and experts have also used digital image processing techniques to present 2D auspicious totems in multimedia forms, or transformed them into 3D relief products. Their processing technique for converting 2D auspicious totems into 3D models is nothing more than converting the colored auspicious totems into grayscale mode, and then setting the appropriate relative height according to the grayscale value corresponding to each pixel. But for those auspicious totems whose colors are relatively large or whose gradients are not obvious, the currently used 8-bit (255-level) grayscale mode is not enough. Because it will produce jagged features in this area, which will affect the overall appearance. Therefore, this article intends to use image processing technology to filter, smooth and edge enhance the commonly seen auspicious totem image files, and then use multi-layer analysis of grayscale images to smooth out the problem of excessive changes in grayscale values. Finally, make it 3D model and output it into an STL format file that can be accepted by 3D printers to achieve the purpose of integrating the auspicious totem plane image with the 3D printer system.**

Keywords—*Personalized product, 3D printer*

I. INTRODUCTION

Auspicious totems probably appeared in the late primitive society. Today, we find murals depicting hunting scenes of ancient humans, and they are burned on pottery pots and jars used as daily necessities. We often see some decorative patterns carved on them. The ancients worshiped witchcraft and were afraid of inexplicable evil spirits and diseases, so they often left totems to ward off evil spirits and exorcise demons. Some animals were considered by the ancients to have the ability to reproduce and be fertile, and their shapes were often drawn as a sign of seeking children and blessing childbirth.

In the early bronzes, all kinds of decorations were already in full bloom. At that time, the etiquette between people's classes had taken shape. The lives of the nobles were far richer and more luxurious than ordinary families, and their aesthetic requirements were far higher than those of ordinary people. Therefore, in their happiness and auspicious patterns are often used for decoration in daily necessities.

Then people began to inject a lot of mysterious content into auspicious patterns. The release of imagination plays an important role in the development of auspicious pattern styles. Therefore, various mythical beasts have become ways of presenting patterns and decorations. And because the society at that time was rich in material and people's lives were colorful, a large number of auspicious totems depicting daily life activities such as politics, economy, entertainment and military were also produced. These have laid a solid foundation for the development of auspicious totems of various ethnic cultures [1]. The purpose of this article is to use multi-layer analysis of grayscale images to improve the sense of defects caused by the color contrast of the 2D plane images in the past, making them smoother and refined.

In addition, affordable 3D printers have gradually reduced the entry cost of the manufacturing industry, just as e-commerce has lowered the entry threshold for product sales and services. Therefore, 3D printing will gradually shift from the niche market to the mass market. The driving forces behind this include lower printer prices, potential cost and time savings, more powerful features, and enhanced performance that creates efficiencies and markets.

The working process of a 3D printer is: (1) Design the 3D CAD model of the part. (2) Convert CAD files into STL format files, determine the placement position, and construct the cutting layers and related supporting materials. Finally, the print command is sent to the 3D printer. (3) The 3D printer reads the cross-sectional information and moves, selectively extruding the required materials, and stacking the final product. Therefore, for ordinary users, how to construct the required models is a technical threshold that is difficult to overcome. Therefore, even though the current price of 3D printers is within the range acceptable to the general public, they cannot be widely used by ordinary users. Therefore, another purpose of this article is to help ordinary users how to use 3D printers to print the auspicious totems left by

various ethnic cultures as decorations to promote the beauty of the inherent culture.

II. IMAGE PROCESSING RELATED TECHNOLOGY

Image processing is simply to digitize images, so that people or computers can obtain more and more useful information from the processed digital images, and make more reliable follow-up judgments, analysis, and applications. Generally speaking, the method of digital image processing can be roughly divided into three processes: front-end, middle-stage and post-processing [8].

(1) Front-end processing: In the application of digital image processing, the front-end processing program must first be used to enhance image contrast, grayscale and noise removal to facilitate the mid-stage processing program.

(2) Mid-stage processing: The mid-stage processing process can be divided into image segmentation and representation and description. The purpose of image segmentation is to divide the digital image into several areas; for example, the binary method, equalization, area method, boundary method and edge method, etc., all use different threshold values to separate the main objects for reparation the post-processing. The representation and description are to display the important features of the image information as a basis for image quality adjustment; for example, the phase value distribution of a grayscale image can be used as a basis for the equalization of the entire image.

(3) Post-processing: how to combine applications with other fields is the category of post-processing; for example, combining neural network-like algorithms and image processing technology to identify patterns is an image post-processing processing function.

A. Grayscale image

Generally speaking, when we are doing image processing, we will represent each pixel in a color image as an RGB value, and each color of RGB occupies 8 bits, a total of 24 bits, so it is also called three-channel image. And a grayscale image only needs to be represented by one channel, that is, 8bit. So if we want to convert an RGB color image into grayscale, the most direct and simple way is to add the three RGB values and divide them by three to get the result we want. However, because the human eye actually has different perceptions of the brightness of the three colors, green, red, and blue. The grayscale method mostly uses the function Gray=f(R, G, B) proposed by Hasan and Karam [6] to map the color space to the gray space. Which is;

Gray = 0.299 * Red + 0.587 * Green + 0.114 * Blue

Its conversion relationship is shown in Figure 1;

(a) Original image   (b) Grayscale image

Figure 1 Grayscale image picture

B. Filtering to remove noise and smoothing

For subsequent processing procedures, noise removal and smoothing are usually required. However, in order to remove noise, the image contrast may be reduced, and good quality may require a lot of processing time. Therefore, a suitable method is usually selected according to actual needs. At present, there are common filtering and smoothing methods: mean filtering, box filtering, Gaussian filtering, median filtering, bilateral filtering and custom filtering. Generally speaking, filtering methods can be divided into two types, linear filtering and nonlinear filtering. Among them, linear filtering has a core with fixed parameters, and the common ones are mean filtering, box filtering and Gaussian filtering. Non-linear filtering does not have a core with fixed parameters, and common ones are median filtering, bilateral filtering and custom filtering. In this paper, Gaussian filtering is used to remove noise and smooth digital images. Gaussian smoothing filter, also known as low-pass filter, is mainly used to eliminate the high-frequency changes on the image and strengthen the low-frequency part, make the changes of the image more uniform, which can produce a blurrier image and reduce the part of the sharper image. It is usually used to reduce image noise and reduce the level of detail. Different from the mean filter and the box filter, the weight value of each pixel is the same. The mask of the Gaussian filter will strengthen the weighting value of the center point, and reduce the weighting value far from the center point [9]. For example, the mask of Gaussian filter can be shown in Table 1.

Table 1 Gaussian smoothing mask

1	2	1
2	8	2
1	2	1

From a mathematical point of view, the Gaussian blurring process of an image is the convolution product of the image and the normal distribution. Since the normal distribution is also called Gaussian distribution, this process is also called Gaussian blur. The value of each pixel is the weighted average of the surrounding adjacent pixels. The value of the original pixel has the largest Gaussian distribution value, so it has the largest weight value. The further the adjacent pixels are from the original pixel, the smaller the weight value is. If Table 1 is used as the Gaussian

smoothing mask of the 3*3 convolution product to process some of the grayscale image data in Table 2, the calculation method is as follows;

Table 2 Partial grayscale image data

197	25	106	156	159
149	40	107	5	71
163	198	226	223	156
222	37	68	193	157
42	72	250	41	75

1. Calculate the sum of the elements in the mask (1+2+1+2+8+2+1+2+1=20).
2. Divide each element of the mask in Table 2 by the sum of the elements calculated in step 1. Then the mask in Table 1 becomes the mask shown in Table 3.

Table 3 New Gaussian smoothing masks

0.05	0.1	0.05
0.1	0.4	0.1
0.05	0.1	0.05

3. Recalculate part of the grayscale image data in Table 2. For example, Gaussian filtering is performed on the pixel with the pixel value of 226 in the third row and third column of Table 3. The calculation method is:

new value = (40*0.05+107*0.1+5*0.05) +

(198*0.1+226*0.4+223*0.1) +

(37*0.05+68*0.1+193*0.05)

= 163.754 = 164

Therefore, if the 5*5 filter mask is used as the benchmark, and the standard deviation of the mask in the X-axis and Y-axis directions is set to "0" to filter out the noise in the image, the execution result is shown in Figure 2. Show;

Table 4 New values of some gray-scale image data

		164		

Figure 2 The result of Gaussian filter smoothing

III. 3D MODEL AND TRIANGULAR MESH CONVERSION

In this article, the processing technique for converting 2D auspicious totems into 3D models is to take the smoothed grayscale image and set the appropriate relative height according to the grayscale value corresponding to each pixel to obtain the 3D model. Therefore, it can solve the shortcomings of those auspicious totems with relatively large colors or unclear gradients. The currently commonly used 8-bit (255-level) grayscale mode will produce jagged features in this area, affecting the overall appearance.

Currently, all formats accepted by 3D printers are STL format. Therefore, to integrate with the 3D printer system, the 3D model must be converted into STL format. The STL format uses an approximate outer surface to represent the surface or solid entities of an object. The STL file includes a sequence of surface data. Each surface is represented by a unit normal vector and three vertices coordinates, so 12 numbers are used to represent a surface. The output format of STL can be divided into two types: ASCII and Binary. The ASCII STL file is only for users to see its format and further edit it, but it takes up a lot of space. The Binary format is a more reasonable choice.

A. ASCII STL file format

The content of the ASCII STL file lists the geometric data of each triangle mesh line by line. Each line begins with 1 or 2 keywords. For example, in an STL file, a facet represents a triangular mesh surface with a normal vector. The STL 3D model is composed of a series of triangular mesh surfaces. The first line of the entire STL file records the file path and text file name. Each facet in the file consists of 7 lines of data. The facet normal is the normal vector coordinate of the triangular mesh surface pointing to the outside of the entity. The outer loop indicates that the subsequent three rows of data are the coordinates of the three vertices of the triangular mesh surface, and the order of the three vertices is counterclockwise along the normal direction of the mesh surface. So the ASCII STL file format is as follows:

solid name

facet normal ni nj nk

outer loop

vertex v1x v1y v1z

vertex v2x v2y v2z

vertex v3x v3y v3z

endloop

endfacet

endsolid name

B. Binary STL file format

Binary's STL file content uses a fixed number of bits to record the geometric information of each mesh surface. The first 80 bits of the file are used to record the file name, followed by a 4-byte integer to represent the number of triangular mesh faces of the model, and then the geometric information of each triangular mesh face is recorded sequentially. Each triangular mesh surface has 50 bits, which are three 4-bit-floating point numbers (normal vector of the mesh surface), three 4-bit-floating point numbers (the coordinates of the first vertex), Three 4-bit-floating point numbers (the coordinates of the second vertex), three 4-bit-floating point numbers (the coordinates of the third vertex), and the last two bits record the attributes of the triangular mesh surface. So the Binary STL file format is as follows:

UINT8[80] ; Header

UINT32 ; Number of triangles

foreach triangle

REAL32[3] ; Normal vector

REAL32[3] ; Vertex 1

REAL32[3] ; Vertex 2

REAL32[3] ; Vertex 3

UINT16 ; Attribute byte count

Figure 3 is a comparison of the original grayscale image and the grayscale image after multi-layer analysis when converted into a 3D relief model. It can be seen that the 3D relief model converted from the grayscale image after multi-layer analysis will be smoother [7].

3D model of the original grayscale image

Smooth original grayscale image 3D model

Figure 3 comparison of the original grayscale image and the grayscale image after multi-layer analysis when converted into a 3D relief model

IV. SYSTEM OPERATION STEPS

This article uses the OpenCV image processing function library as an image processing tool. After filtering, smoothing and edge strengthening the commonly seen auspicious totem image files, it then uses multi-layer analysis of grayscale images to smooth out excessive changes in grayscale values. Finally, it is converted into a 3D model and output into an STL format file that can be accepted by a 3D printer. Finally, the newly created 3D model is integrated through the commonly used 3D modeling software Rhinoceros to complete the auspicious totem plane image and 3D The purpose of printer system integration. It can be said that innovative techniques are used to integrate traditional crafts into modern processes to show a new look that is different from the past. This not only retains its inherent spirit, but also continues and promotes the ideal of this cultural creativity. The modeling steps are as follows:

Step 1: Load the image of the auspicious totem, as shown in Figure 4.

Figure 4 Original image.

Step 2: Perform filtering, smoothing and edge enhancement, as shown in Figure 5.

Figure 5 Processed original image

Step 3: Initialize the grayscale image, as shown in Figure 6.

Figure 6 Initialize the grayscale image

Step 4: Perform multi-level parsing to smooth grayscale images. The results are shown in Figure 7.

Figure 7 Smoothing grayscale images

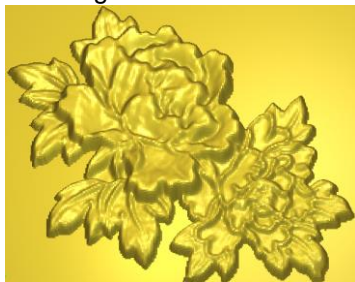Step 5: 3D dimensional grayscale image. The results are shown in Figure 8.

Figure 8 The auspicious totem 3D model

Step 6: The prototype of the product is constructed in the Rhinoceros environment, and the result is shown in Figure 9.

Figure 9 The prototype of the product

Step 7: Input the 3D model of the auspicious image in the Rhinoceros environment and integrate it with the prototype product to complete the 3D model of the personalized product, the results are shown in Figure 10.

Figure 10 The 3D model of the personalized product

Step 8: Output the triangular mesh file of the personalized product model, and use a 3D printer to make it, the result as shown in Figure 11.

Figure 11 The 3D print of the personalized product

V. CONCLUSION

This article uses the OpenCV image processing function library as an image processing tool. After filtering, smoothing and edge strengthening the commonly seen auspicious totem image files, it then uses multi-layer analysis of grayscale images to smooth out excessive changes in grayscale values. And then 3D dimensionalize it and then output it into an STL format file that can be accepted by the 3D printer to complete the purpose of integrating the auspicious totem plane image with the 3D printer system. Finally, a prototype was made through a 3D printing machine, using innovative techniques to integrate traditional crafts into modern processes to show a new look that is different from the past. This not only retains its inherent spirit, but also continues and promotes the ideals of this cultural creativity. Figures 12 and 13 show the finished products produced by processing different auspicious totems and printing them with a 3D printer.

Figure 12 Personalized products with auspicious totems-1

Figure 13 Personalized products with auspicious totems-2

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