Research on Signature Engraving for CNC Programming Based on Edgecam

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Abstract. In order to solve the automatic signature engraving programming of part in small product customization, the method of automatic generating based on Edgecam software was introduced. Firstly, the intelligent systematic ideas in Edgecam is proposed, then, the transformation algorithm for digital image processing was constructed, the key technology of signature engraving and CNC programming were studied, the program was written in VB.NET, PCI, PDI and other secondary development languages in Edgecam, finally, the case study used in typical signature engraving with the proposed method, which provides reference for the other engraving intelligently and rapidly in other product.

Introduction

In order to meet the personalized and special needs of high-ranking people and the general public online shopping, in the field of industrial manufacturing has created a network-based customization technology. After choosing their best small commodity online, they will write their names or pictures engraved on the surface of goods that will be transfer to the seller through internet. After receiving the demands, the seller will design the CNC program, which can be engraving the signature in the machine tool.

Edgecam is commonly intelligent CNC programming software for CNC lathing, CNC milling, CNC wire cutting, turn-milling machining and other areas developed by VERO Company, which quantities used by the customer in the forefront of independent CAM software. Edgecam can read the model data created by the most of mainstream CAD software, design the automatically programming system in other special complicated CNC programming areas with the secondary customized languages [1,2].

Signature engraving words are manual script saved by such format as BMP, PNG or JPEG and so on, which can not be automatically programming with CAM software. So, it demands that design the programming method to the engraving of picture and signature.

In order to solve the automatic signature engraving programming, this paper is study the key techniques of digital image processing, architecture of secondary developing system and the function creation of engraving programming.

Key Technologies

Architecture of System

Figure 1. Flowchart of system.
The BMP files of signature were input into the Edgecam software, created the signature engraving operation. The flowchart of system is shown in Figure 1.

**Digital Image Processing**

The BMP file of the signature image consists of a series of pixels, which format used is ARGB. In the style of ARGB, the letter of “A” means that the RGB color mode is accompanied by an alpha (transparency) channel whose intensity is a hexadecimal representation of the decimal number in the range of 0 to 255; FFH (255) is the full intensity, 00H (0) means that there is no color in the channel.

First, the color values \( R_i, G_i, \text{ and } B_i \) of each pixel are read, and then, the grayscale is performed by the weighted average method:

\[
C_i = A \times (R_i \times W_R + G_i \times W_G + B_i \times W_B)
\]

(1)

where the specific weight is:

\[
\begin{bmatrix}
W_R \\
W_G \\
W_B
\end{bmatrix} = \begin{bmatrix}
0.30 \\
0.59 \\
0.11
\end{bmatrix}
\]

(2)

A black-whitening process is performed, if \( C_i < 100 \), then, \( C_i = 0 \), the result is black; if \( C_i \geq 100 \), then, \( C_i = 255 \), the result is white. The resulting positional coordinates traversal are placed in the array \( X(i, j) \) and \( Y(i, j) \), and the resulting black or white values are placed in the array \( C(i, j) \).

Set the resolutions of the picture are \( \text{PicWidth} \) and \( \text{PicHeight} \) along X-axis and Y-axis respectively, the dimension of width of engraving area is \( \text{StockWidth} \), the dimension of height is \( \text{StockHeight} \), the accuracy of interpolation is \( T \), the steps are \( IStep \) and \( JStep \) along X-axis and Y-axis respectively, there are:

\[
\begin{bmatrix}
IStep \\
JStep
\end{bmatrix} = \begin{bmatrix}
\frac{T \times \text{PicWidth}}{\text{StockWidth}} \\
\frac{T \times \text{PicHeight}}{\text{StockHeight}}
\end{bmatrix}
\]

(3)

where, \( IStep = \lfloor IStep \rfloor \), \( JStep = \lfloor JStep \rfloor \), if \( IStep = 0 \), then, \( IStep = 1 \); if \( JStep = 0 \), then, \( JStep = 1 \).

**Programming Operation Definition**

Edgecam is designed base on the .net framework, and has some such secondary development languages as PCI (Programming Command Interface), PDI (Programming Development Interface) and so on, which can be used to access the pfp file of Edgecam’s part and the files of manufacturing processes in SQL server database. It can be make use of the computer languages of VB.NET, C# and C++ to utilize PCI and PDI to communicate with Edgecam’s Interface functions[3,4].

This system uses VB.NET 2010 and calls PCI and PDI to generate the DLL dynamic link library. The interface menu is generated by the Edgecam interface customizer, which is called in the main interface[5]. The system input dialog is shown in Figure 2.

The systematic algorithm of signature engraving programming is as follows:

1. Call the plug-in module to generate the input dialog, if an error is taken place, then show the error message dialog and exit;
2. Read the input parameters from the input dialog, check the parameters of the rationality, if an error is taken place, then show the error message dialog and exit;
3. Input the image file;
(4) Traverse the pixels in the graph, and perform digital image processing, calculate the coordinates of $X(i,j)$, $Y(i,j)$ and $C(i,j)$;

(5) Coordinate transformation, and calculate the tool path point;

(6) Define a machining operation, generate moving path, machining path and retraction path;

(7) Finish the next pixel path generation, until all is complete.

![Figure 2. Input dialog.](image)

Take the drilling of the signature for example, the origin of the programming coordinate system, along $X$-axis and $Y$-axis, is at the center of the blank, the origin of the programming coordinate system, along $Z$-axis, is at the top of the blank, set the original coordinates of pixels are $X_0(i,j)$ and $Y_0(i,j)$, set the values of color is $C_0(i,j)$, the coordinates of transformation are $X(i,j)$, $Y(i,j)$ and $C(i,j)$, then, for the concave engraving, there are:

$$
\begin{align*}
X(i,j) &= X_0(i,j) - X_{\text{origin}} \\
Y(i,j) &= Y_0(i,j) + Y_{\text{origin}} \\
Z(i,j) &= C_0(i,j) \times Z_{\text{Depth}} / 255
\end{align*}
$$

(4)

where $X_{\text{origin}}$ and $Y_{\text{origin}}$ are the distance between the center of blank and the left-top point of the Maximum contour, $X_{\text{origin}}$ is along $X$-axis, $Y_{\text{origin}}$ is along $Y$-axis. Depth is the Maximum depth along $Z$-axis, which is an unsigned number.

Post-processing is the way of converting generic programming operations into specific machine tool instructions, Edgecam uses the CodeWizard module to build post-processor, which can be create the kinematics model, geometry model and numerical control system model, can be used in the code constructor to build complex instructions. Custom programming functions defined in the CodeWizard can be invoked on the programming interface of Edgecam. The definition of complex functions using CodeWizard comes with CODE language, which has common function definition, variable definition, mathematical operations and logical operations and other functions, can access the Edgecam CAM definition module variables[6].

The dialog of input parameters defining in the whiteboard of code constructor in CodeWizard is as shown:

```plaintext
;CODE:%ENDM
;CODE:%MACRO=5033=..=SYJCSH=4,5,6,7,9,10,12,16,28,29,
;CODE:%COMMAND
;CODE:#Version:1
;CODE:Verb 2503
;CODE:PIC Machining|SYJCSH  5033  2 x40C  0  0
;CODE: Feedrate  5 x5 x0 x0  0  0  0  None,5000
```

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Case Study

In the Edgecam example test image shown in Figure 3, the material is LY12 aluminum alloy.

![Figure 3. Test image.](image)

The test data are as shown in Table 1.

<table>
<thead>
<tr>
<th>No.</th>
<th>Size (mm)</th>
<th>Method</th>
<th>X Step (mm)</th>
<th>Y Step (mm)</th>
<th>Tool (mm)</th>
<th>Machind Time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>50×50</td>
<td>Drilling</td>
<td>0.12</td>
<td>0.17</td>
<td>D0.2R0</td>
<td>5.1</td>
</tr>
<tr>
<td>2</td>
<td>50×50</td>
<td>Drilling</td>
<td>0.12</td>
<td>0.17</td>
<td>D0.4R0</td>
<td>5.1</td>
</tr>
<tr>
<td>3</td>
<td>50×50</td>
<td>Drilling</td>
<td>0.12</td>
<td>0.17</td>
<td>D0.4R0.2</td>
<td>5.1</td>
</tr>
<tr>
<td>4</td>
<td>23×12</td>
<td>Drilling</td>
<td>0.05</td>
<td>0.04</td>
<td>D0.2R0.1</td>
<td>1.05</td>
</tr>
<tr>
<td>5</td>
<td>23×12</td>
<td>Milling</td>
<td>0.05</td>
<td>0.04</td>
<td>D0.2R0.1</td>
<td>0.75</td>
</tr>
</tbody>
</table>

The simulation and actual machining part of NO. 1 are shown in Figure 4.

![Figure 4. Simulation and machined part.](image)
Summary
In the Edgecam software, it make use of the language of VB.NET, together with PCI and PDI and other secondary development tools to design a gift signature engraving automatically programming system, the system is convenient to input data and easy to programming.

In programming, the methods of drilling and milling both can meet the machining demands; the less the values of machining step, the more the accuracy; under the same conditions, the efficiency of milling is higher than that of drilling, and the quality of milling is higher than drilling.

By using the example test, the qualified picture is generated, through which verify the correctness of the method and the rightness of the developed software.

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References