An area filling algorithm for 3D printing

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Abstract. There are many different processing for 3D printing. The Slicing 3D CAD model is the pretreatment process of 3D printing. Area filling is the necessary step no matter what kind of slicing way is used. In this paper, an area filling algorithm for 3D printing is developed. In which the cubic polynomial and the coefficient of curve line were obtained by the secondary development technology. The cast study result shows that the area filling algorithm is effective.

1 Introduction

3D printing has many different forming processes, such as SLS (Selective Laser Sintering), LOM (Laminated Object Manufacturing), SL (Stereo Lithography), and so on[1]. Different from traditional machining processes, it is based on principle[2-3]. The material is accumulated step-by-step and layer-by-layer in 3 dimensional spaces under the control of computer[4]. When the current layer has been finished, next materials layer is covered on it. So it can quickly manufacture product which is designed by CAD system with complicated shape, and without any fixture.

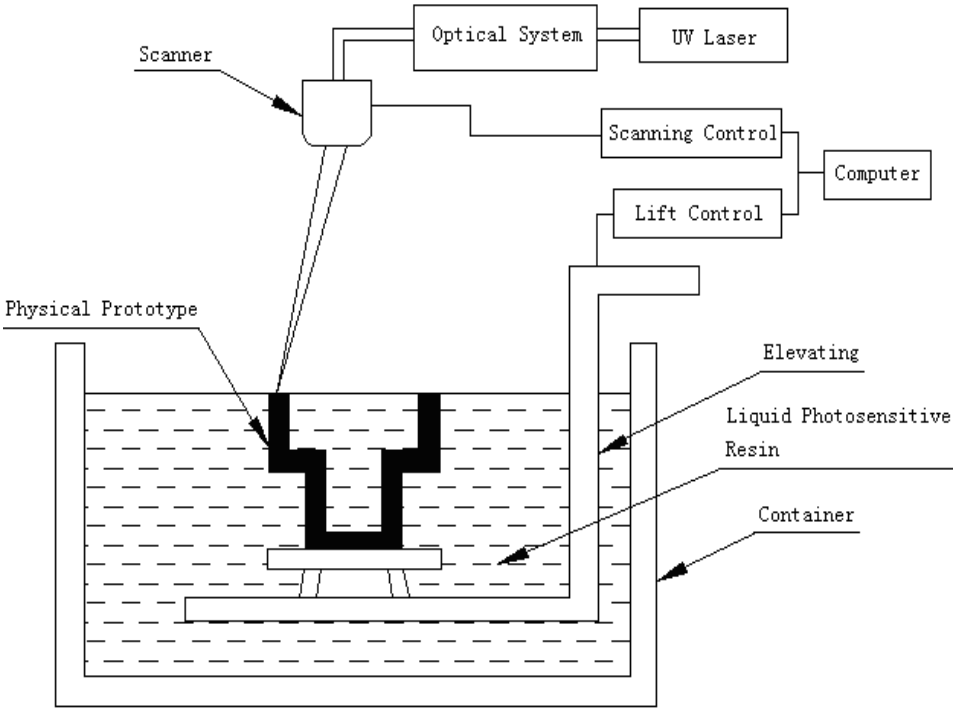

Fig.1 Process principle of SL

3D model of product is designed by CAD software, and the process of 3D printing is driven directly by the CAD model[5]. The Slicing 3D CAD model is the pretreatment process of 3D printing. There are two ways to slice 3D CAD model[6-8]. One way is that the 3D CAD model was transferred to STL data format. And then, the slicing software slices the STL file. The data obtained by slicing is the input of 3D printing equipment[9]. The other way is that the 3D CAD model was sliced into a series of cross sections directly using some mathematical methods. No matter what kind of slicing way is used, the cross sections should be filled by a series scanning lines.

2 Area filling algorithm

3D printing processes could be divided into two types. One is the contour line scanning. The contour coordinates can be transformed into scanning path. The other one is area filling. The extra filling paths must be added into the scanning codes. Parallel paths are developed in this paper by using the area filling algorithm. With the lines parallel to the x-axis, for example, the equation of filling lines is given by (1), as follows:

$$y = T \tag{1}$$

The 2D boundary of section is (x_{min}, x_{max}), (y_{min}, y_{max}), as shown in Fig.2. There are 4 intersection points between one filling line and the 2D contour line, which are (1, 2, 3, and 4). The equation of 2D section contour line is given by:

$$\begin{cases} x = K_{x0} + K_{x1}r + K_{x2}r^2 + K_{x3}r^3 \\ y = K_{y0} + K_{y1}r + K_{y2}r^2 + K_{y3}r^3 \end{cases} \quad (0 \le r \le 1) \tag{2}$$

Where the 8 coefficients *K* can be got by secondary development to the CAD system, and the coefficient *r* is any value from 0 to 1.

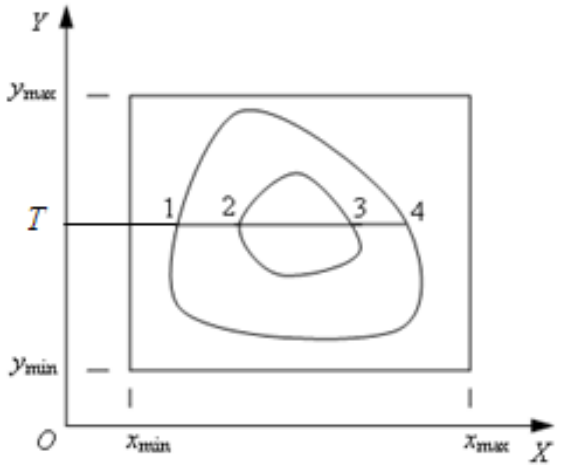

Fig.2 2D boundary of section

By the formula (1) and formula (2), we can get a function of *r*, as follows:

$$f(r) = (K_{y0} - T) + K_{y1}r + K_{y2}r^2 + K_{y3}r^3 = 0 \tag{3}$$

The root *r* of equation (3) can be calculated by using Vieta Theorem and Newton iterative method. Set *r* to formula (2), and the coordinates of intersection points between filling line and 2D section contour line are obtained. One filling line has an even number of intersection points on 2D section contour line. For each filling line, the intersections are sorted by the filling path (left-to-right or right-to-left). That is ascending order or descending order according to *X* coordinates. By numbering intersection points start from 1, the filling line is set from odd number intersection point from even number intersection point. The filling line is not set from even number intersection point to odd number intersection point, because that is the waste cavity, as shown in Fig.3.

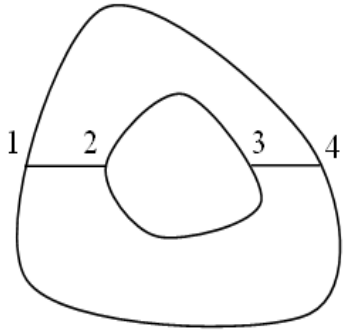

Fig.3 Setting the filling

The density of filling can be set by adjusting the distance between line and line adjacent. Change the value of *T* in formula (1) circularly according to the filling line density, and a series area filling

line can be got. As shown in Fig.4, the filling line shouldn't be set inside the middle loop, because that part is the waste cavity which is needn't be processed.

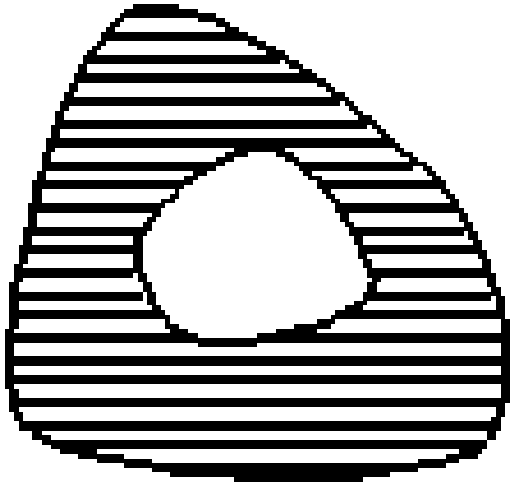

Fig.4 Area filling lines

3 Case study

By taking CAD software as lower system, the OLE (Object Linking and Embedding) and COM (Component Object Model) were used to develop an application program. The cubic polynomial and the coefficient *K* of curve line were obtained by the secondary development technology. The prototype of 3D printing is shown in Fig.5.

Fig.5 Prototype of 3D printing

Acknowledgement

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