Advances in Engineering Research (AER), volume 105
3rd Annual International Conference on Mechanics and Mechanical Engineering (MME 2016)

Data Generation of Layer Slice in FDM Manufacturing

Hong-Fu ZHOU[1,2], Yuan-Xian OU,[1,2,a], Yang-Hua HE [2] and Qin FAN[3,2]

[1]School of Mechanical and Automobile Engineering, South China University of Technology, 510641, Guangzhou, China

[2]Foshan Ye Peng Machinery Co., Ltd., 528131, Foshan, China

[3]School of Machinery and Automation, Wuhan University of Science and Technology, 430081, Wuhan, China

Keywords: Layer slice, FDM, Additive manufacturing, STL.

Abstract. The research presents a data generation method for layer slice in FDM additive manufacturing, which solves the intersection between surface STL file and slicing plane and gets the slicing counter surface data. In the research it designs the layer slicing algorithm and tests it in a FDM machine to fabricate the parts with the layer slicing additive manufacturing method.

Introduction

Additive Manufacturing (AM) appeared in the late 1980s, and it develops into more methods, which include Stereo Lithography (SLA), Selective Laser Sintering (SLS), and Fused Deposition Modeling (FDM). In the technology of additive manufacturing, or the AM fabricating, it takes 3D model design with CAD software, such as Solidworks, generates into a Stereo Lithography (STL) file, and downs to 3D printers for lay slicing and each layer printing [1].

The additive manufacturing processing includes slicing the model into a series of thickness layers in Z direction, fabricating each layer and accumulating the layers into a product [2].

The Data Reading and Analysis from STL File

Stereo Lithography (STL) format is an intermediate data format and it generates by different CAD system and receives by most 3D printer machine.

STL File Structure

STL file is a surface model of 3D object which approximates the space surface with plenty of small triangles and it records each triangle data with three vertex coordinates and the triangle normal vector.

For avoiding data error, the STL model should meet the following conditions:

(1) The right-hand rule: three vertexes sequence and the normal vector abide by right hand rule;

(2) Share vertex rule: every adjacent two triangles have only two same vertices;

(3) Share edge line rule: each edge line shares by only two triangles;

(4) The rule of adjacent facets: each triangle connects only by three adjacent triangles.

The saving of STL format is in Binary or ASCII. For ASCII format, it is a text file format, which is the set of triangles geometry data and it shows in Figure 1.

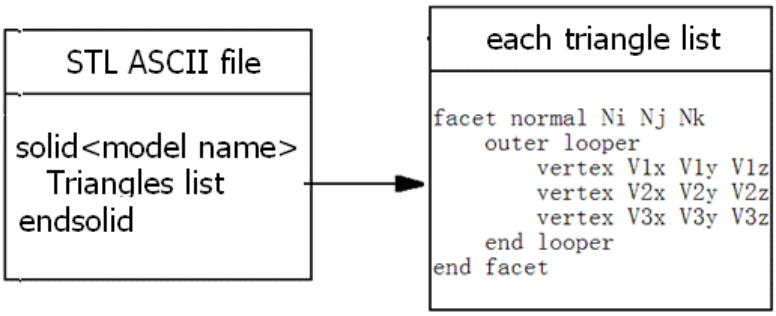


Figure 1. STL file ASCII format

Reading the STL File

The saving size of binary format file is small than ASCII format, only about 1/5 of the ASCII files. The processing of reading ASCII format STL file shows in Figure 2. In Figure 2, it judges the STL file in ASCII or Binary record by checking whether the STL head file includes the string with char (0) characters.

The Section Slicing of STL Model

The Slicing Processing from STL Surface

The processing for generating cross section contour includes reading the STL file, calculating the intersection line of the STL triangle plane with a slicing plane [3], and generating the manufacturing route which shows in Figure 3.

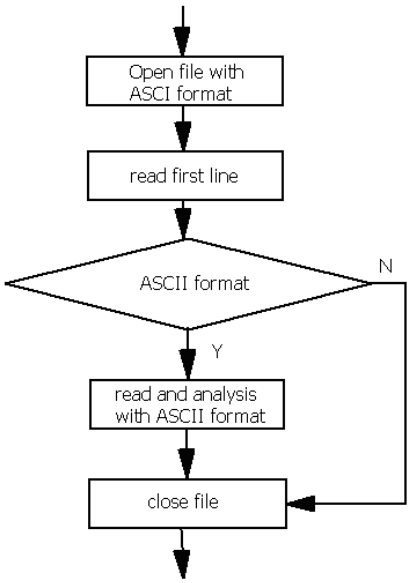


Figure 2. Reading STL file

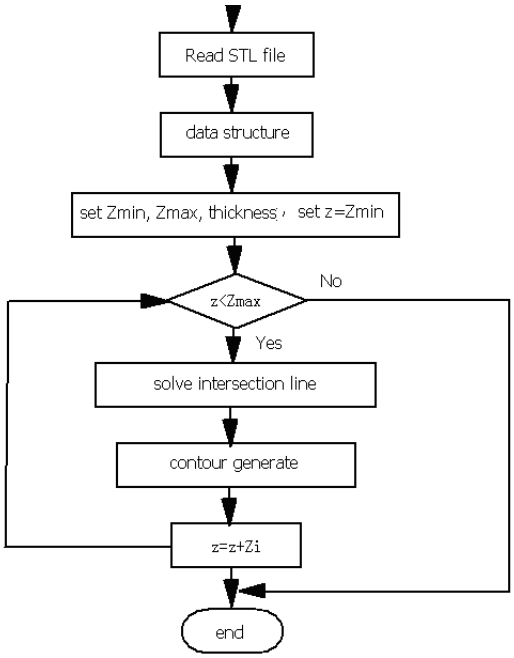


Figure 3. General process of the slicing

The Intersection Calculating between STL Model with Slicing Surface

The Intersection Judgment

The intersection judgment is by comparing the height of the slice plane with STL triangle vertexes [4]. It takes the height of the cutting plane zi, and triangle three vertices of the z coordinate values, let: z1=v1.z, z2=v2.z, z3=v3.z

If zi > min (z1, z2, z3) and zi <Max (z1, z2, z3), than in z = zi height, the two surfaces, which are the slice plane and a STL triangle plane, have intersection.

The Calculating of the Intersection Point

If the slicing plane intersects with STL triangular plane, it calculates that two edge lines of the STL triangle intersect with the cutting plane, where the triangular three edges interest with the slicing plane is as a special case. Taking mid(z1, z2, z3) for mid-point in z1, z2, and z3, it compares the height of mid(z1, z2, z3) with the slicing plane height zi.

When zi > mid(z1, z2, z3), the two edges of triangle intersecting with cutting plane connect with a maximum height of the vertices of the triangle.

When zi < mid(z1, z2, z3), the two edges intersecting with cutting plane connect with the height of the minimum vertex of the two edges in the triangle.

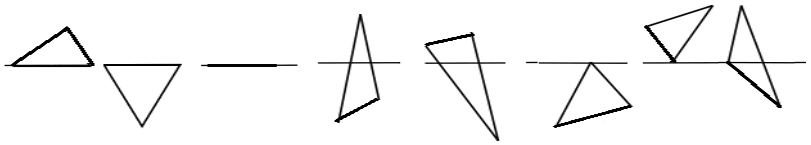
Marking the two vertexes coordinates in the cutting edge are (x1, y1, z1) and (x2, y2, z2), the corresponding linear equations for the cutting edge are:

$$\frac{x-x_2}{x_1-x_2}=\frac{z-z_2}{z_1-z_2}=\frac{y-y_2}{y_1-y_2} \tag{1}$$

The intersection point coordinates as following:

$$\begin{cases} x = x_2 + \frac{z_i-z_2}{z_1-z_2}(x_1-x_2) \\ y = y_2 + \frac{z_i-z_2}{z_1-z_2}(y_1-y_2) \\ z = z_i \end{cases} \tag{2}$$

The relative positions of STL triangles to cutting plane in height, zi, have the following cases, which show in Figure 4.



（a） (b) (c) (d) (e) (f) (g) (h)

Figure 4. The relative position of slicing plane with STL triangle surface: (a), (b), two vertices height equal zi height; (c) for all three vertices equal zi height; (d) under zi of the two vertices; (e) above zi of two vertices; (f), (g),(h) one vertex height equal zi height, where (h) a vertex of mid-point equal zi height.

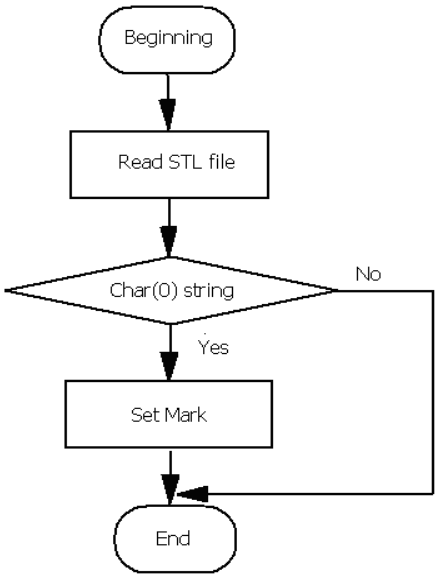


Figure 5. Judging ASCII or Binary format

The Slice Software Design

1) The judgment of ASCII and Binary format in STL storage format

There are more programming methods to judge the STL file format in Binary or ASCII. For example, it searches whether STL file exists a char(0) characters and it’s based on the binary STL file has a basically char(0) string in storing data, but the ASCII file without, Figure. 5.

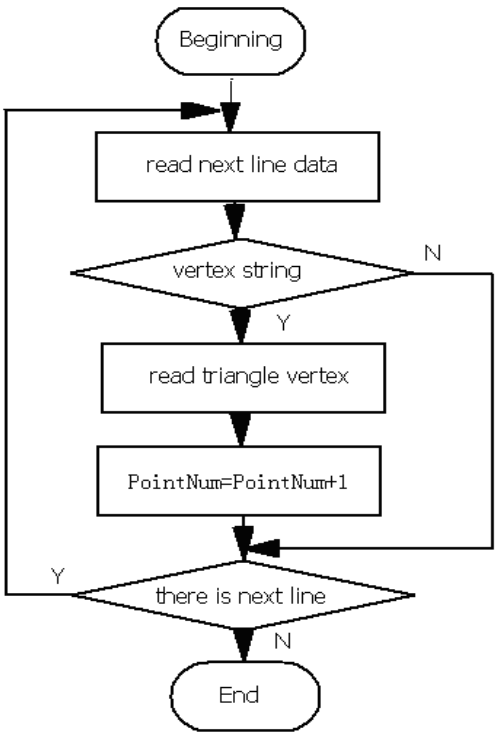


Figure 6. The vertex data reading process

2) Reading vertex data

The sub-programming reads the vertex information of triangle, it judge whether it has 'vertex' character, then read the triangles data and extracts the 3 vertexes of a triangle in the STL file information, Figure 6.

3) The processing for intersection of slicing plane with triangle in STL

In the design, the vertexes are sorted by the height coordinate, and intersection is solved by each of the triangles with slicing plane.

4) Slicing data storage

Each layer sets up a new TXT file to save each layer counter data, and writes the contour data in a TXT file.

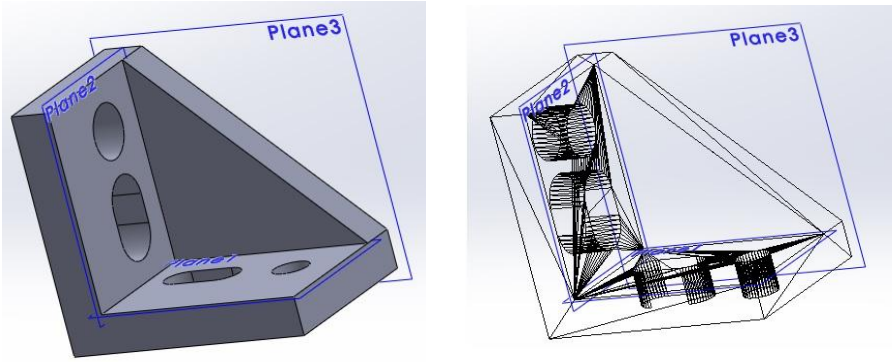
5) Generating the FDM head path route

From the slicing data, it generates the FDM head movement trajectory, and outputs.

The Testing of the Slice Program

The slicing program function is in rapidly slicing STL triangles and output of additive manufacturing path. The soft consists of three parts, reading the STL file, slicing STL model triangles and generating additive manufacturing path.

Following is an application example to generate the slicing data with the program, where a rib part in rehabilitation arm to fabricate with the slicing method. In the application, the CAD design shows in Fig. 7(a), and STL file shows in Fig. 7(b).



(a) (b)

Figure 7. Rib of rehabilitation arm design: a) CAD design b) STL file

It generates the slicing data with the design method for the support rib part in rehabilitation arm and prints it with FDM method, which shows in Figure 8.

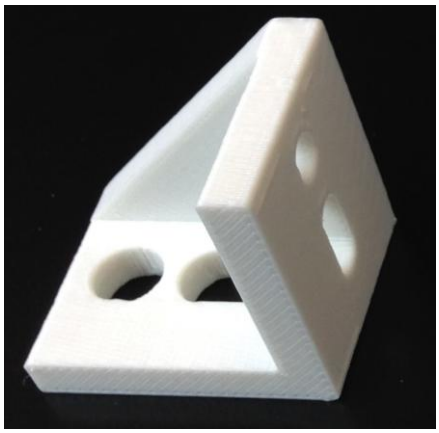


Figure 8. Rib part printing by the slicing method and FDM

Conclusion

This research analyzes the method of STL triangles slicing into contour plane, designs the slicing software and fabricates an example with the layer slicing method. In the research, it prints a sensor rib part with the slice method.

References

1. L M Galantucci, G Percoco, U Dal Maso (2007) A volumetric approach for STL generation from 3D scanned products, journal of materials processing technology 2 0 4 (2 0 0 8) 403–411.

2. F. Javidrad n, A. R. Pourmoayed, Contour curve reconstruction from cloud data for rapid prototyping, Robotics and Computer-Integrated Manufacturing 27 (2011) 397–404

3. Park HT, Chang MH, Park SC. A slicing algorithm of point cloud for rapid prototyping. In: Proceedings of the 2007 summer computer simulation conference, San Diego, California; 2007.

4. Pan Haipeng, Zhou Tianrui, Generation and optimization of slice profile data in rapid prototyping and manufacturing,Journal of Materials Processing Technology 187–188 (2007) 623–626.