The Research Status of Adaptive Slicing In 3D Printing

Yi Shen

Enginring Institute, Huzhou University, Huzhou, Zhejiang, China
sy755084@outlook.com

Abstract. This article reviews the way adaptive slicing improves quality. Efficiency and strength in 3D printing research at the current stage. This article also reviews the way of adaptive slicing to reduce support research, such as using adaptive slicing to adjust the layer thickness of each print layer. This arithmetic tries as much as possible to reduce the print layer thickness of the printout, then the printing time could be shortened, and so on. Under the condition that the printing can be guaranteed to be successful. At the end of this article, it talks about the future development direction of adaptive slicing in 3D printing. This field can research more in optimizing terms of mechanical properties, such as improving rigidity, toughness, and so on. As well as ,this field can also research more in optimization terms of multi-axis 3D printing, such as five-axis 3D printing, eight-axis metal 3D printing, and so on.

Keywords: 3D ptinting, Adaptive slicing, Review

1 Introduction

Nowadays, 3D printing technology is becoming more and more popular in people's view. 3D printing technology, also known as additive manufacturing. This technology is used to create parts by layering materials one upon another. 3D printing has many advantages, such as flexible design, cost saving, increased efficiency and so on. 3D printing has a wide application. For example, before mass production, the designer can use the 3D printing technology to print a sample piece. Then the designer can test it and research it to avoid large-scale production defects. For example, the scientist can use the 3D printing technology to print a sample piece of the thing, such as a cultural relic, and so on. Then the scientist can try to understand the performance of the original piece by researching the replica to cut costs. The Almetwally team just copied the sample of rock core by 3D printing technology and to research those rock cores that are not easily accessible underground by the sample of rock core, then they save the cost of researching rock cores [1].

Today, 3D printing technology still has some flaws, such as poor surface precision of the print, poor mechanical properties, too much support, and so on. These problems will all have an impact on the quality of the 3D printing sample, these could make the sample fail to meet the requirements. For example, Tay, Daniel Yi Wei team just showed clearly that although concrete 3D printing can create some complex structures, it's difficult to create without support [2]. So we need to optimize the layering process

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of the current 3D printing, then let the precision and strength of the sample meet the requirements.

2 Improve the quality of 3D printing

First is some ways to improve the quality of 3D Printing. Although 3D Printing has strong flexibility and customization capabilities, and printing a sample with many shapes and styles to meet the individualized demands of users, it has insufficient precision in details.

2.1 Algorithm improvement

Zhu Min's team, regarding the issue of the step effect that 3D printing has, came up with an adaptive slicing algorithm. This algorithm is based on the STL model and can improve precision and step effect. This algorithm gets relevant data and information about the triangle patch normal vector by seeking and calculating some information from the STL document. Then, calculate the included angle of the triangle patch and layered plane by a normal vector of the triangle patch to adjust print thickness, and then reduce the step effect. It also reduces the layering thickness by calculating and analyzing of 3D printing dihedral angle [3].

Geyin Min team regarding the issue of step effect and adaptive slicing calcilate complex that 3D printing has, come up with an adaptive slicing algorithm. This algorithm is based on the STL model and works to improve the STL model. This algorithm explains that the precision of 3D printing is not high by reading and analyzing STL model data. The reason why the precision of 3D printing is not high is that the nozzle diameter of the 3D printing machine and the layering thickness are all too big. Then to improve layering thickness by calculating the included angle of the two triangle patch reseau normal vector. This way can effectively avoid the loss and skewing of model feature details[4].

2.2 Fused deposition modeling

Fused deposition modeling is a technology that heats the filamentous material at a temperature slightly above the melting point of the material, then uses the nozzle to spray out the deformed material, then lets it cool and solidify.

Huangyun Qing bases on FDM technology to analyze and research some fields of 3D printing. Aiming at the 3D printing step effect and print offset problem, he has put forward an optimization of print thickness and an adaptive slicing algorithm flow. This can effectively enhance the surface quality of the 3D printing sample [5]. Based on some defects of FDM 3D printing, Zengshan Lin came up with improvement methods in multiple aspects. Among them, Zengshan Lin came up with an area printing algorithm targeted at the problem of equal-thickness stratification algorithm and adaptive slicing, are all use uniform thickness stratification. This algorithm divides the printing into two layers, namely the inner layer and the outer layer, then thickness print for the

inner layer to guarantee sample strength and thin print for the outer layer to guarantee surface quality. This way can effectively improve the surface quality of 3D printing [6].

Ning Lv's team came up with an adaptive slicing arithmetic for calculating the optimal volume error to target at the step effect problem that FDM technology has. This arithmetic makes sure each layer has the best printing thickness by calculating the best volume error of each layer when 3D printing is printing, then to improve the surface quality [7]. Baishi Geng carried out 3D printing modeling and analysis aimed at the accuracy of 3D printing nozzle scanning, and it is based on FDM technology. It can effectively enhance the scanning accuracy of 3D printing nozzles and improve the molding precision of the 3D printing [8]. Wu Yan came up with a way to improve the normal vector angle team of the tangent plane and triangle patch to aim at the step effect problem of 3D printing, and it's based on NTASM. This method takes the vertical sharp-angled model and a parallel acute angle model as the experimental subject. This method improves the identification of the detailed thickness model by changing the normal vector angle of the tangent plane and triangle patch of the 3D printing sample. This method can effectively enhance the molding precision of the model and reduce roughness [9].

2.3 Powder bed fusion

Powder bed fusion is a technology that spreads the powder material on a flat surface at first, then uses laser irradiation to melt the powder, and powder cooling and solidification molding in the end.

E. Persembe's team made a new 3D printer to address some problems that the silkworm leaf powder bed 3D printer has. This new 3D printer can control 3D printing inkjet and adaptive layer thickness better, so it can meet higher precision requirements [10].

3 Improve the efficiency of 3D printing

Then is improve the efficiency of 3D printing. Although the efficiency of 3D printing is faster than traditional processing methods for parts, some 3D printing processes also need to cost a few hours. So, we need to improve the efficiency of 3D printing.

3.1 Algorithm improvement

Yifei Hu team came up with a 3D printing adaptive slicing algorithm, and it's based on improving the 3D printing area ratio and precise tip height. This arithmetic sets the print layer thickness by precise tip height and optimized improvement of rutting in the affected area, then attempts optimization. This arithmetic can reduce printing time and can keep the accuracy within a certain range [11]. Based on the outer contour of the CAD model, the Chensong Mao team came up with an adaptive slicing algorithm. This algorithm aims at minimizing message loss when a CAD model changes to an STL

document. This algorithm effectively avoids loss of information due to format conversion by directly through CAD analysis. It's improved efficiency while maintaining the quality of analysis [12]. Xiaoqi Wang team come up with two formulae to solve the problem of step effect and how to balance printing time and quality. One of them can solve printing time and it's a formula between printing time and thickness [13].

3.2 Fused deposition modeling

The algorithm Ning Lv team put forward can not only improve the surface quality of 3D printing samples, but also improve forming efficiency. Common 3D printing usually uses the same printing thickness, so it will cost too much time when printing higher precision because every layer uses the same thickness. But the algorithm Ning Lv team put forward can confirm the best printing thickness of each layer, then it will let each layer have a different thickness. So it can reduce some unnecessary improvement of accuracy to improve printing efficiency [7]. Similarly, Zengshan Lin's area printing algorithm can also improve printing efficiency. This algorithm makes a difference in thickness between inside and outside can also reduce some unnecessary improvement of accuracy to improve printing efficiency [6].

Zhaoxin Yi research on the preliminary work of FDM, such as analyze and read the STL file of 3D printing and so on. He come up with a adaptive slicing arithmetic to improve step effect. At first, this arithmetic confirms the triangle patch that intersect each layer by different height of each layer.Then this arithmetic confirms the final layer thickness by conducting an analysis and classification of these triangle patches. This arithmetic can reduce the matching and calculating time of finding the triangle patch that intersects each layer and then improve hierarchical efficiency[14].

3.3 Stereo lithography apparatus

Stereo lithography apparatus is a technology that uses ultraviolet rays to expose the liquid photosensitive resin material to light, then let it solidify and form into a shape.

The Cheng Lin team comes up with an LCD SLA arithmetic of adaptive slicing to solve the low efficiency of SLA. Traditional 3D printing uses the same thickness of each layer, and it lacks flexibility. As mentioned earlier, it's low efficiency. The Cheng Lin team's arithmetic can solve this problem by using arithmetic to make different layer thicknesses to improve printing efficiency [15]. He Bin come up with an improved solution to improve some aspects of SLA, such as support and so on. Among them, he came up with an equal-thickness stratification aimed at the balance between step effect and printing time. At first, this arithmetic classifies the triangular patches. Then let these triangular patches establish a topological relationship. Ultimately, let these triangular patches intersect with a plane and form the outline. While resolving the step effect, this arithmetic can also enhance efficiency[16]. Yeweng Dan based on the SLA to develop a control software. The topological sort algorithm of this software can conduct statistics and analysis on data in printing, then improve hierarchical efficiency[17].

4 Improve the strength of 3D printing

Then is improve the strength of 3D printing. Improving the strength of 3D printing can improve the success rate of 3D printing and save costs, and improve efficiency. It can also improve the impact resistance of the sample, so it can prevent the sample not being damaged too quickly.

4.1 Fused deposition modelling

Lee. Wonchul based on FDM to come up with an improved solution to solve the problems caused by excessive or insufficient compressive stress when printing. This solution carries out post-production adjustments of printing arguments by getting printing pictures from an adaptive hierarchical system. This makes the compression force control within reasonable bounds. This method can improve the strength of 3D printing [18]. Zengshan Lin's arithmetic can also improve the strength of 3D printing. It is because this arithmetic lets the layer inside become thicker. So it's to improve the strength [6].

5 Reduce the printing of supports

Traditional 3D printing has some support, and the support needs to be removed when the printing is over. When removing the support, it will have a negative impact on the quality and accuracy of the samples. So we need to reduce the support.

5.1 Fused deposition modeling

Gongyv Cheng team came up with an idea of applying the robotic arm into 3D printing to solve the problem of the waste support in 2.5FDM 3D printing. Then they come up with an adaptive hierarchical algorithm of a degree-of-freedom manipulator based on the decomposition of projection. At first, this algorithm imports the model data of the relevant processing parts. Then it will do the calculation of the no-support route and layering. Finally, it will create the G-code command that the robotic arm can understand through some calculation. Ten, the robotic arm can work in 3D printing, and printing without support is achievable[19, 20].

5.2 Ceramic 3D printing

Ceramic 3D printing is a technology that uses additive manufacturing technology, such as FDM, then use this technology print ceramic materials into a shape. This technology can improve the production efficiency and quality of ceramics, and under the premise of ceramics, can be customized in terms of.

Fanchao Zhong's team, based on ceramic 3D printing, came up with a tool beneficial for 3D printing of ceramics to in account the soft and sticky nature of the printing material, clay. This tool can check whether the contours and trajectory curves of the design conform to the self-supporting and non-self-intersecting constraints. This tool will automatically correct if it's incorrect. This tool can avoid the collapse of ceramic 3D printing and achieve self-sufficiency.

6 Conclusion

This article reviews some common ways to improve 3D printing by adaptive hierarchical technology. It has improved on quality, efficiency and strength. This article also reviews the way to reduce support research. This article can help the reader quickly know some ways of adaptive hierarchical technology to improve 3D printing and reduce time of reading some related articles. This article can also help people who just want to try to research this field to get an idea and make sure the idea will not be identical. This field can have more research in some other mechanical properties, such as how to improve sample toughness by changing the printing angle of some printed layers in the future. This field can also have more research in improve multi-axis 3D printing, such as how to reduce the step effect of five-axis 3D printing and so on.

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