COMPOSITE MATERIAL WIRE PRINTING OF THE PARAMETRIC CONSTRUCTION PROCESS AND ROBOTIC FABRICATION

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Abstract

In recent years, 3D printing technology has been continuously refined and applied in various design fields, but at the same time it is also easy to copy due to computer aids. Therefore, the uniqueness of materials and construction methods make the technology irreplaceable. The following is a study of wire print.

Wire print ,is a better printing method which partially replaced FDM (Fused Deposition Modeling) to reduce material and time costs considerably.

The purpose of this study is to develop a method that can efficiently generate line segments and paths in three dimensions space and how to transform a digital model into a g-code for 3D printers and robots by simply using parametric modeling software (grasshopper), materials experiments and tools design.

The research is mainly divided into three parts. The first is about material attempts and the application of effects. The second is about the method of parameterizing the generated paths and the conversion of g-code to the wire print. Third, is about the operation of mechanical equipment and the tool head of robotic arms design modified. This research three dimensions printing technology can be applied to parametric ceramic products or larger-scale spatial designs, enabling architects and designers to conduct more capacity development in future.

***Keywords*—Parametric software, wire print, Robotic arms fabrication, Composite Filament Additive manufacturing,**

I. Introduction

THE digital age today, the application of computer-aided design often increases the complexity of the design, but it also reduces the originality. Taking the 3D printing technology as an example, with the premise of complete equipment and materials, the parametric design enables the same digital path to produce a large number of products that are similar but different. Due to that the works discussed in this paper will be more creative towards the limits of materials and equipment to highlight the originality and value of this research.

There dimensions printing technology is defined as RP (rapid prototyping) technology, but in fact there are two problems to be solved. First, the choice of extrusion materials and the FDM production have limitation of load-bearing 94proportional to the quality and scale of objects (time limitation). The wire print technique, however, solves the shortcomings of the original part by printing outlines only instead of the printed entities, not only saving the material and time, also increasing the amount of prototype proofing. But converting a digital model to a mesh outline is something people who need a program background or a particular machine only. Cornell University and Disney Research Studio have done linear printing applications in the model proofing research. RC4 of UCL designed the “Point” elements such that the print paths are always arranged in a unitary array and the groups are organized into new mesh objects. These cases all show that the freedom of linear printing is always limited by the material not machine. In the preservation of the advantages of linear printing, finding more flexible construction method and materials testing, are the next steps.

II. Research Problem

Two problems are encountered in the experiment: one is how the software controls the free extrusion path of the tool, and the other is that when the printing scale is too large, an alternative to the existing fused plastic composite material and its printing method must be found. In summary, the most efficient way is to find out

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without support, and more able to overcome gravity and the force from material itself. The first question is how to effectively proof the product instead of using the traditional FDM printout, so that the motion of the print-head must not be in accordance with the g-code action generated by the slicing software. In the experiment, I tried to use the grasshopper software to change. The second problem, after exceeding the print capacity limitations of traditional 3D printers, was to try robots with a larger print range and use the print head as an extrusion platform to create larger prints path.

III. Research analysis and system design:

Use In order to create a linear free extrusion path, realizing ways to control the machine to export non-sliced g-code is important. The difference between FDM production and wire print extrusion, effects the g-code coding. There are the following different of researching:

3.1. PARAMETRIC PATH STEP STANDARDIZATION:

LAYERED

The path exported by the slicing software forms numerous closed curves that do not overlap each other in each XY plane. The path produced by wire print is a continuous curve or grid line, and the order of the points and vectors must be continuous to sort, so there will be a total of points in the Z axis or collinear, like a spiral.

(Figure 1)

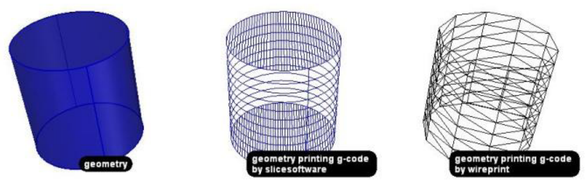

Fig.1. different path to print the same object make different characteristic and costs

BRACING AND FILLING:

The design of the path, because it is a grid-like, in the continuous rendering of the rectangle will be designed bracing that the path can be completed by a stroke. However, due to the slopes and nozzle extrusion limitations, some surfaces will make the structure more stable with a filled or repeated path. (Figure 1)

LIMITATION:

The nozzle design in the front must have heating aluminum block. the purpose is to make the heat close to the extrusion point, on the contrary will make the material out of circulation or even blocking, That angle between the nozzle and the aluminum block edge, becomes the limit slope of the grid or structural bracing unless more axial movement of the nozzle in the Z direction is ignored (like robotic arm extrusion).

(Figure 2)

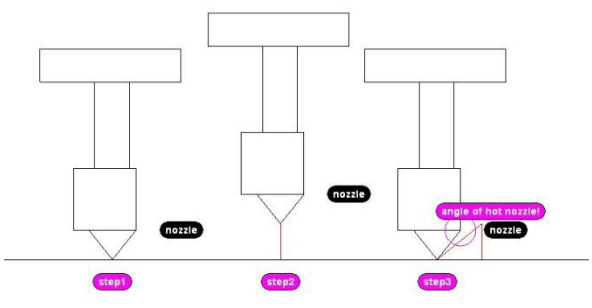

Fig.2. the nozzle run the path is limited by hot nozzle, in The experiment, the range of safe angle is 0 degree to 35 degree.

CUSTOMIZED:

Relative to the path created by slicing software, wire print makes the print platform more flexible, with more activity and plotting possibilities on the Z axis, and relatively more interesting patterns and structures. At the same time, It does not need support material and paper print frame, eliminating a lot of time and material costs. (Figure

3)

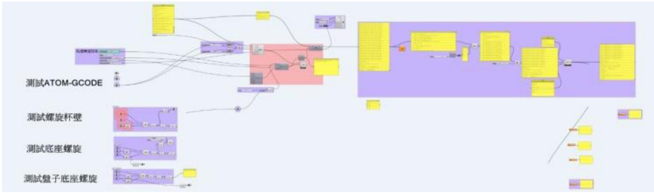

Fig.3. Using grasshopper to design the path of PLA extrusion.

PROBLEM AND SOLUTION:

The current changes made in the printer are still hierarchical printing. In addition to the use of six-axis arm to improve spans and degrees of freedom, but also to adjust the material simultaneously to increase the ability of three-dimensional space bridging the gap, especially when scaling the same time. So far, study PLA / ABS, Pottery, fiber and thermal fuse composite extrusion materials.

3.2. MATERIAL EXPERIMENT:

In the study, looking for materials that could be extruded linearly, in order to adjust the tool head design and path design in parameters and experiments:

3.2.1. POTTERY MATERIAL:

Pottery printing is the material to be tested before testing the composite material. Its characteristics do not need to go through the hot nozzle, as long as to extrude by the air pressure and controlled nozzle directly. The finished product must be baked. If the process does not take into account the stress changes, the final product will have cracks, so the path of extrusion design becomes very important, as a result of the experiment to complete the continuous path extrusion and the setting of angle & speed. (Figure 4,5,6,7)

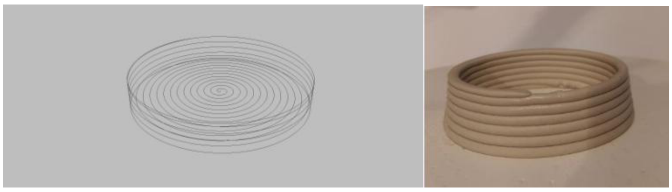

Fig.4.Wire print can make continuously path

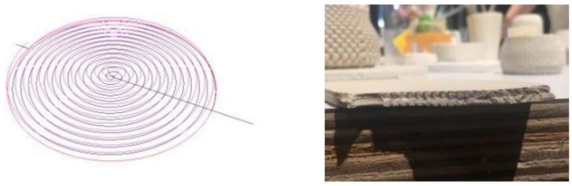

Fig5. Because of the crack after baking, put two layers and make the space separated to combine easily

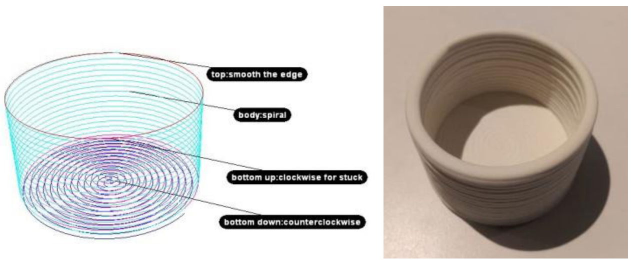

Fig.6. A pottery printing cup is made of one top, a body, two layers of bottom. This setting makes the pottery production unbreakable after baking.

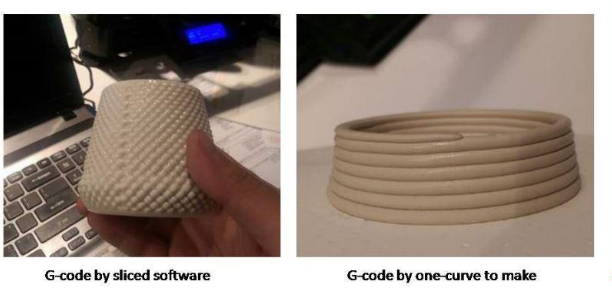

Fig.7. Using the software to contour the g-code is not good at pottery material, because of its construction method will make unrepaired after 500 degree baking.

3.2.2. THERMOPLASTIC AND FIBER MATERIAL:

In the material extrusion printing, there has been an attempt to extrude the way not out of the Z-axis method, Compared to pottery coagulation is definitely better than the hot melt plastic even longer. With the Robotic arms of different axial free extrusion characteristics, the text of the experiment with two kinds of composite materials combination. The first is the rough nozzle. When the thermal go through, the outer edge will melt and easy to be molded, at the same time, the fiber bundle is sticking after the extrusion attached to the plastic, The central Part of the solid is still solid, allowing to test different angles, recording which angles are easiest naturally formed in the air. The next, with the fiber in the hot-melt printing inside, coaxial extrusion, like reinforced concrete, steel fiber tensile, cement is hot melt plastic. The next step of research will focus on different fiber types and numbers combined with the thermoplastic extrusion. (Figure 8)

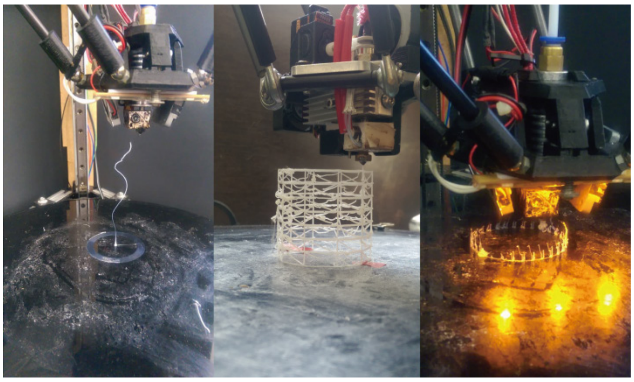

Fig.8. Wire print can make continuously path, in this experiment not only save the time but lots of material.

3.3. ROBOTIC ARMS AND TOOL HEAD DESIGN:

3.3.1. PLA Print extruder tool head and path:

The beginning is to use the common delta machine to do path simulation, so the manufacturing is often limited by the body of printer space and the unchanged Z-axis direction extrusion. After disassembling the printer and assembling on robotic arm to overcome the problem of print range, but there are many problems to solved like the weight limit, power supply, tool head size design, extrusion material cooling and flow problems…etc. In design, most of all is to reduce the front load. The power equipment, electric control machinery and equipment can be placed in the third four-axis, the first and second axis placed material and fiber, the fifth, six-axis are used to assemble the hot nozzle of the tool head And cooling system. The front end of the tool should be sharp to reduce the tool head can only print at a small angle. After the design and improvement of the tool head, the structure and space extrusion have also been successfully printed out. (Figure 9,10,11,12)

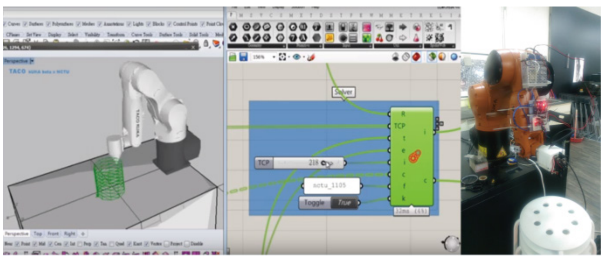

Fig.9. Using grasshopper to generate the path and control the robotic arms and electric element fast and precise.

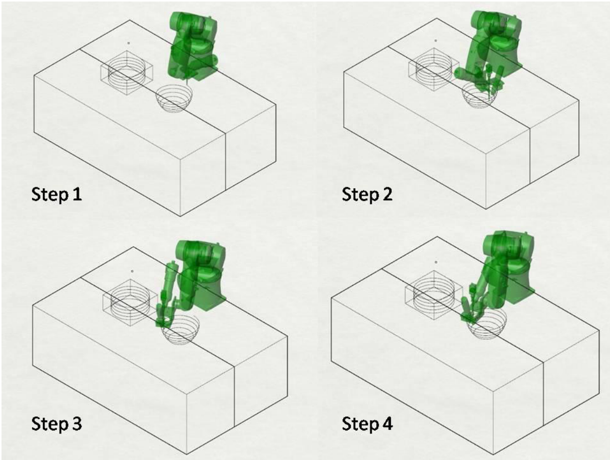

Fig.10. Wire print process with the tool head design and robot.

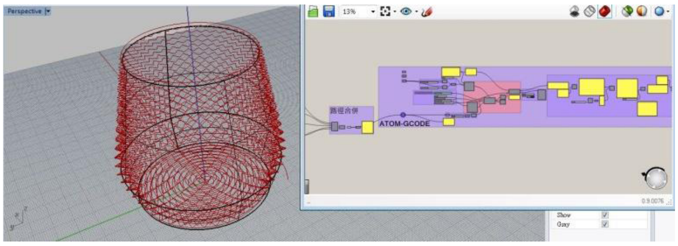

Fig.11. Parametric wire print process from grasshopper software (can range the distance by slider).

3.3.2. Pottery print material extrusion tool head and path

In the future, there will be a co-operation case of a dome print case, which will also include relevant processes and parameters in its research. Due to the inability to use the hot nozzle and the cooling system to immediately enhance the extruded material, it is printed almost vertically only. The stacking method and the pattern design are more limited by the structural properties of the material, which is not discussed in detail in this chapter.
(Figure 12-16)

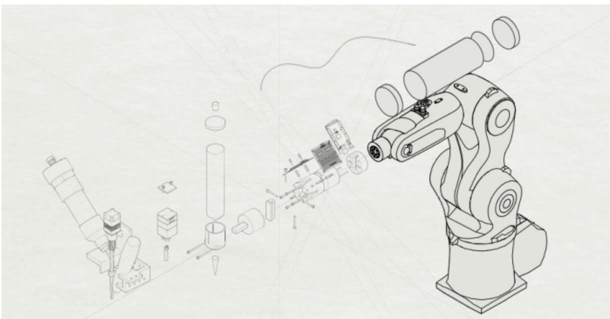

Fig.12. Pottery material is a material not easy to solidify, so wire print with robotic arms is not easy to accumulation. The tool head design different from before is the cooling system.

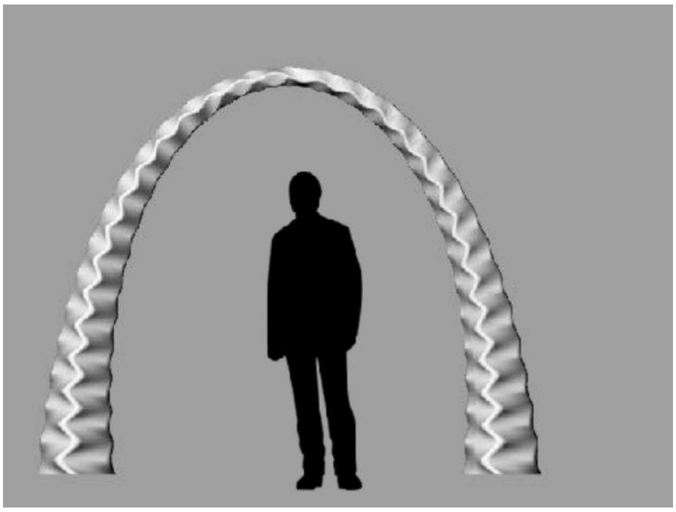

Fig.13. In the case, design the arch by pottery material is a challenge for stiffness of pottery material.

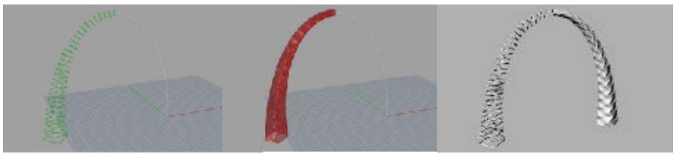

Fig.14. separate the design and use the parametric software to make towel different radius. Make sure the structure stable, mirror that in the end.

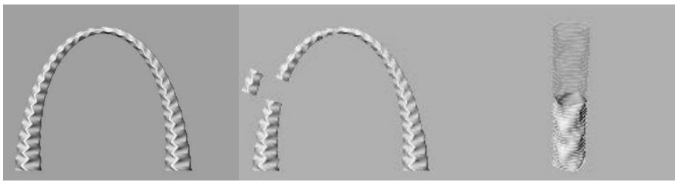

Fig.15. Because of the printing process, I can't produce that in one printing path. Fabricate them divided and assembly them, after the pottery material unit solidification.

Fig.16. Pottery material wire print can make one-curve path to print, continuously extruding not only enhance the stable of structure, but

Protect the pottery material without breaking after baking. This research will be more vigorous for the application of structural pavilion and spatial design by designer and architect.

IV. Conclusion:

Today's 3D printing technology is still considered to be copy easily. Due to its fused deposition method, it can only slowly "copy" geometry, but cannot quickly "create" the free path.

This manufacturing method is not only un-rapid, but un-original. As the scale increases, the same materials will be limited and take a lot of time and cost. This is not ideal for fast proofing and fabricating in 3D space.From this study, the study aims to optimize the accuracy of additive manufacturing processes with less material and time cost. At the same time, the disadvantages of additive manufacturing of materials (support materials) and time (printing time) are overcome. The principle is the same as knitting and weaving when the continuity of the stable discharge produces a straight path. From the software setup point of view, the rapid prototyping machine can extrude the free axial movement of the extrusion platform to create any three-dimensional extrusion path. For material engineering studies, using coaxial composite extrusion, the change in the extrusion path for testing the strength of the composite material can be found in different ways, the most suitable combination selected, and finally the larger span structure is printed with the robotic arms to determine that the composite material can have more forming conditions.It is believed that in the future, on the same kind of material, it is possible to arbitrarily select the "filled-in" path and the "weaved" path to synthesize the printing path, which is a new construction method that takes both design and low cost into consideration.This removal relies on the steps of “deposition” and “supporting-molds”, designers and architects can have more capability to design and applications.

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