Digi-Craft: A Creative Process in Form-Finding Beyond the Accuracy of 3D Printing

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Abstract. This study aims to explore the creative way in using 3D printer during form-finding process. We found a creative process blurring the accuracy of 3D printing. We use the "Stringing" effect as the modelling method and enhance the abstraction of 3D printing, which called Digi-Craft. Finally, we successfully fabricate the coral-like, hanging lines, meshing surface 3D printed models. These models' shapes are not fully created in 3D model; some parts are "Stringing" parts which we controlled by 3D printing factors. We hope this method will improve the creativity of form-finding design process in using 3D printing.

Keywords: Form-finding · 3D printing · Stringing · Accuracy Abstraction

1 Introduction

3D printing was known as "rapid prototyping". Its official nomenclature of "Additive Manufacturing" (AM) is defined as "a process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies" (ASTM 2012). There are different methods of AM, including the most widely adopted technologies, fused deposition modelling (FDM), stereolithography (SLA), selective laser sintering (SLS) and 3D printing (3DP), but new additive processes continue to be developed and commercialized (Petrovic et al. 2011).

In the late 20th century, 3D printers were extremely expensive and could only be used to print a limited number of products. Consequently, the development of open source hardware and low-cost 3D printers induce the 3D printing began to lead a worldwide manufacturing revolution. It expands the freedom of complex forms/shapes manufacture, and gives a great impact to design field too.

2 Problem and Objective

If we reviewing the traditional additive manufacturing process, it actually began from the ancient period, around 2500 BC. The Traditional additive fabrication began with clay coiling pottery, by making a long snake of clay and coiling it up into a pot shape.

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The clay coiling process is a handmade process and it performs the hand-craft inaccuracy and abstraction. In the manufacturing process, artist have the opportunity to modify the shapes of pottery at any time by hand (Fig. 1).

Fig. 1. Clay coiling pottery (around 2500 BC)

However, 3D printing showing the accuracy of the digital manufacture process. The 3D model was first created and then export to .STL format CAD file. As the CAD file is not machine readable and thus needs an intermediate software, Slicer. The intermediate software such as Kisslicer, CURA, etc., enable slice the geometries into layers, and deals with extruder heating, layer thickness, speed, and calculates the toolpath to creates a Gcode file, which is machine readable. The whole process is very accuracy and the model manufacture in layers digitally.

As the 3D printing has the advantage in complex and freeform model making, designers or artists enable to utilize this technique to represent their design forms. However, the accuracy operation while manufacture prompt to the limitation of the creativity in conceptual design process. As the tools in aiding design thinking of form finding in the conceptual design stage, does the 3D printing process have its characteristics of abstraction?

In order to enhance the usage of 3D printing in the form making process, especially to aid in the early conceptual process, furthermore to blurring the accuracy process and beyond the establish operation, this study attempts to combine the characteristic of inaccuracy and abstraction like the hand-craft clay coiling process to digital 3D printing process. The aim of this study is to find out the creative way of using 3D printing and to propose a new model making method: Digi-Craft, a form finding process beyond the accuracy of 3D printing.

3 Methodology

From questionnaires by designers and data analysis, we conclude the design factors which can affect the accuracy and abstraction in form-finding design process. The following shows the factors concluded as Table 1.

Table 1. Design factors of accuracy and abstraction.

	Accuracy factors	Abstraction factors
Stiffness	Rigid	Soft, flexible
Form	Geometric shape, math form	Freeform shape, natural form
Material	Metal, plywood	Fabric, clay
Structure	Compression	Tension

Then we conducted the 3D printing experiment based on the analyzed factors. In order to find out the abstraction and inaccuracy in 3D printing manufacture operations, we test the freeform, natural shapes, and tried to test the fabric-like, flexible-like models. To control the machine parameters, we adjust the four main 3D printing control factors:

a. Temperature (extruder heating, bed heating)
b. Speed (travel speed, extruder speed)
c. Retraction
d. Cooling (fans).

4 Unexpected Discovery

3D prints sometimes show small strands of plastic on places where the 3d printers shouldn't print and the print head must only travel from one place to another. These unwanted strands of plastic is called Stringing (Fig. 2). We found that the Stringing effect in 3D printing is very interesting, normally it's a drawback of 3D printing. If we create the fine CAD 3D model to slice and send to print normally, it will not appear in the model fabrication process. But if we set the wrong temperature, speed or other issues, it will appear and damage the model in the result. As this effect appear unexpectedly, and also inaccuracy, we decided to use it in form finding process to represent the fabric-like and flexible-like characteristic. After testing the parameters of the five control factors, we success to create the stringing effect according to our desire, but still keep the abstraction (Fig. 2).

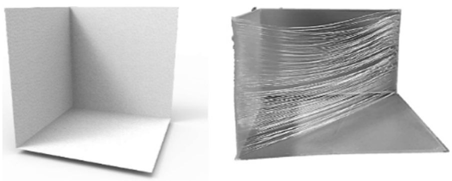

Fig. 2. Stringing effect in 3D printing

We used the same 3D model CAD file (simple modeling) to print out slightly different 3D printing models, which integrate the rigid parts (3D model) and flexible parts (3D printing factors). Finally, we successfully fabricate the coral-like, hanging lines, meshing surface 3D printed models (Fig. 3). These models' shapes are not fully created in 3D model; some parts are "stringing" parts which we controlled by 3D printing factors.

Fig. 3. Model making: integration of rigid parts (3D model) and flexible parts (stringing)

As we need to create the Stringing parts, we tried to figure out the toolpaths generated by the Slicer software in the beginning (Fig. 4), however we cannot modify the toolpaths in the existing software. As we need to create our own toolpath so that we can generate the stringing shape which we desire. Therefore, we try to use the "lines modelling" or "toolpath modelling" method in creating design forms to generate the toolpath directly from coding tools (Processing, Grasshopper). Then controlled the 3D print factors to print the forms (Fig. 5). The models are printed very fast and province materials.

Consequently, we propose a new 3D printing modelling method that can generate the fabric-like, hanging-lines and thinnest surface models. We tried to turn the disadvantages to advantages by creative thinking. We find out the creative way of using 3D printing and conclude a new model making method which called Digi-Craft, a form finding process beyond the accuracy of 3D printing. We hope this method will improve the creativity of form-finding design process in using 3D printing.

Fig. 4. Analysis process of the toolpaths (stringing) generated by Slicer software

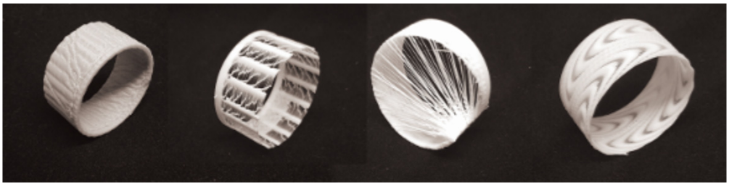

Fig. 5. 3D printed model making from Digit-Craft method

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