The Study of Generating External Structure for Scanned Object by 3D Printing

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Abstract

The original purpose of this project is studying the possibility of printing the external structure on a scanned object based on its scanned data, and a skill of applying buffer layer is submitted in the previous proposal to make the external structure could be built. If this skill is feasible, it can accelerate 3D printing with an embedded mould substantially. In the comparison test, several facts that influences the printed buffer layer to provide stable base for external are discovered, and the scanning resolution needs to be improved for accurate printing. The further application of shoe's 3D printing for this prototype is set, and a handy scanner is designed and integrated into the prototype.

1. Background

Currently as well known, the most 3D printing technologies are processed by printing thin layers on the flat platform layer by layer, and that's why it consumes so much time. The intension of this study is tried to seek the possibility of proceeding 3D printing on an irregular surface that comes from the scanned data. If this skill could be verified and developed, and that means the remanufactured surface can be used as base and replace the volume that is generated by 3D printing in the past, and save the time from printing the volume for these support or filled solid.

In the frequent samples in below fig 01, obviously the time and material for printing the support occupy quite high percentage for the whole fabrication, and of course this situation depends on the model itself and how it place on the platform. The machine needs to spend much time on moving over these area in each layer. So, If in a case of the surface is made for match another object after finished, applying the object as an initial foundation in the 3D printing and that will save the time and material to print support or infilled volume.

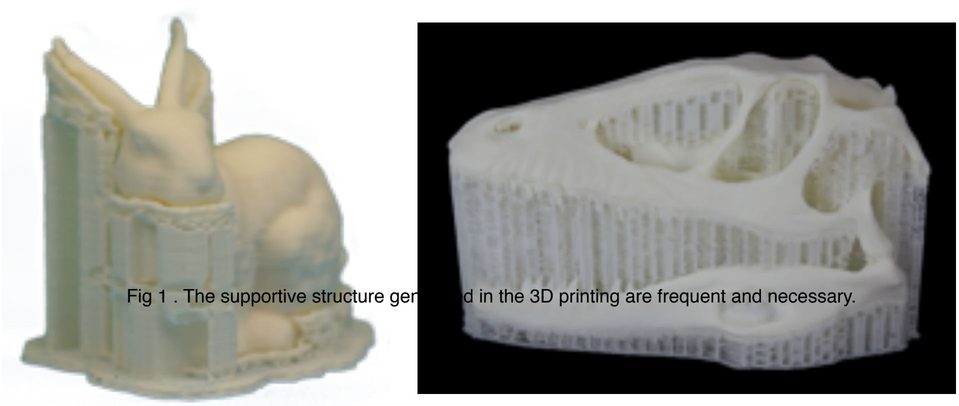

Fig 1 . The supportive structure generated in the 3D printing are frequent and necessary.

Somehow, several critical work principles of 3D printing limits this development:

(1) The foundational surface may obstruct the extruder(or called as J head)'s moving path. No matter the printing process starts from any angle on the surface, the protuberances on the surface have high possibility to hit the extruder in its movement. The upper space on the printed object should be kept as clear for extruder to pass. However, the movement of extruder is based on the method of 3D printing decomposed the printed form and how it generates the Gcode, and it's difficult to set the machine to recognise the barrier and calculate the path for avoid hits.

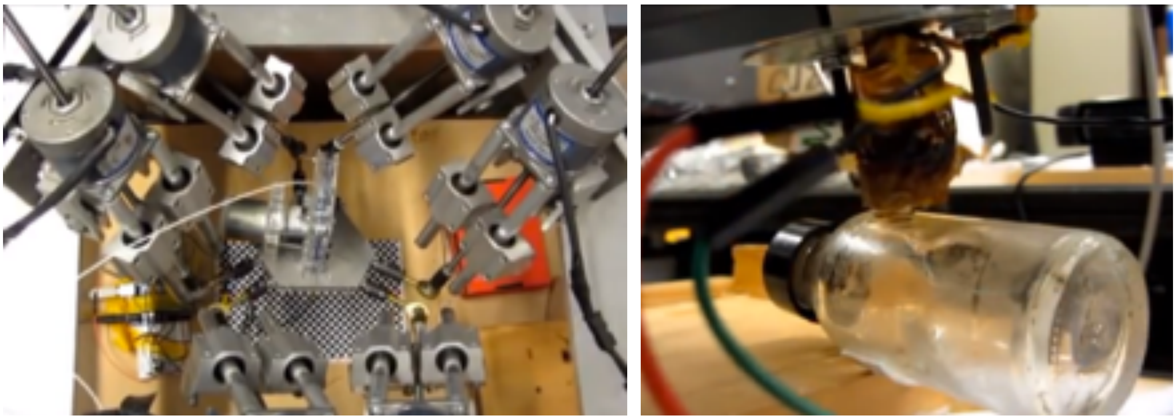

Fig 2 . The 3D printer equips 6 axes for printing on the surface of bottle.

(2) The extruder needs to keep a tiny distance about 0.3mm between the surface during the whole printing process in most situations. This distance matters how the extruded filament will form and contact the surface. Keeping the distance is important to the quality of result. Due to the fixed angle of extruder, the distance will be changed when extruder moving over on the surface. That's why some similar studies try to make the extruder angle adjustable, such as the pic as below, the special extruder equipped 6 stepper motors for changing the angle to adopt the surface. However, this machine modification will increase mass parameters in the G-code and higher cost than the 3D printer itself.

2. Buffer layer

For solving these above problems by the limited modification on current structure of FDM printer, a printing skill to print buffer and low resolution layer between surface and printed object is submitted in this study. This layer is constructed by a continuous N structure that printed by normal FDM machine, and it can solve both problems about hitting the surface and keeping the distance.

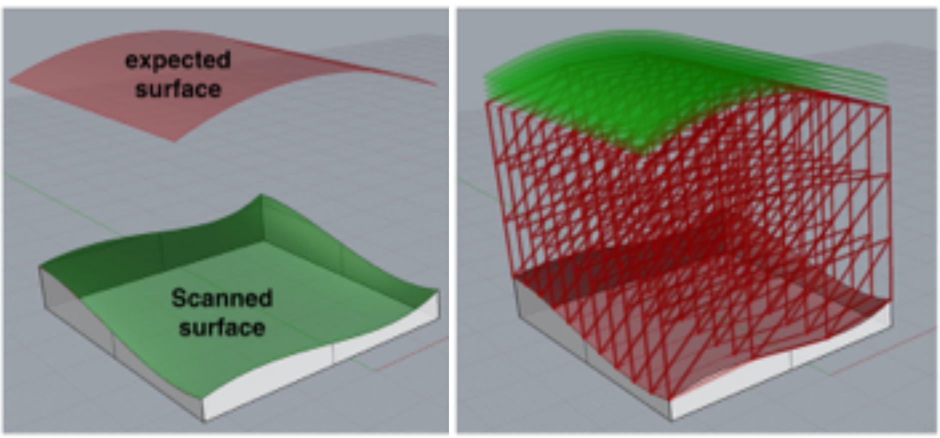

Fig 3 . The buffer layer between the surfaces and connect both by the N structure.

Its function is very similar to the raft layer of current 3D printing, but in the 3 dimensional structure. It provides better adhesion base for the first layer, and makes the printed result easier to be removed from the heating bed.

For the problem about the basic surface blocks the extruder’s path, the printing buffer layer will keep the extruder in a safer hight and only contact the surface by points. Compare to the moving along the surface in other researches, the point-to-point contacts don’t require the high accuracy of extruder’s movement, then the extruder will leave surface and back the hight after each point. Besides, the N move of printing this layer will keep extruder moving in a clear space, but the size of extruder’s front head will limit the step distance of N move.

For the problem of keeping the distance between the surface and extruder, the frequency of contacts is also reduced by the way of point contacts. The distance of each point contact may also be changed because of inaccuracy reasons, and increasing extruded quantity may extend contact area if the distance is farer then usual.

3. Verification

For generating the G-code of buffer layer, a G-code generator program is developed in this project. The program can accept 2 surfaces as inputs, and the volume between 2 surfaces will be sliced and filled with the N structure. The reason why applied N structure is its route can avoid to crush the previous structure and create a new surface height rapidly. This program is applied in the follow-up test for generating G-code.

In the test, an experiment is designed to test printing the surface and buffer layer together first, then next stage is printing the buffer layer on an existing surface fixed on the platform. This experiment can verify whether the buffer layer can attach on an existing surface in the two separated printings and form a firm base.

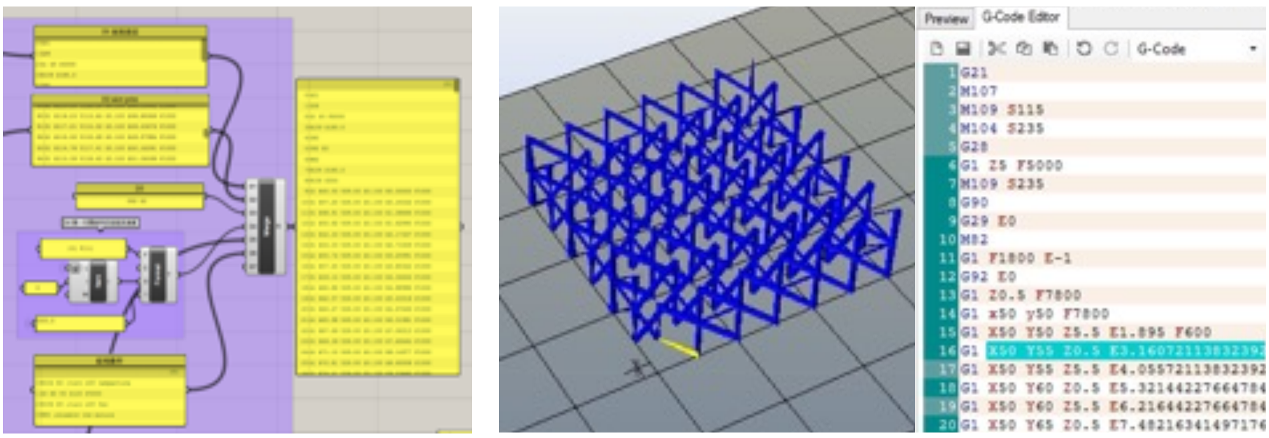

Fig 4. Left: The summary part of G-code generator program. Right: The G-code of mesh printing generated by our program formed a low-density layer.

Predictably, in the first stage, the printing the surface and buffer layer in the same Gcode and task has the higher chance to finish the whole printing, and provide a better base to continue the printing of external form. In some cases, the extruder crushed or drag the previous printed structure, because the angle and size of extruder head. The ideal step size of N structure is between 3-5 mm, but small step will limit the adaptive ability on the surface. Smaller horizontal step, such as 3 mm, can absorb the drop height about 1 mm. Special tiny head can avoid to crush or drag the finished structure, such as the J head in the right of below picture.

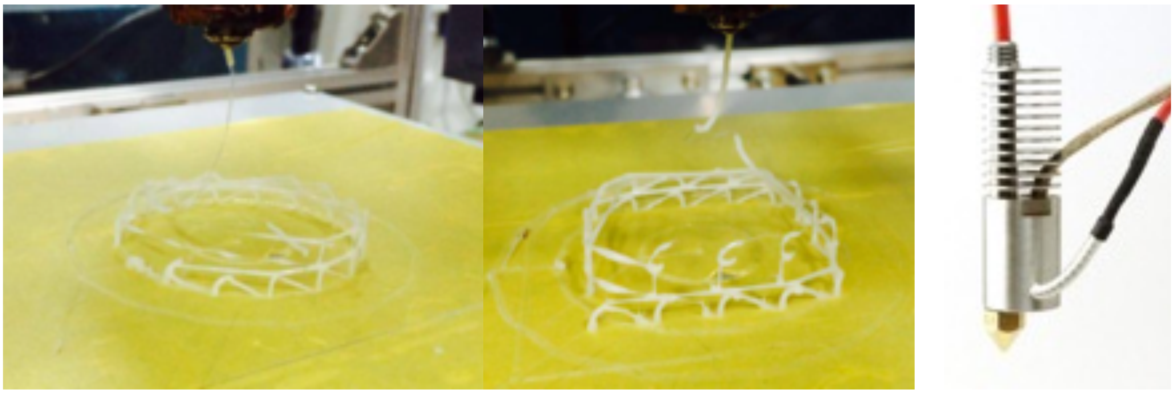

Fig 5.Left. The overlong step fail the printing. Middle: The extruder drag the part of finished structure. Right: The J head with tiny front end.

During the second stage, the basic surface is printed first, then restart the 3D printer and reload the platform(with the printed surface on it) for printing the buffer layer in the next operation. The purpose of reboot machine is simulating the situation of obtaining scanned data from other rescue from the printing task. Somehow, usually the surface's position will be changed after reloading the platform, and the follow-up printing will lost the contact with the basic surface in the almost five tests. The possible solutions included detecting the surface before the printing buffer layer, or scanning the surface again before the printing buffer layer.

4. Application

Before deciding the solution, the follow-up application for this printing skill should be clarified. In the original assumption, the 3D printed shoe based on the scanned feet is the goal application, such as the customised shoe for diorthosis treatment as below. This is an attempt of fabricating a customised shoe in this project disable people. The patient has the transformed limb and relay on special shoe to aid walking. First, the foot is scanned and remanufactured by 3D printing, and applying flexible material to print the customised shoe around the foot. However, in the regular printing, the shoe will be filled with supportive material and it's very difficult to be removed. In our project, if printing the shoe on the foot directly would save a lot of time, and the inner foot model could be reused for several times.

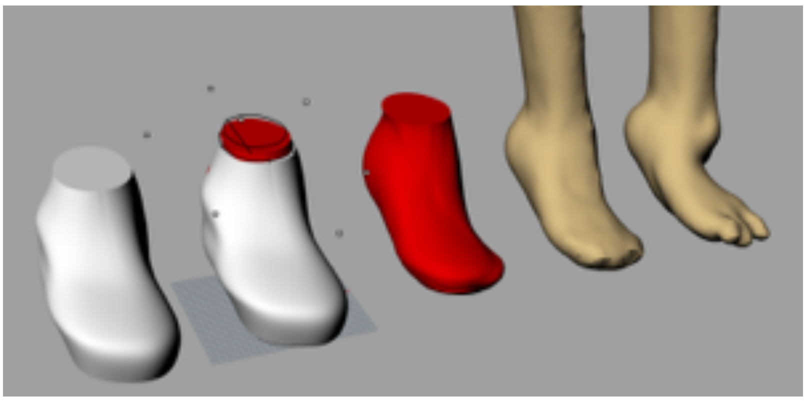

Fig 6.From right to left are the scanned model of original foot, fixed model, the inner surface of shoe, the solid shoe and final model.

Therefore, a 3D printer integrated the scanning function would be an ideal solution in this case, and the multiple-functions product are announced before, such as XYZ printer, FLUX and ZEUS. However, all of above product are operated by their special software and firmware and only XYZ printer is available for order now. In spite of the availability, hacking them is necessary in the follow-up step. Consider the application for the prothesis and shoe printing, the forming space of those product doesn't match the requirement of minimum size. Therefore, redesign a prototype that integrated a scanner replaced the idea of hacking existing machine.

Besides, in the original proposal, a delta robotic is assumed to apply as the part of final prototype, but the scanner's volume should be considered to be placed into the inside. Before design the 3D printing module, survey and redesign a scanner become the priority in this stage.

5. Integration with scanning function

Because lack of background to develop the software in our team, the scanner products attached with software are sought and surveyed, such as the below products. Exclude the expensive industrial scanner, two types of common scanners are considered for modification, included the fixed scanner with a rotary platform and handy scanner. The handy scanner on the left of below picture, Sense produced by 3D System company, is selected.

Fig 7. Left: Two main types of common scanners, handy type and platform type, the left is the Sense scanner. Right: Industrial scanner.

For reducing the volume and weight, the handle is removed and only the optical component is remained as the below. A new back shell is designed and printed, and it can equip the scanner on the moving carrier of prototype. In the scanning trial, it's difficult to keep holding stable and easy to lost visual tracking, but moving scanner by the mechanical carrier and arm can solve this problem.

Fig 8. The simplified scanner and ready to be equipped on the carrier.

Predictably, the scanning will become mass and frequent task for the shoe printing, this multiple-function prototype will improve the process efficiency. Somehow, the scanner module's volume is quite remarkable to put into the Delta robotics in the original proposal, and the extruder that can contact foot surface in the right angle is not available yet. A customised printing mechanism is still in the constructing.

6. Further process

Although many 3D printers are integrated with the scanner function, but most of them have very low resolution and are limited for small object only. A better resolution, bigger space and efficiency of scanning are expected to be integrated into the 3D printer in this project. However, the proper scanner requires enough distance and moving space, and such 3D printer are not available yet. We suggest to continue develop this prototype.

Besides, several fact influence the 3D printing on the irregular surface are discovered or clarified further, especially the inaccuracy fact. The limitation of drop curvature on the surface is also calculable, if based on a clear structure printing. If the structure changed, the limitation to adopt the surface could be decreased.