BOLCOF: Base Optimization for middle Layer Completion of 3D-printed Objects without Failure

Kenta Yamamoto
University of Tsukuba
kenta.yam@digitalnature.slis.tsukuba.ac.jp

Riku Iwasaki
University of Tsukuba
riku@digitalnature.slis.tsukuba.ac.jp

Tatsuya Minagawa
University of Tsukuba
mina.tatsu@digitalnature.slis.tsukuba.ac.jp

Ryota Kawamura
University of Tsukuba
kawamura@digitalnature.slis.tsukuba.ac.jp

Bektur Ryskeldiev
University of Tsukuba
bektour@digitalnature.slis.tsukuba.ac.jp

Yoichi Ochiai
University of Tsukuba
Pixie Dust Technologies, Inc.
wizard@slis.tsukuba.ac.jp

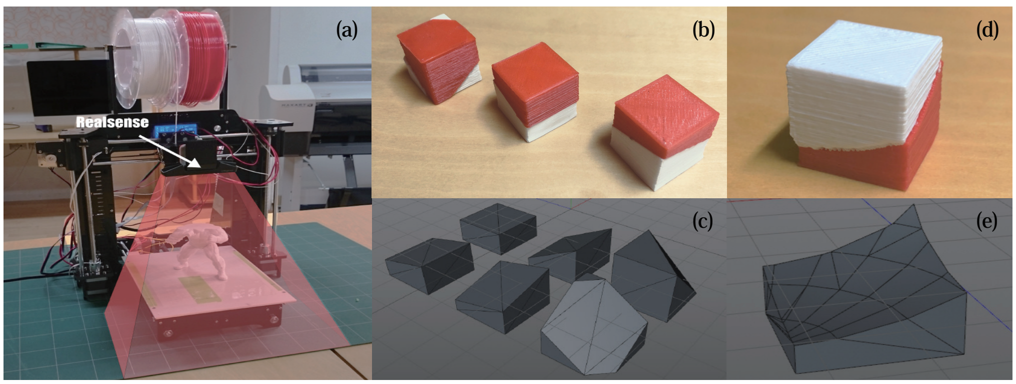

Figure 1: (a) 3D printer with BOLCOF-method installed. The depth sensor is attached to a ready-made 3D printer. (b), (d): Photographs of the result of printing on the object whose printing has been completed in the middle. The white filament part is the form printed earlier and the red filament part is the form printed afterwards. (c), (e): Models of objects that have been printed halfway.

CCS CONCEPTS

• **Hardware** → *Printers*;

KEYWORDS

3D printing , sensing , geometry

ACM Reference Format:
Kenta Yamamoto, Riku Iwasaki, Tatsuya Minagawa, Ryota Kawamura, Bektur Ryskeldiev, and Yoichi Ochiai. 2018. BOLCOF: Base Optimization for middle Layer Completion of 3D-printed Objects without Failure. In *Proceedings of SIGGRAPH '18 Posters*. ACM, New York, NY, USA, 2 pages. https://doi.org/10.1145/3230744.3230768

1 INTRODUCTION

3D printing failures can occur without completion of printing process due to shaking, errors in printer settings, and shape of the support material and 3D model. In such case it could be difficult to restart printing process from the last printed layer in conventional 3D printers, as the printing parts to which the nozzles are supposed to be attached are lost. In order to restart printing from the middle layer, Wu et al.[Wu et al. 2017] proposed a method of printing while rotating the base of a 3D printer. However, such approach required time for two objects to bond after segmentation, with limited availability of methods for adhesion between parts. Wu et al.[Wu et al. 2016] have also proposed a method to print 3D models at any angle through 5-axis rotation of the base of a 3D printer, but the manufacturing cost of such approach was relatively high. Therefore, we propose a system that prints 3D models on existing object by utilizing an infrared depth camera. Our method makes it possible to attach a 3D-printed object into a free-formed object in the middle of printing by recognizing its shape with a depth camera.

2 PIPELINE

As shown in Figure 2, in this study we investigate how an object, scanned on 3D printer's table, can be reproduced with consideration of printing material, shape, and printer's motor movement. We created parts as seen in Figure 1(a) and incorporated them into

SIGGRAPH '18 Posters, August 12-16, 2018, Vancouver, BC, Canada

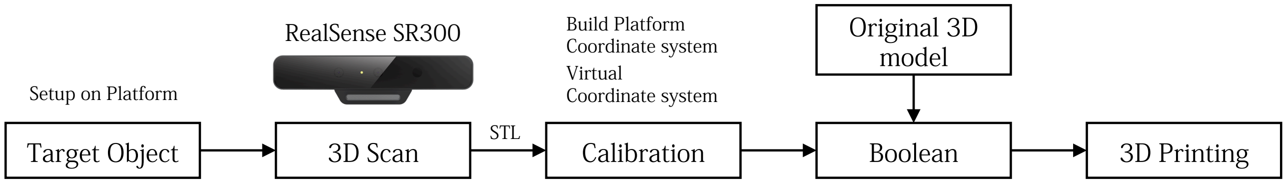

Figure 2: We developed the process of 3D printing that restart to print from the middle of layer.

HICTOP printer[1]. The depicted position in which the part was fixed allows to measure it at the same angle as the nozzle, and furthermore it allows extending the range of nozzle's output. When the Z axis is raised to the maximum level by a 3D printer, the distance from the table is approximately 25 cm. Also, if the shape acquired by RealSense[2] is tilted with respect to the actual table, an error occurs when the nozzle of the 3D printer is moved in the X, Y, and Z axis directions, causing the printing to fail. To overcome that, we installed a rectangular parallelepiped of the same scale as the actual table in CINEMA4D[3], and calibrated by mapping the surface of the table. The heat bed of HICTOP has a play on the base and the head part by the spring. Therefore, even if the heat bed is pushed in, the output can be performed after the nozzle reaches the ideal height for printing.

In this research, errors occurred in the Z axis of the existing shape surface scanned through RealSense. In order to adhere the filaments, it is necessary to slightly push the nozzle. Therefore, by using a spring with a weaker repulsion force than the original part, investigation was made so that the nozzle can be pushed in while preventing destruction of the existing shape. Using a spring longer than 30 mm will make the heat bed unstable. Therefore, a spring has a spring coefficient of 0.3584$[km/h]$, an outer diameter of 5 mm, a wire diameter of 0.8 mm, and a length of 30 mm was used.

The user fixes the object to be printed on the base of the original 3D printer. Move RealSense mounted on a 3D printer to a predetermined position, perform scanning, and convert it to STL format. The scanned data is aligned with the zero coordinate of the nozzle of the 3D printer. After that, calibration is performed so that the coordinates of the surface of the object can be accurately handled even if RealSense is deviated. Then recognize the calibrated existing object as a new shape table and scaling with the output object. Furthermore, the user adjusts the shape of the target shape and adjusts the position of the scanned existing object. After the decision, the common part between the existing object and the target shape is deleted, and only the part to be additionally printed remains. In order to visualize intermediate processing and monitor errors this time, visualization is performed using CINEMA4D after STL conversion.

3 RESULT

We assumed the surface of the object where 3D-printed failed and generated fragments of cubes with sections of various angles as shown in Figure 1. In the figure, it was shown that although there was a gap, it could be restored back to the final target object. It was also found that restoration is possible not only on flat slopes but also on curved surfaces. Because a 3D printer can print directly on existing objects, it can print Stanford bunny directly on a non-flat surface like a cap (Figure 3 (a)).

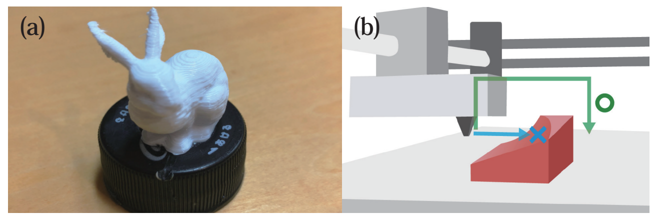

Figure 3: (a) A Stanford bunny model can be printed directly on the surface of a non-flat bottle cap. (b) If a printing process is adopted in which the height of the nozzle changes according to the shape of the object, printing on an object with a large change in height becomes possible.

4 DISCUSSION

In this study we have developed a method which allows continuation of object printing without adhesive, which we have successfully tested with the fragments of a broken bowl on the 3D printer platform. Currently the main challenge for us is to solve the issue of collision of the nozzle with the fragment during the printing process, as our method is unable to detect the moment of collision between the nozzle and the object (Figure 3 (b)). In the future we are hoping to avoid collision by outputting G-code that includes vertical movement of the nozzle. Alternative approach would be replacing the nozzle with a thinner option and adding a rotating platform.

REFERENCES

Lifang Wu, Miao Yu, Yisong Gao, Dong-Ming Yan, and Ligang Liu. 2017. Multi-DOF 3D Printing with Visual Surveillance. In *SIGGRAPH Asia 2017 Posters (SA '17)*. ACM, New York, NY, USA, Article 6, 2 pages. DOI: http://dx.doi.org/10.1145/3145690.3145728

Rundong Wu, Huaishu Peng, François Guimbretière, and Steve Marschner. 2016. Printing Arbitrary Meshes with a 5DOF Wireframe Printer. *ACM Trans. Graph.* 35, 4, Article 101 (July 2016), 9 pages. DOI: http://dx.doi.org/10.1145/2897824.2925966

[1]https://www.hic3dprinter.com/
[2]https://realsense.intel.com/
[3]https://www.maxon.net/en/products/cinema-4d/