Silk Fabricator: Using Silkworms as 3D Printers

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Figure 1: Left: time lapse photos of the output process of silk printing. Right: application examples of the silk fabricator.

CCS CONCEPTS

• **Applied computing** → *Media arts*; • **Hardware** → *Printers*;

KEYWORDS

Silkworms, 3D Print, Bio Art, Digital Fabrication

ACM Reference format:
Riku Iwasaki, Yuta Sato, Ippei Suzuki, Atsushi Shinoda, Kenta Yamamoto, Kohei Ogawa, and Yoichi Ochiai. 2017. Silk Fabricator: Using Silkworms as 3D Printers . In *Proceedings of SA '17 Posters, Bangkok, Thailand, November 27-30, 2017,* 2 pages.
https://doi.org/10.1145/3145690.3145704

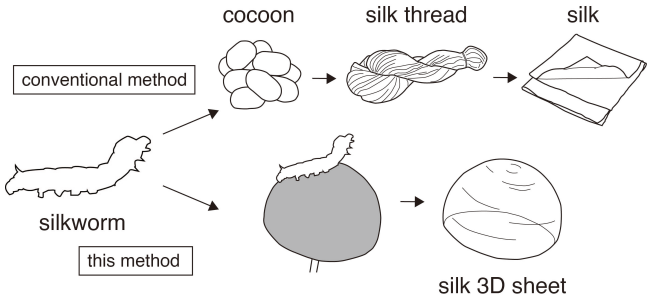

Figure 2: Comparison of the typical process and the proposed method.

1 INTRODUCTION

Digital fabrication has evolved over time with the development of various methods such as three-dimensional (3D) printing and laser cutting. Three-dimensional printers are capable of easily producing output from complicated models designed in a computer. In addition, bio technologies are applying for fabrication [Yao et al. 2015]. How can 3D printers be made to output computationally-designed models of 3D sheets? Typically, the production of objects made of silk threads requires several steps (Figure 2): (1) silkworms form cocoons, (2) cocoons are made into threads, and (3) threads are transformed into clothes or other products. In the past, silkworms have been considered primarily as organisms that create silk threads, rather than as being capable of providing a method of silk production. Silk Pavillion [Oxman et al. 2014] was the first example where silkworms were regarded as providing a viable production method. However, this study only focused on making large but simple structures. In this study, we propose a new method to construct arbitrary three-dimensional silk sheets using silkworms (Figure 1). Our method can be applied to small objects printed with 3D printers. First, we print a 3D model in several parts to prevent silkworms from forming cocoons. When designing the model, we ensure that the silkworms have sufficient space to create silk sheets. Second, we print the portions of the model with a 3D printer. Third, we place silkworms on these portions, allowing them to spit silk

SA '17 Posters, November 27-30, 2017, Bangkok, Thailand

threads. Finally, we peel off the produced sheets and connect them. This approach depends on the fact that when silkworms are placed on the surface of a three-dimensional object, they create silk sheets matched to the shape of the surface.

2 METHOD

In order to ensure that silkworms do not make cocoons on the model, it is necessary to divide the model by angle, and then evaluate whether the silkworms can traverse the divided model. Many algorithms are available for dividing a 3D model. Here, we make a program for dividing a 3D model based on the following algorithm (for details see [Mitani and Suzuki 2004] and [Lévy et al. 2002]). Figure 3 shows the divided model. The portions of the divided model are thickened and then printed by the 3D printer. After printing, the surface of the 3D model is scraped so that the silkworms do not fall off its surface. Finally, silkworms, which already had started to spew yarn on the model, are left to continue until they finish.

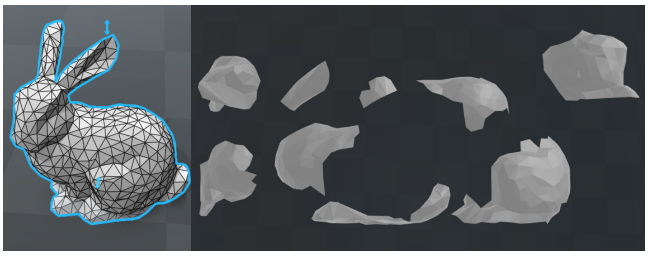

Figure 3: Divided model. The number of triangles is 1370. The height is 295.38 mm. Right is diveded models.

3 APPLICATION

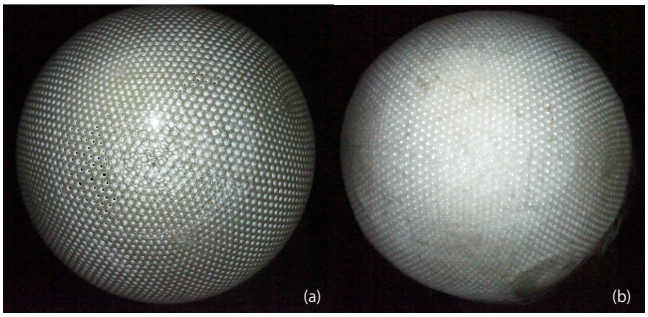

Figure 4: Comparison of lit objects with internal light source. (a) hemisphere of 3D model printed by a 3D printer. (b) silk-sheet of hemisphere with (a).

By using a 3D silk sheet, a user can produce a non-woven fabric of an arbitrary shape. Therefore, this technique makes it possible to create masks and bandages that are suitable for being worn, and to create lanterns of arbitrary shapes. If the lampshade of a lantern is made from a silk sheet, the sheet will be able to diffuse light, making it possible to create a uniformly-lit lantern. Figure 4 shows the results before and after applying a silk sheet to the surface of a hemisphere. In addition, this method can be applied to more complicated shape like that in Figure 5.

Figure 5: Application examples

4 CONCLUSION

In this research, 3D model sheets were created with new materials, and a 3D model segmentation algorithm for paper crafts was used in the approach to the research. Since we confirmed that silkworms could not stretch threads uniformly when the surface area of a 3D object was large, we divided the object into multiple parts. We succeeded in generating new 3D objects using silkworms, but several aspects of this work remain incomplete. For instance, the silkworms could not spew yarn and produce 3D silk sheets because they could not traverse elongated 3D objects. Additionally, silkworms could not make thread for finely-decorated objects. Therefore, the development of a method that can more accurately make 3D silk sheets is needed.

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