Reconfigurable Three-Dimensional Prototype System Using Digital Materials

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1 Introduction

Digital materials are discrete elements such as LEGO Blocks that it can be a kind of reconfigurable 3D matters. There are two advantages of using digital material rather than a continuous material. Firstly, it is easy to change the form after shaping by assembling and disassembling the elements. Secondly, There is never that the error of the part impacts the whole form in the shaping because the elements can be connected exactly by the joint system. There are many researches of digital material focus on the modular connection by press fitting or bonding. Such a digital material can't be assembled and disassembled smoothly after shaped. In our research, we designed the digital material "Kelvin Block" (figure 1a) that specialized in smoothly reconfiguring, and we developed the machine "3D Assembler" (figure 1b) to arrange Kelvin Blocks automatically. The size of Kelvin Block is 40mm×40mm×40mm that is optimized to the volume of the joint system.

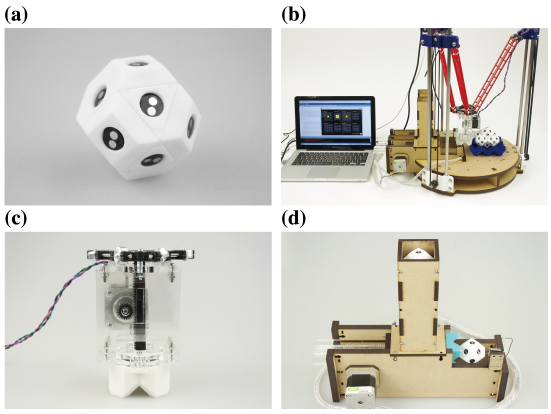

Figure 1: *(a) Kelvin Block (b) G-Code Gen, 3D Assembler (c) Extruder (d) Separator*

2 Design and Development

The shape of Kelvin Block is the truncated octahedron. It can be connected each other by the magnetic joint embed in each surfaces. It is not necessary to consider about the orientation of blocks when assembling, because these parts have two magnets expose both poles on each surface.

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The truncated octahedron has the feature that the upper unit can be snapped by lower layer to the right position, we call this feature "Self-alignment". Furthermore, by our magnet joint system, the coordinal error of each block will be fixed when assembling. This means that we can assemble blocks in high accuracy by the dropping them within inaccuracy. 3D Assembler has two functions. "Extruder" (figure 1c) is for reconfiguring blocks, and "Separator" (figure 1d) is for passing blocks to Extruder one by one. During assembly, the Extruder carries and drops blocks on the positions. In disassembly, we detach the blocks from the objects with Extruder. In addition, we also developed the "G-Code Gen" (figure 1b) that generates the G-code for controlling 3D Assembler. The interface of G-code Gen allows us to shape the form by selecting the block's positions on each 2D layer. Through developing our system, we could reconfigure the 3D object smoothly with the discrete elements. We demonstrated arranging blocks to form the physical typography (figure 2a) and the basic 3D geometries (figure 2b) with this system. We can shape overhangs such as "H" and "T" by rotating the form by 90°.

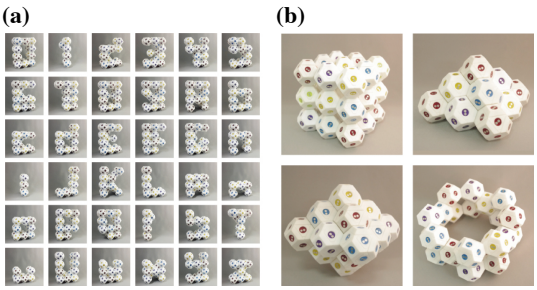

Figure 2: *(a) Physical Typography (b) Basic Geometries*

3 Discussion

In our system, the resolution of each block is very low, and we use the magnets within limited attracting force for disassemble. Therefore, our system is appropriate for the educational tool for children than the prototyping system for the designers. In recent years, 3D printers popularly lead into many schools as the tools for learning digital fabrication. However, in the case of children, the mechanical operation of 3D printer may cause the risk to get burned or clamp injured. On the other hand, in our system, no hurt will happen in only assemble and disassemble the blocks. The children can make the form for their ideas through designing the 3D object by G-Code Gen. In the future, we will verify the benefit of our system on the educational application by holding workshop for children to experience our system.

Reference

Cheung, K. C., Gershenfeld, N. 2013. Reversibly Assembled Cellular Composite Materials. *Science* 341, 1219.