Morphological Computation on Two Dimensional Self-Assembly System

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1. Introduction

Self-assembly is a process in which components autonomously organized into structure without external direction. There are many researches of self-assembly system at molecular scale to macro scale. Such a self-assembly system may serve as the new production method with the characteristics, such as decomposability, self-repairing, self-replicating and adaptability. For developing such a new production method, an understanding of the interaction of shape and pattern, which can be called as morphological computation, is important.

There is a few research about morphological computation on self-assembly system without a target structure [Miyashita et al. 2009] [Nakajima et al. 2012], however, there is few research about that with target structure. Therefore, this research focuses on the morphological computation on self-assembly system with target structure.

In this research, we first designed and implemented a two-dimensional self-assembly system and second we conducted some experiments using the system for understanding of morphological computation on self-assembly system.

2. Design and Development

We designed and developed a two dimensional self-assembly system where components which have a concave-convex pattern and one magnet on their each side (figure 1a) are put into a container and by shaking the container, the components move around and are bonded if they have a complementary pattern on their side and finally the target structure is assembled (figure 1b).

We developed the optimization tool, which can optimize a concave-convex pattern using genetic algorithm in order to eliminate a bonding error and reduce a metastable-state where components that have partially complementary pattern, are bonded with relatively weaker magnetic force. As the result of testing the tool, it has been demonstrated that an assembling-time required to assemble a target structure in case of using optimized patterns is a few times shorter than that of not optimized.

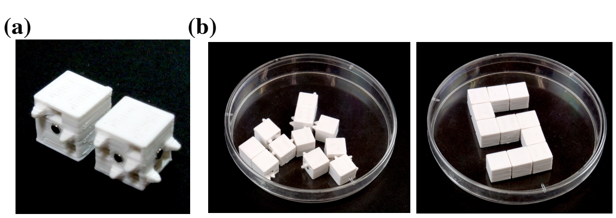

Figure 1. *(a) Components. (b) Assembling a target structure.*

We also developed a physics simulation tool for simulating a behavior of the self-assembly system on a computer as an experiment environment in computer simulation (figure 2a) and the shaker machine which can shake a container by arbitrary kinetic patterns as an experiment environment in real world (figure 2b).

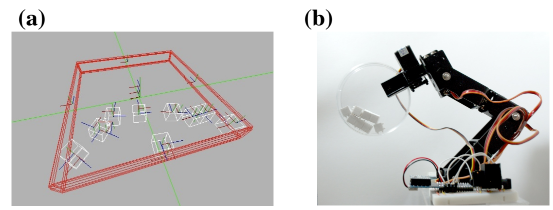

Figure 2. *(a) Physics simulation tool. (b) Shaker machine.*

3. Experiment

We first conducted some experiment in computer simulation and we observed a behavior of the self-assembly system where the set of three kinds shapes of components and three kinds of shapes, sizes and kinetic patterns of container were applied. As the result, it has been shown that there is a relatively strong correlation between assembling-time and interaction-frequency between each components and angular speed of component. It has also been shown that there is a tendency that as the shape or pattern more resembles to a circle, assembling-time becomes shorter (figure 3a). In addition, by comparing motion trajectories, speed and angular speed of components of each set of shapes and patterns, it has been shown that there are different tendencies of the pattern for each set of shapes and patterns (figure 3b).

We also conducted an experiment in real world in same condition to that of computer simulation. As the results, it has been shown the same tendency to that of in physics simulation.

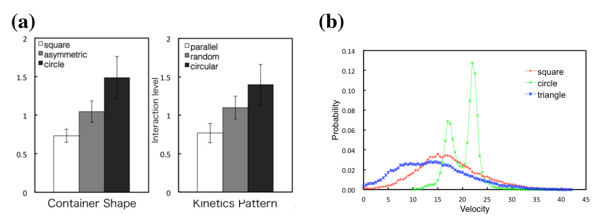

Figure 3: *(a) Comparison of interaction level. (b) Comparison of motion trajectory.*

References

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