Morpho Sculptures: Digital Fabrication Methods of Engraving Flat Materials into Shape Changing User Interfaces

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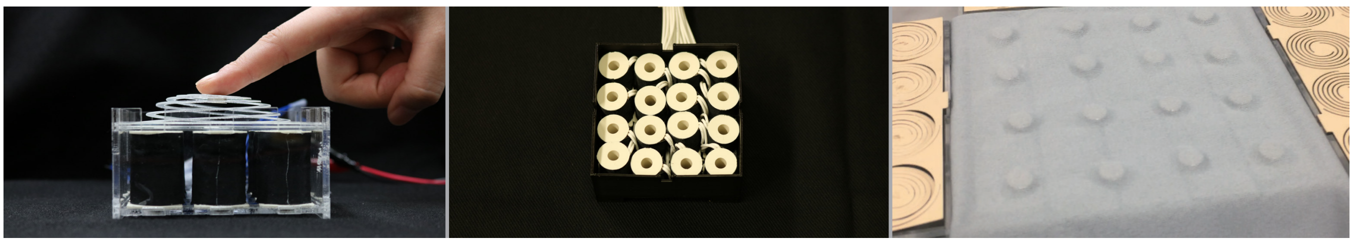

Figure 1: Left: The application example that use our shape changing interface as button. Center: 3×3 actuator array. Right: Application image of table type actuator.

CCS CONCEPTS

• **Hardware → Sensors and actuators**;

KEYWORDS

Actuator,Hardware,Interface

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1 INTRODUCTION

In recent years, many materials mass-produced in industrialized societies are flat, thin, and with many squares. Within such a social context, customized machines like conventional shape-changing interfaces will take much time and labor to become popular. We aimed to overcome the weaknesses of such conventional shape-changing interfaces and make them easy to manufacture and apply even for PC users. In order to achieve this, it is necessary to revise the manufacturing method. If it is possible to prepare a flat plate which is inexpensive, available and easily processed, it becomes possible to disseminate the shape changing interface at low cost. In recent times, processing machines such as laser cutters have become more widely available so it is becoming increasingly possible to reduce the cost of estuaries. Therefore, we redesigned the manufacturing method for shape changing interfaces using flat plate which, with our method, can be produced at lower cost and with less labor. Many objects in the world are made by processing flat plates, so the processing of flat plates is an important factor. By using the manufacturing method of shape changing interfaces proposed by us, it becomes possible to embed them naturally in interiors such as furniture made from flat plate.

2 RELATED WORK

Various shape changing user interfaces have been proposed in previous studies. In Project FEELEX [Iwata et al. 2001], they tried to provide users with a spatially continuous surface on which they can effectively touch an image using any part of their bare hand, including the palm. It was a pioneer of 2.5-dimensional display which adds the three-dimensional feeling of the screen surface in addition to the two-dimensional display. InFORM [Follmer et al. 2013] is also representative ones.

Cross-Field Haptics [Hashizume et al. 2017] is research that proposed a new haptic design method by using both electrical stimulation and tactile presentation by magnetic fluid. In Cross-Field Haptics, it is possible to express richer tactile sense by combining decoch-and-feeling due to magnetic fluid and rough feeling due to electrical stimulation.

3 IMPLEMENTATION

Our actuator consists of a plate with a permanent magnet as a movable part attached, and a coil for generating a repulsive force of the magnet. The figure of our system is shown in the figure 2. The surface of the actuator is made of a soft and thin plate material.

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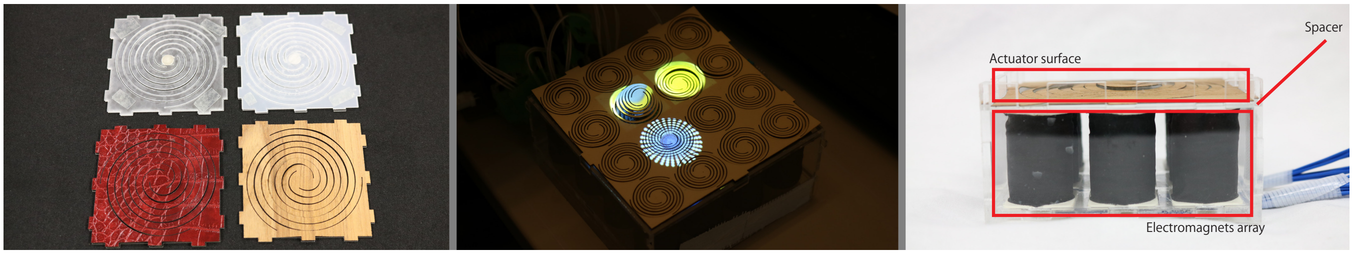

Figure 2: Left: The materials of our shape changing interface. We create the leather, polypropylene, woody board and cardboard. Center: 8×8 actuator array for application. Right: The structure of our shape changing user interface.

Since the material of the board is not limited, it is possible to change to not only polypropylene board but also acrylic board, soft wood board, thick paper and the like.

In this prototype we mounted actuators with polypropylene board, cardboard, wood board and synthetic leather. The machining shape of the surface was a triple spiral swirl and the swirl width was designed to be about 5 mm. The coil used as the electromagnet was about 2000 coils, the rated voltage was 12 V, and the resistance value was about 30 Ω. I put an iron core in the coil. The figure 2 shows the outline of the plate after processing. Using these coils and plate materials, we construct a shape changer interface. In addition, a microcomputer was used to drive the electromagnet.

The prototypes were made with 3 × 3 smaller ones and 4 × 4 larger ones as the basic form. The outline of these prototypes is shown in Figure 2. The surface material of the prototype of 4 × 4 is made of cardboard, and the surface material of the 3 × 3 prototype can be changed to polypropylene, pet resin, wood grain board, synthetic leather. In addition, it is possible to connect a plurality of cells by driving each 4 × 4 actuator as a cell. In this paper, a large prototype with 4 × 4 cells arranged at 2 × 2 was fabricated.

The operation of the shape changing interface is performed using Processing. The actuator is driven by moving the cursor in the area on the screen imitating the surface of the actuator. We performed several user studies using this function.

4 DESIGN AND APPLICATION

Our shape change interface can realize various applications ranging from a small number and small scale to a large number and large scale. Shape changing actuators for applications can have one cell consisting of 4 × 4 actuator arrays and others consisting of 3 × 3. Small-scale applications would use this cell alone. Large-scale applications, it can be realized by using 2 to 4 cells. Below are some examples of applications.

4.1 Button

Examples of small applications include buttons such as power and volume. These are applications composed of one cell. You would use the protrusion of the actuator as a button. As shown in the figure, it is possible to produce a richer expression by displaying marks by projection and by changing the tactile sense of the actuator.

4.2 Table type actuator

It is also possible to move an object on the actuator using a plurality of cells or a single cell. Moving the position of the object by operating the actuator with respect to the object arranged on the actuator array is possible. The figure shows how the user is manipulating the ball on the actuator. The actuator is driven according to the input from the PC, and it is possible to operate as intended by the user.

4.3 VR and AR experience

Conventional applications of AR and VR are not able to cause the change in real space. We could not feel the feedback even if you defeat the AR object on the desk.If we arrange the proposed actuators around us, it is possible to cause feedback to the real space by the AR objects.For example, it is possible to express sounds and vibrations when destroying a shooting target with this actuator.

5 LIMITATION AND FUTURE WORK

In this study, we used the surface materials that processed triple-helical structure. At first we tried to other structure such as square shape or triangle shape. However, these shapes are shorter range of motion than triple-helical structure. Therefore currently we process triple-helical structure to surface material. We speculate that we need more consideration to the shape of surface.

Although in this research, we used 2000 turn of coils to drive actuator. We speculate that it is necessary to evaluate the characteristic change by changing the property of coil. We also speculate the shape of surface material. We use triple-helical structure to surface however it is not enough consideration to the processing patterns. Therefore, we need more experiment about it. Currently, we created 12 × 12 electromagnet array of 144 pixels, we need to create larger shape-changing interfaces in future.

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