

Development of BrushDevice Facilitating Painting Operation in 2D/3D Space

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Abstract: We have proposed a set of devices for various manipulations in spatial works. The devices use a metaphor of existing tools which are familiar in everyday life. Such tools have good affordance, and at the same time, every user already has a mental model for their operation. We believe that such advantages not only lead users to the correct operation, but provide an intuitive operation. Initially, we realized TweezersDevice for pick-and-move manipulation in the spatial works. Now, we have developed BrushDevice for painting in 2D/3D space. This paper describes the design, mechanism, prototype, pilot test, and findings.

Keywords: Mixed reality, brush device, input device, device set, interactive painting systems.

1. INTRODUCTION

We have proposed novel interaction devices for various operations in spatial works such as mixed reality (MR) space; ToolDevice that uses a metaphor of existing tools which are familiar in everyday life. Such tools have good affordance, and at the same time, every user already has a mental model for their operation. These advantages not only lead users to the correct operation, but provide an intuitive operation.

To realize such a device set, we firstly listed up the works requiring a large work space, such as design, layout and 3D modeling. Secondly we extracted necessary operations to complete these works “pick and move,” “model” and “draw,” and decided to develop ToolDevice for these three operations.

Initially, we realized TweezersDevice [1] for pick-and-move manipulation in the spatial works. Now, we have developed BrushDevice for painting in 2D/3D space. This paper describes the design, mechanism, prototype, pilot test, and findings.

2. RELATED WORK

There have been some studies on simulation of traditional graphical styles. For example, Curtis [2] and Chu [3] presents a physically-based method for simulating ink dispersion in absorbent paper and realizes the various artistic effects of watercolor such as drybrush and flow effects. Baxter [4] presents the paint model of oils or acrylics for use in interactive painting systems named “IMPaSTo.” Saito [5] developed a physics-based 3D model of a brush, and realized expressive strokes using Japanese style painting or calligraphy.

As the input devices for these systems, pen tablets are widely used [2]-[5]. However, its operational feeling (such as reaction and frictional force) is different from real painting tools, because of its rigid nib.

To resolve this problem, some input devices for digital painting imitate the shape of real painting tools or use real brushes. For example, Vandoren [7] introduced “IntuPaint” for simulation of oil painting. In this system, input devices use the shape of real painting brushes.

In “Thermo-Painter,” [7] users use hot or cold water instead of paints. Their touch regions are detected as a temperature distribution of the surface which is captured by a thermo-infrared camera located behind the surface. Users can directly use physical paintbrushes and airbrushes with hot water for digital painting. Besides, Ryokai introduced I/O Brush [8] as a new drawing tool. It looks like a common physical paintbrush.

Following these previous studies, we aim to develop BrushDevice using characteristics of real painting tools. There are various painting tools in the real world such as painting brushes, air brushes, pastels, and color pencils.

In this paper, we propose a device that imitates the shape of a paint brush, because many people from beginners to professional artists use it widely.

On the other hand, many studies target on real planes [2]-[8]. In Thermo-Painter [7], users can paint on a real hemispherical object. However, the system does not target complex 3D objects and virtual objects, because the painting results are projected on the real surface behind the screen. Osaki [9] developed a system that users can draw in the air, and Schkolne [10] presented “Surface Drawing,” where users can create 3D surfaces by moving a hand in 3D space. In these previous studies, they target only 3D space to draw.

As the input device, Osaki uses a mouse-like device and Schkolne uses a glove using a magnetic sensor. On the other hand, in this research, users can paint on not only a real 2D plane but also 3D objects that are difficult to operate on a 2D display. Additionally, users can paint on a virtual plane and 3D objects (Fig. 1). To expand the traditional painting operation and improve the expressiveness, 3D space also can be used as a canvas.

3. DESIGN AND PROTOTYPING OF BRUSHDEVICE

3.1 Painting targets

As presented above, in this research, users can paint on not only real planes that were targeted in previous studies, but also 3D objects, virtual planes, and 3D objects. Fig. 2 shows the plan to develop BrushDevice.

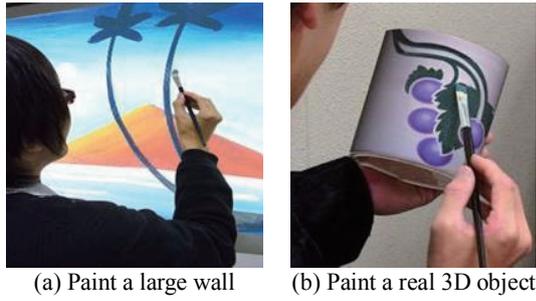


Fig. 1 Concept of our system

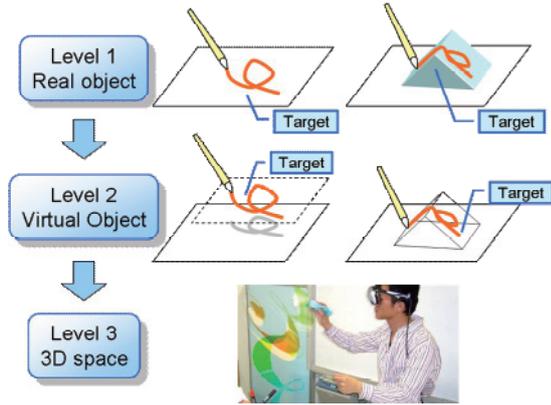


Fig. 2 Plan to develop BrushDevice

3.2 Characteristics of brush stroke

In the real world, the brush stroke has many characteristics (e.g. line weight, density, brightness, reflection level, or smoothness). Particularly, line weights depends on the shape of brushes used and applied the force from hand to brush. Therefore, we focus on line weights

In the real world, when users want to change the size of stroke, they tilt the brush or press it against the target. However if the target is a virtual object, they can not press on it. Therefore, we proposed five input methods:

- Moving speed of the device (Motion)
- Tilt of the device (Tilt)
- Distance from the device to the canvas (Distance)
- Pressure from the device to the canvas (Push)
- Grip force to grab the device (Grab)
- Movement of the stick of the device down (Stick)

3.3 Consideration of the input method

To realize six input methods, we developed four BrushDevices using real round paint brushes (Fig. 3). Each device has a magnetic sensor (Polhemus FASTRAK) to get the position and orientation. The moving speed, tilt and distance are estimated from this sensor (Fig. 3 (a)). The pressure from the device to the canvas is detected from a bend sensor (Jameco Electronic FLX-01) which is attached along the device (Fig. 3 (b)). The grip force is detected by a pressure sensor (Nitta Flexiforce) (Fig. 3 (c)) and the movement of the stick is detected by an analog stick controller (Alps RKJXK122400Y) (Fig. 3 (d)). The pressure sensor and analog stick controller are mounted on a triangle pencil grip attached to the handle for easy

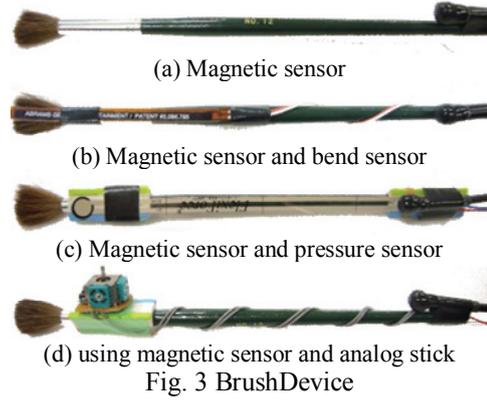


Fig. 3 BrushDevice

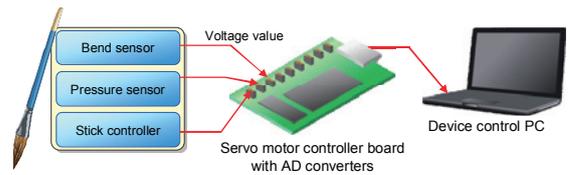


Fig. 4 Getting voltage value from sensor

Table 1: How to draw a thicker stroke

Motion 1	Move the device slowly
Motion 2	Move the device rapidly
Tilt 1	Tilt the device vertically to the canvas
Tilt 2	Tilt the device horizontally to the canvas
Distance 1	Move the device close to the canvas
Distance 2	Move the device far from the canvas
Push 1	Press the device to the canvas strongly
Push 2	Press the device to the canvas weakly
Grab 1	Grab the device strongly
Grab 2	Grab the device weakly
Stick 1	Press the stick of the device down
Stick 2	Bring the stick of the device back

grasping.

A bend and pressure sensor, and stick controller are connected to a servo motor controller board with AD converters (Kyoritsu RBIO-6A). The voltage values of each sensor are measured as input values. We use a Panasonic Let'sNote R5 for the management of the device. The voltage value from each sensor is sent by serial communication (Fig. 4)

Table 1 shows each method to draw a thicker stroke. We use the following two formulas to decide the line weight from input sensor values:

(i) from large input value to thicker stroke

$$Weight = \frac{Input - Input_{min}}{Input_{MAX} - Input_{min}} * Weight_{MAX} \quad (1)$$

(ii) from small input value to thicker stroke

$$Weight = \left(1 - \frac{Input - Input_{min}}{Input_{MAX} - Input_{min}}\right) * Weight_{MAX} \quad (2)$$

3.4 Interactive painting system in mixed reality space

We developed the MR system with which the users are able to paint using BrushDevice in MR space (Fig.

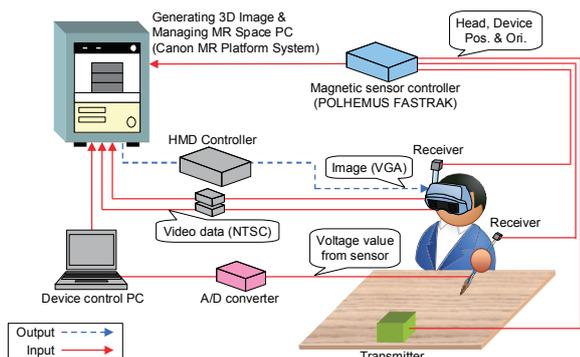


Fig. 5 System configuration

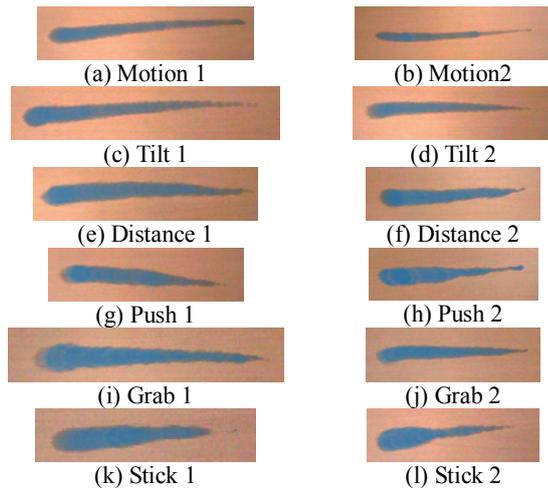


Fig. 6 Painting results of changing line weights with each method

5). Canon MR Platform system for managing and displaying the MR space. Users watch the MR space and painting results through a HMD (Canon VH-2002).

Fig. 6 shows painting results of changing line weights using BrushDevice with each method. From the results, we found that users can change line weights with all methods although the lines drawn with Push, Grab, and Stick were not as smooth as other methods.

4. PILOT TEST

4.1 Operation

This paper describes about Level 1, i.e., a real 2D plane and a real 3D object (Fig. 7). In this test, eight participants paint on a tabletop or real 3D objects in the MR space freely with each method (Fig. 8). After the pilot test, we collected their comments about the operational feeling.

4.2 Results and user feedback

Fig. 9 shows examples of painting the same motif on a real plane, and Fig. 10 shows other examples. From the experience of the pilot study in our laboratory we found the following:

Motion 1, 2: It was difficult to paint in detail, because the users needed to often change the moving speed to change the line weight. In addition, they did not know how much speed was needed for painting as they like.



(a) 2D plane (Desktop) (b) 3D object
Fig. 7 Paintings created using Distance 1.



(a) Real world (b) User's view
Fig. 8 Prototypes; the users can paint real objects in the MR space (using Distance 1).

Tilt 1, 2: In the case of a 2D plane, they could change the line weight easily; however, in the case of a 3D object; it was difficult to change line weight because of a curved canvas. When the user painted on a curved canvas, the device's orientation against it changed opposite to their expectation depending on its position. In addition, it depended on the taste of users as to which method is preferred.

Distance 1, Push 1: Most users felt that these methods were natural for the shape of device and it was similar to real operation. However, some users felt that the operational feeling of Push 1 was not good because the bend sensor could get value only in one direction.

Distance 2, Push 2: The user felt these methods are not intuitive because these were substantially different from the usages in the real world.

Grab 1, 2: Most users commented that they could not paint until they pushed the pressure sensor strongly. Consequently, they were tired from using the device for a long time.

Stick 1, 2: Although the many users took a long time to become accustomed to an analog stick, they commented that this method was easy to use once they got used to the device.

4.3 Discussion

From the pilot study, we found that the method is similar to that in the real world, cases Tilt 1, 2, Distance 1 and Push 1 were favorable in the case of painting real planes or 3D objects.

There were some problems with the sensors. Firstly, because the bend sensor for Push 1 and 2 could get values only in one direction, it was impossible to detect the correct value when the brush was twisted. Secondly, because the pressure sensor for Grab 1 and 2 is a sheet-like sensor, the users could not tell how hard to press, and consequently felt tired.

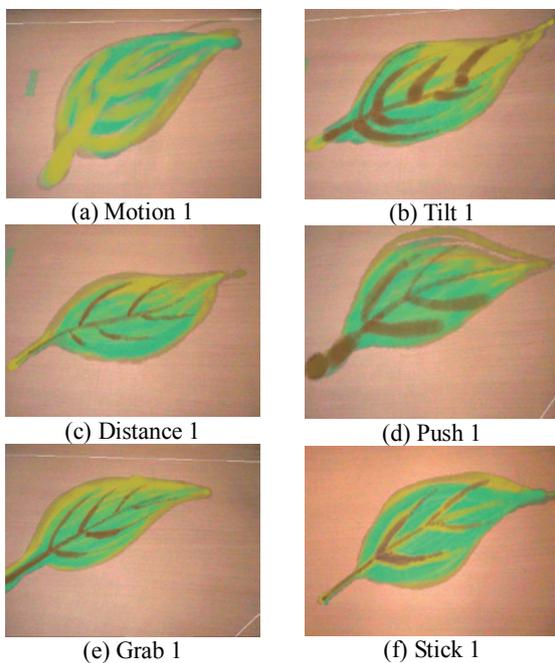


Fig. 9 Examples of painting same motif on real plane

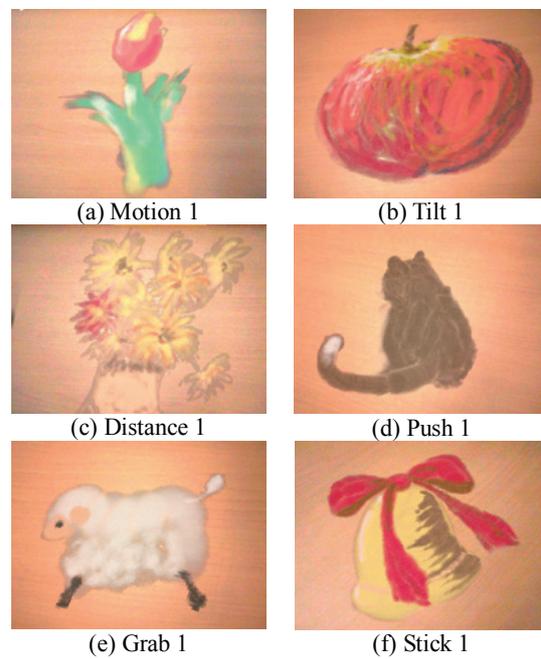


Fig. 10 Examples of painting on real plane

5. CONCLUSION

In this research, we proposed BrushDevice for painting in 2D/3D space. This paper describes the details and the test-bed for its evaluation.

From the pilot study, we found that the method is similar to that in the real world, such as Tilt, Distance, and Push) were favorable in the case of painting real planes or 3D objects.

In addition, we analyzed in depth the characteristics of each method obtained from the pilot test. by experiments.

We are also planning to:

(1) do experiment and analyze in depth the characteristics of each method obtained from the pilot test.

(2) make the formula used to decide the line weight from the input sensor values in each method using the characteristics from the experiment.

(3) consider a method to generate the formula for each user automatically using the line drawn in advance.

In the methods which did not perform well in steps (2) and / or (3), we have to reconsider the input mechanism, and improve the devices.

(4) develop a system which targets a virtual object and 3D space. In the case that targets are real objects, users can get haptic and tactile feedback, by placing the device on a real object. However, in the case of a virtual object or 3D space, it is impossible. For future work, we have to develop a method to represent the placement of a device to canvas (virtual).

(5) consider about the different shaped devices such as a flat brush and a small round brush.

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