Daichi's artworking:
Enjoyable painting and handcrafting with new ToolDevices

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1. OUTLINE

Daichi is a boy who is bad with computers. One day, he makes a sketch of lovely table and chair, and wish to create their 3D models, however... We provide a system that even Daichi can easily enjoy artworks as if he handcraft and paint in the real world. In conventional systems with a mouse and a 2D display, creating 3D models or painting on them are not so easy. In our demonstration, we solve this problem by providing a new ToolDevice in the mixed reality (MR) space. Our new ToolDevice is a set of input devices and use a metaphor of existing tools which are familiar in everyday life.

2. MR EXPERIENCE

In this demonstration, there are two modes; handcrafting and painting. In these modes, by using a new Tool Device, the users are able to experience painting and handcrafting as if they do in the real world.

2.1. Handcrafting

In this mode, users can create 3D models by (a) picking and moving, (b) cutting and (c) joining virtual wooden board with TweezersDevice, KnifeDevice and HammerDevice.

(a) Pick and Move

The users can pick a virtual wooden board by picking it up with TweezersDevice. When the board is picked, its size is felt from the fixed angle of the device and its reaction force. While picking the board with the device, it can be translated and rotated directly in 3D space. The board can be released by reducing the pressure of the users' fingers and opening TweezersDevice. If the user wants to remove some peaces of the boards, they are thrown them to trash bin with TweezersDevice. When the board is released into a trash bin, a sound feedback is presented with removing it.

(b) Cut (Figure1 and 2)

A wooden board can be cut by pushing KnifeDevice against the table (it is detected with tactile switch) and sliding. When the user releases the device from the table, wooden boards are cut along the cutting plane and a sound effect is also presented.

(c) Join (Figure3 and 4)

To join two virtual wooden boards, the user has to place one board to overlap with the other using TweezersDevice, and swing HammerDevice on them. When the boards are joined, they are highlighted with red color for a second, and sound effect is presented.

Figure 5 shows examples of artworks made with our handcraft system.

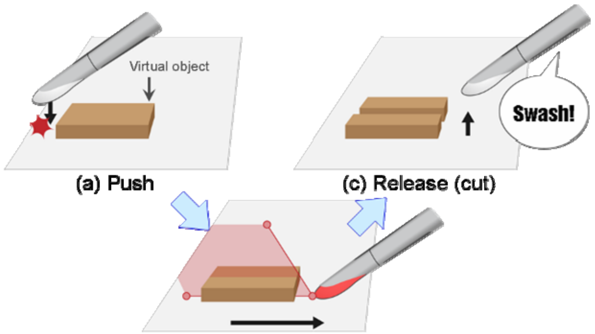


Figure 1: Procedure of cutting

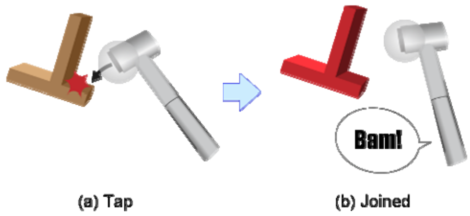


Figure 3: Procedure of joining

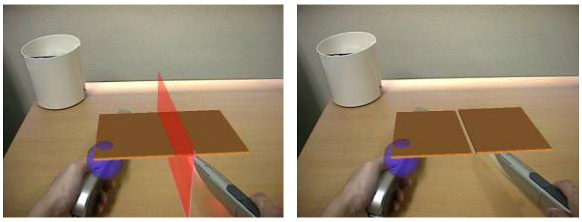
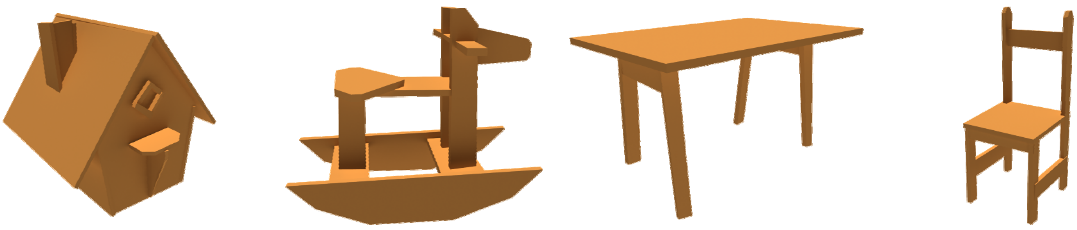


Figure 2: Scene of cutting a virtual wooden board

Figure 4: Scene of joining virtual wooden boards



(a) house (b) rocking horse (c) table (d) chair

Figure 5: Artworks made with our system

2.2. Painting

In this mode, users can experience painting with BrushDevice on various canvases, not only on a real 2D plane but also on real 3D objects and virtual 2D/3D objects. The brush type such as round and flat can be used by changing attachments of the device. The line weight depends on the brush type and on the force from the hand to the device. A virtual palette helps the users to select or create colors.

(a) Real world (b) User's view

Figure 6: The users can paint real objects in the MR space.

Figure 7: Examples of painting on a real 2D plane

Figure 8: Examples of painting on a real 3D object (left and center) and a virtual object (right)

3. NEW TOOLDEVICES

New ToolDevice is for various operations in a large electric working space, such as MR space. It is a set of interaction devices using 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 the mental model for their operations. These advantages not only lead users to the correct operation, but provide an intuitive operation.

The features of our new ToolDevice are as follows.

- To increase a presence of virtual objects and improve the operational feeling, our devices imitate not only the shapes of existing tools and their usages, but also the tactile and audio sensation.
- New ToolDevice users select and use various devices depending on their works.

To realize such device set, we firstly list up the works requiring a large space, such as designing, layout and 3D modeling. Secondly we extract necessary operations to complete these works "(1) pick and move," "(2) model" and "(3) draw," and decide to develop new ToolDevice for these three operations.

3.1. TweezersDevice for Picking & Moving Operation

We associate pick and move functions with that of the tweezers which is a tool only for pick and move manipulation (Figure 9). The tweezers is a tool that can pick and move physical objects by adding pressure on its sides with fingers. The user can feel the object's size and softness from its reaction force.

Figure 9: TweezersDevice

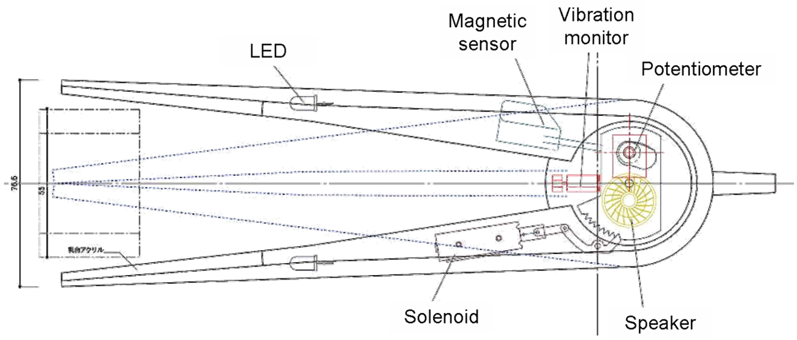


Figure 10: Internal mechanism of TweezersDevice

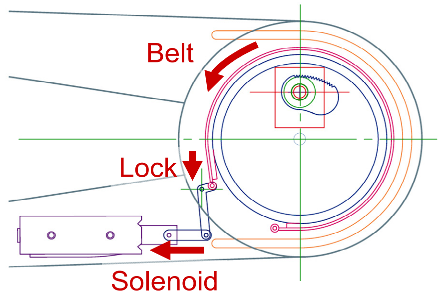


Figure 11: Force feedback mechanism

Figure 12: Knife and Hammer Device

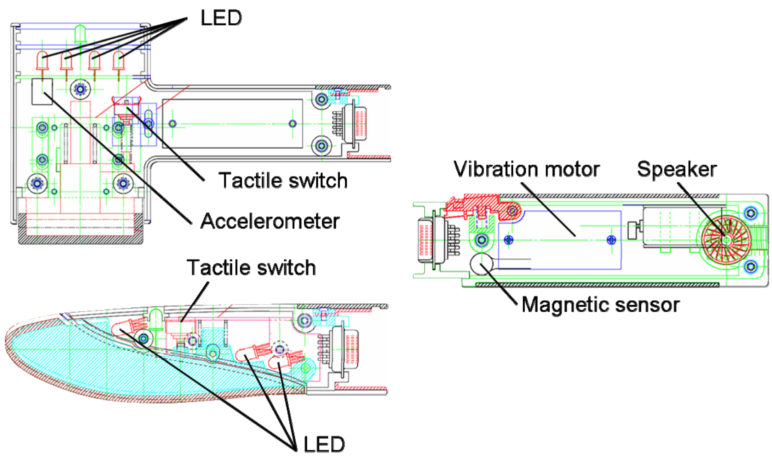


Figure 13: Internal mechanism of Knife and Hammer Device (Upper left: Knife attachment, Middle right: Hammer attachment, Bottom: Body of Device)

To realize similar operational feeling to the tweezers, following electronic components are built into TweezersDevice (Figure 10)

- Magnetic sensor to detect the position and orientation of TweezersDevice in 3D space.
- Potentiometer to detect the opening angle of TweezersDevice.
- Force feedback mechanism to present reaction force while picking virtual objects. (Figure 11)
- Color LEDs, a speaker and a vibration motor for the confirmation of manipulation.

The manipulation methods are described in 2.1.

3.2. Knife and Hammer Device for Modeling Operation

There could be many operations to create a 2D/3D models, for example, cut, join, bend, carve, etc. and we firstly realize devices for cut and join operation. We associate cut and join functions with that of the knife and hummer.

The devises, respectively, can be built independently. However, it will be rather efficient to build devices which are composed of an attachment to serve a role of the common functions and attachments with separate functions. Therefore we have realized KnifeDevice and HammerDevice by changing different attachments in addition to the common main body (Figure 12). In the main body, common functional parts are built in, and in the separate attachments, all other mechanisms which are specific functions to each tool device. The knife has a feeling to compress while cutting, and the hammer generates a reaction force and collision sound when it beats something. To realize a similar operational feeling to the knife and hammer, the following electronic components are built into the body and attachment of the Knife and HammerDevice (Figure 13)

[Body]

- Magnetic sensor to detect the position and orientation of the device in 3D space.
- Speaker and Vibration motor for the confirmation of manipulation.
- The resistance which is used attachments identification mechanism.

[Attachments]

- Accelerometer to detect swinging (only HammerDevice).
- Tactile switches to detect contact with real object.
- Color LEDs for the confirmation of manipulation.

3.3. BrushDevice for Drawing and Painting Operation

For other examples, as to various drawing and painting tools, we consider brushes, which have a variety of tip and whose line weights are user changeable.

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, it can not press on. Therefore, we prepare the following five input methods which can be selected:

(a) Moving speed of the device

(b) Tilt of the device

(c) Distance from the device to the canvas

(d) Pressure from the device to the canvas

(e) Grip force to grab the device

The kind of brush, such as round and flat, can also be varied by changing attachments (Figure 14), like the KnifeDevice and HammerDevice.

To provide operations described above, following electronic components are built into BrushDevice (Figure 15)

- Magnetic sensor to detect the position and orientation (i.e. (a)(b)(c)) of the device.
- Analog stick controller for measuring the pressure from the device to the canvas (i.e. (d)).
- Slide valuable resistor to detect the grip force (i.e. (e)).
- The resistance which is used attachments identification mechanism.

Figure 14: Attachments

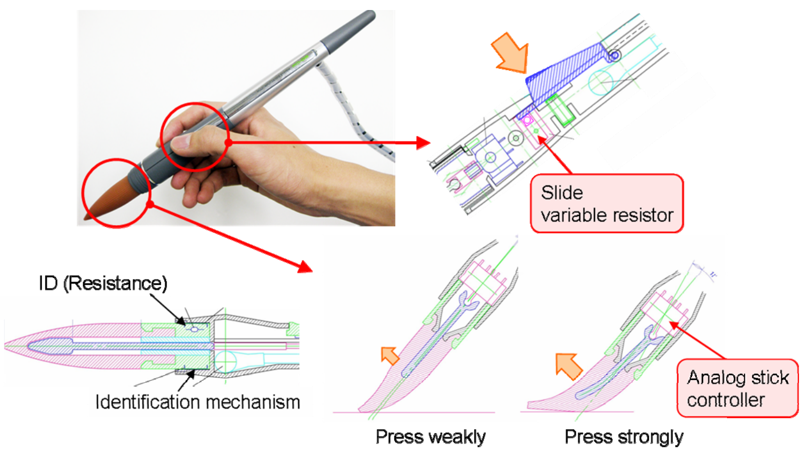


Figure 15: Internal mechanism of BrushDevice