Various Tangible Devices Suitable for Mixed Reality Interactions

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ABSTRACT

In this paper, we present various novel tangible devices suitable for interactions in a mixed reality (MR) environment. They are aimed at making the best use of the features of MR, which allows users to touch or handle both virtual and physical objects. Furthermore, we consider usability and intuitiveness as important characteristics of the interface, and thus designed our devices to imitate traditional tools and help users understand their use.

KEYWORDS: Mixed reality, tangible device, interaction, tool, user interface, tabletop.

INDEX TERMS: H5.2 [Information interfaces and presentation]: User Interfaces. - Interaction styles, Input devices, and strategies; H5.1 [Information interfaces and presentation]: Multimedia Information Systems - Artificial, augmented, and virtual realities.

1 INTRODUCTION

There are massive mixed reality (MR) researches but only a few projects focus on its interactions systematically. Since the early studies of virtual reality (VR) have started, there has been little progress in developing an interactive interface.

One of the most notable features that a user can perform in the MR environment is to handle both virtual and physical objects. This feature should be introduced into the interactive methods. Human interface studies have proposed various interactions, but they are not always suitable for use in the MR environment. Moreover, in the interactive art field, some refined interactive devices have been proposed and have gained popularity among researchers. However, they are often designed for each application, and only a few of these interfaces are systematic and general.

Our research goal is to provide intuitive means to interact with MR space; thus, we proposed a set of physical interfaces. These interfaces are designed to guide users in understanding how to use them; therefore, we employed a tool metaphor to represent their usage. Familiar objects may sometimes help users understand unfamiliar things. In personal computers, this idea is implemented as the desktop metaphor in GUIs and helps users comprehend computer operations. As shown in Figure 1(a), we have introduced the idea into an interactive device and built physical devices called ToolDevice. We then used our devices for interactions in a MR environment [1][2].

In this research, we have applied our devices to a tabletop MR environment as part of an ongoing study and developed some examples by building other physical devices to extend ToolDevice interactions, as shown in Figures 1(b) and 2.

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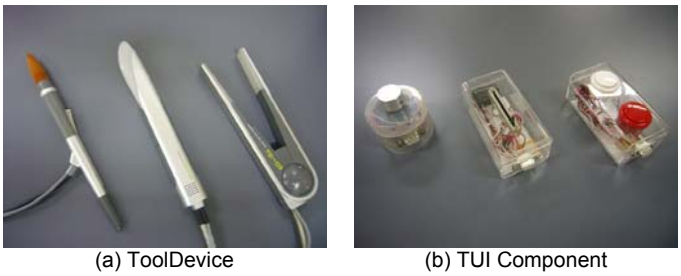
2 RELATED WORKS

Tabletop studies have proposed various means of interaction. The most popular tabletop interface may be multi-touch hand gestures. With the diffusion of multi-touch devices, these gestures have become widely used. M. Wu et al. introduced multi-finger and whole-hand gestural interactions for a multi-touch display. X. Cao et al. presented ShapeTouch, which uses contact shapes on surfaces for manipulations of objects and interactions. In these studies, multi-touch gestures are designed for easy understanding of manipulations mimicking daily hand movement, although they lack tactile feedback. In addition, the more gestures are used, the more difficult it is to remember the meaning of each one. ToolDevice reminds users of what the device can be used for by its appearance and provides easy handling of the tool.

Some physical user interfaces have also been presented for tabletop interactions. J. Underkoffler et al. introduced acrylic blocks for a user interface that allows the user to scale or rotate a virtual map by moving objects. P. Baudisch et al. proposed lumino, which is a glass-fiber-containing cubic interface that enables vertical arrangement interactions. These studies provide abstract shape interfaces and assign them for each interaction, so users need to know what the interface can do in advance; the interfaces also lack intuitiveness. The use of the ToolDevice can be intuitively understood at a glance.

3 APPLYING TOOLDEVICE TO A TABLETOP MR SYSTEM

In everyday life, various tools are used for working at a table, for example, paperwork, photo editing, and poster layout. In this



(a) ToolDevice (b) TUI Component

Figure 1: The tangible devices suitable for MR interactions.

Figure 2: The tabletop-oriented application of the ToolDevice.

study, we learned from this type of work and applied the ToolDevice to a tabletop MR system.

3.1 Tangible Devices and Pairing Interactions

[Supplemental ToolDevice for Tabletop Works]
For using ToolDevice on a tabletop system, we also designed a new tabletop-oriented ToolDevice. Its basic concept is the same as that of the previous ToolDevice: supporting MR interactions and easy understanding of its use. We also incorporated a table feature into ToolDevice on which users can place objects. First, we listed commonly used tools on the table and extracted a ruler, a magnifying glass, and a paperweight from them for table interaction.

[TUI Component]
Furthermore, to extend ToolDevice's intuitive but monotonous features, we combined it with other tangible devices called tangible user interface (TUI) components. Digitized interactions are sometimes more convenient than real-world interactions; for example, graphics software usually provides color charts for selecting colors, whereas real painting requires color mixing on a palette or of the use of multiple tools such as colored pens and pencils. To easily incorporate such digital advantages into our system, we use dial-, slider-, and button-type TUI components with the ToolDevice. These components were designed by referencing audio instrument controllers and Silicone Illuminated Active Peripherals (SLAP) widgets [7].

[Hand Gestures]
By observing daily tool use, we found that people tend to use either hands or multiple tools at the same time. For example, we usually place a hand on a sheet of paper to prevent it from moving while writing. Therefore, we used this idea to design two hand gesture manipulations—a pointing gesture that can handle exactly one virtual object, and a wiping gesture that is used for multiple digital objects. Both hand gestures can be employed while using the ToolDevice, just as we do in daily life.

3.2 Implementation

We developed a tabletop MR system (Figure 3) with an embedded projector (1024 * 768 pixels) for displaying graphics on the tabletop's surface (132.8 cm * 90.0 cm). Infrared LEDs and two infrared filtered cameras (640 * 480 pixels) are placed beneath the table. While the devices are placed on the projection surface (table), infrared rays are reflected and white shadows are casted onto the captured image. Using this technique, markers attached to the back of each device can be uniquely identified and tracked. Hand gesture is detected by the ViconPeaks motion capture system which uses infrared technologies. The user wears a pair of glove devices on which retro-reflective markers are attached.
Which pair of devices (or hand gestures) is used in combination can be detected by their position, their distance from each other, and information on whether each device is grabbed by the user. This grab information is detected by pressure sensors attached to the devices.

3.3 Interaction Examples

As an example of an interaction using the ToolDevice, TUI Component, and gesture interactions together, we developed a poster layout system mimicking general tabletop work such as poster design and photo editing. In this system, for example, the slider-type TUI Component enables users to change the magnification rate of Loupe and modulate the tip size of Pen (Figure 3 (c)). The dial provides variable photographic filter effects by pairing Loupe and color chart to change colors in Pen (Figure 3 (d)).

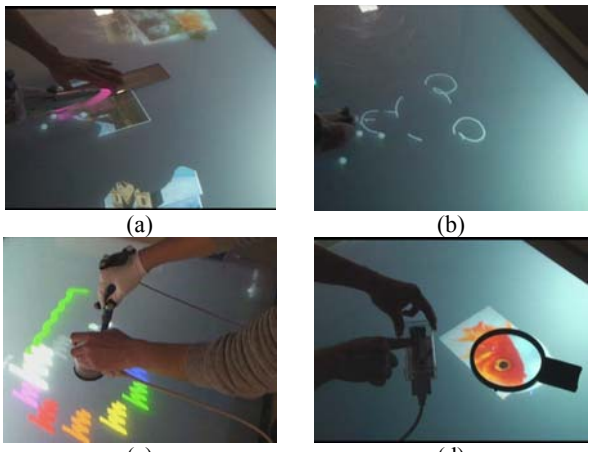


Figure 3: (a) KnifeDevice and Ruler are used for cutting virtual pictures on any lines. (b) Lines can be drawn anywhere on the projection area with the Pen. (c) Pairing between the Loupe and slider can change a rate of magnification of the picture underneath the Loupe. (d) Colors and line width of the Pen can be changed by rotating/moving the dial/slider.

4 Conclusion & Future Work

In this paper, we introduced the application of ToolDevice to tabletop interactions. We also designed and developed TUI components for extending ToolDevice interactions. Our pilot test showed that users could use the ToolDevice and auxiliary devices easily and intuitively. The tool metaphor helped users understand the usage of the device. We also gained positive feedback on TUI component, that is, it was easy to operate. However, the user comment on the pairing interaction suggested that some visual feedbacks should be required to indicate the pairing event. In addition, some replied that there is still room for improvement in mechanism of the device and its usage.
In future work, we will continue to investigate the intuitiveness and utility of our tangible devices. Another improvement is to build a wireless TUI component because the cable made user annoyed.

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