TOOL DEVICE:
Handy Haptic Feedback Devices Imitating Everyday Tools

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Abstract

In this paper, we propose handy haptic devices named Tool Device. Tool Device is designed with metaphor of everyday tools, such as scissors, tweezers and syringe, which have good shape affordance by themselves, and allows users seamless manipulation of multimedia data in an extended information environment. Just as users feel haptic feedback from everyday tools while handling physically, the Tool Devices can also have haptic feedback to show the quantity and freshness of the handling data. We developed two types of the Tool Devices, a Syringe Device and a Tweezers Device, and studied their application to the manipulation of music and text data. Results showed that the Tool Devices were easy to manipulate because of their shape and haptic feedback, and users could use them without any training.

1 Introduction

Because of digital technologies' improvement, users not only can manipulate various types of multimedia data in one machine, but also can transfer or share those data with other machine via high speed network. In this paper, we propose handy input devices named Tool Devices, whose designs imitate shapes and haptic feedbacks of everyday tools. The Tool Devices allow users to manipulate multimedia data, such as text, image and sound, in an extended information environment simply and seamlessly.

D. A. Norman pointed out that users form mental models through experience, training and instruction (Norman, 1990). Since novice users have not undergone any training and instruction, experience is the only trigger for them to estimate the manipulation method. Everyday tools, such as scissors, tweezers and syringe, have good affordance by themselves. Moreover most users have experience of using them. An advantage of the Tool Devices is that, since users already know how to use the original physical tools, even novice users can easily apply those methods to Tool Device manipulation.

In addition, while using an everyday tool, haptic feedback to users' fingers helps them to sense what kind of object they are handling. On the other hand, while using a mouse or a keyboard, there is no haptic feedback that shows how many documents a file includes or when a document is updated. To make intangible digital data touchable, we added force and thermo feedback functions to the Tool Device, which display quantity and freshness of the data.
In this paper, we introduce two types of the Tool Devices: a Tweezers Device and a Syringe Device.

2 Related work

Computer augmented environments incorporate benefit of digital information into real world. For instance, Tangible Bits (Ishii & Ullmer, 1997) feature objects' form and haptic feedback physically to display digital data instead of graphical user interface. Pick-and-Drop (Rekimoto, 1997) uses a physical tool (pen) to transfer digital data directly between information appliances. In these works, user can manipulate digital data by handling objects or tools physically. However both interface systems require users to learn how to use them. The Tool Devices also use objects to manipulate digital data physically, but, since the Tool Devices imitate shapes and haptic feedbacks of everyday tools, users have already known how to use the original tools and can apply those methods to Tool Device manipulation.

Haptic feedback plays an important role in the Tool Devices. To be equipped into a handy Tool Device, the haptic feedback device should be small. Various haptic feedback systems have already been developed, such as PHANTOM ("The PHANTOM"). However, most of them are large systems. Though vibration is used in some small haptic feedback systems, it is a simple signal and cannot display haptic feedback of every day tool manipulation. In our system, we develop small haptic feedback system that displays natural haptic feedback, such as hardness of object.

3 Tool Device

3.1 Tweezers Device

Tweezers is a tool that can clip and release physical objects. When users clip an object, reaction force from object appear to their fingers through the tweezers.

In contrast, the Tweezers Device can clip and release digital data by closing and opening it. When users close the device to clip digital data, the reaction force to open tweezers is displayed to their fingers (Fig.1). The more data users clip, the stronger force is displayed. By opening the device, clipped data is released and the reaction force disappears. This idea is based on the fact that users can recognize size and hardness of object from the reaction force.

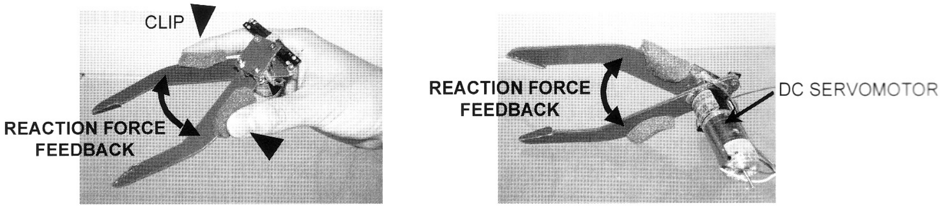
The feedback force is created by DC servomotor attached to fulcrums of Tweezers Device and magnitude of the force is controlled by the voltage to the motor. We use a voltage controller and a servo motor controller via RS-232C ports of Windows PC.

3.2 Syringe Device

A syringe is a tool that can suck up and push out liquid. Users can get liquid by pushing and releasing syringe body, and then they can push out the liquid by pushing its body again. The more liquid users get in syringe, the harder its body expands.

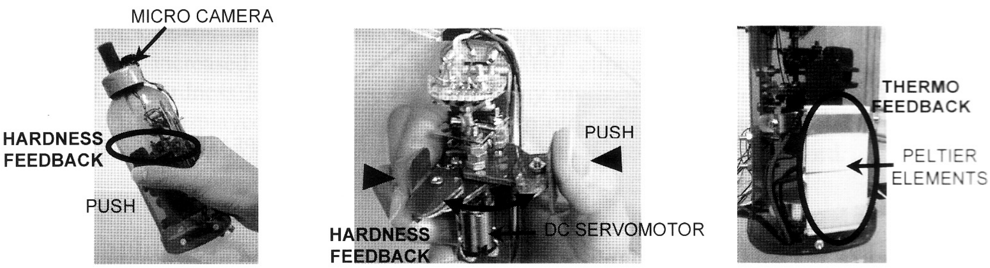
In contrast, a Syringe Device enables users to suck up and push out digital data. Firstly users point target data with a head of Syringe Device and push the device body. The depth of user's push controls how much data to be sucked up. When users release the body, the data is copied to the device and the body expands and becomes hard. To paste copied data to other appliances, users must push the device body on them. Then its body becomes soft and returns to its original hardness.

Similar to Tweezers Device, hardness feedback is created by DC servomotor inside a device body. Users can sense how much data has been sucked up into the Syringe Device by the hardness of the device body. Besides, the Syringe Device has another haptic feedback: a thermo feedback that displays freshness of the data. If the sucked data is new, the surface of the Syringe Device becomes hot. The device becomes cold for the old data. This feedback is based on a metaphor of cooking and is controlled by two Peltier elements (thermoelectric modules). A relay controller switches the Peltier elements on/off via PC's RS-232C ports.



Front **Back**

Figure 1: Tweezers Device



Front **Inside** **Back**

Figure 2: Syringe Device

4 Applications

We constructed music player and text editor applications, which enable users to manipulate music data and text data by the Tool Devices simply and seamlessly in an extended information environment. In both applications, users can clip or suck up data between both digital appliances, such as a touch panel display, a speaker and a printer, and real objects, such as CDs and books (Fig.3).

In the music player application, users can select music data from music title lists on PC's touch panel display or CD labels. The selection method using the Tweezers Device is to touch the front and end position of titles and close the tweezers' hands (Fig.4(a)). To play the clipped music, one can release them in a data-loading cup on a speaker by opening the tweezers. There is a touch switch in the data loading cup to detect whether the data are released in the cup or not (Fig.4(b)). With Syringe Device, users can suck up music titles by pointing the head to them (Fig.5(a)) and play it by pushing them out in the loading cup (Fig.5(b)).

Each haptic feedback of the Tool Devices is linked to features of music data. The reaction force and hardness feedback represent the number of selected music titles and thermo feedback shows freshness of data. In addition to such haptic feedback, graphical animation also supports user's "clipping" and "sucking up" manipulation. When users close tweezers, an image of selected data is compressed, then disappears (Fig.4(a)). When users suck data up by syringe, the data image becomes smaller and smaller like sucked liquid (Fig.5(a)).

To clip and suck up data from real objects, such as CD and MD, we attached a micro camera to Tool Devices and identify each object by color code ID markers posted on it. (Fig.6).

In a text editor application, text data can be copied from PC's touch panel or paper to networked PC or printers.

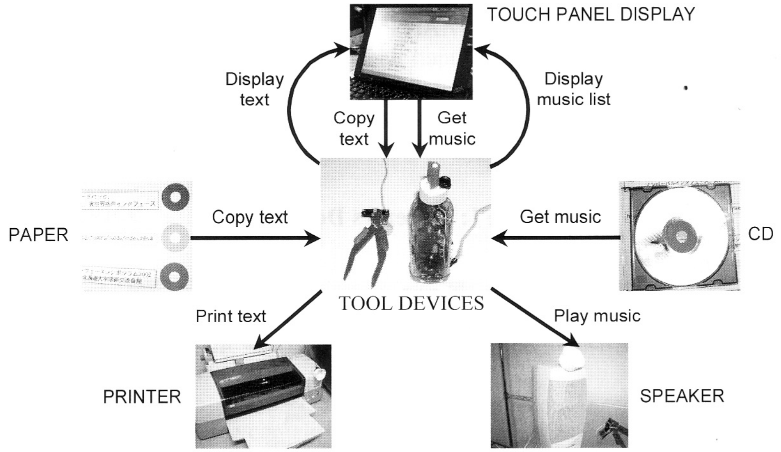
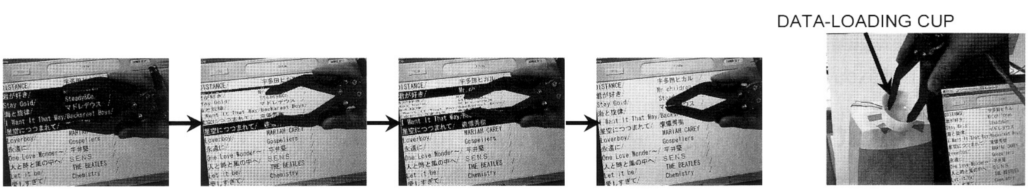
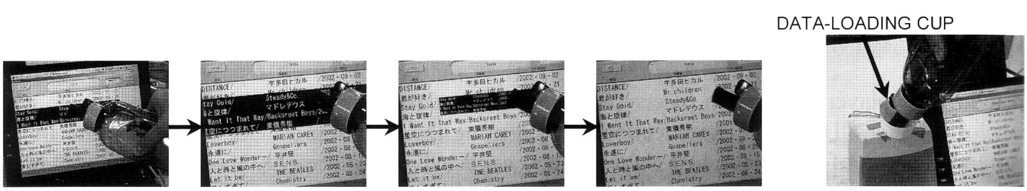


Figure 3: Tool Devices' manipulation in extended information environments



(a)Clipping music data **(b)Releasing music data**

Figure 4: Data manipulation using Tweezers Device



(a)Sucking music data up **(b)Pushing music data out**

Figure 5: Data manipulation using Syringe Device

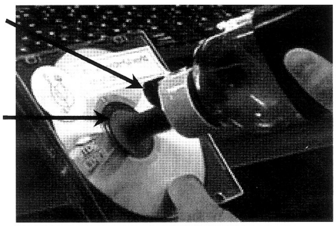


Figure 6: Identification of real objects with color code

5 Evaluation

Experimental task for evaluation was to select some music from music title lists on PC's touch panel display and play them on a speaker. Eight test users, 3 females and 5 males, assessed the easiness of the manipulation using the Tweezers and Syringe Device compared with a mouse and a keyboard. The task for the users was to select some music titles from a music title list on PC's touch panel display and play them on a speaker. They were not instructed or trained before experiments. After experiments, they were interviewed with the impression of the Tool Devises' manipulation and haptic feedback.

The results show that the test users could easily understand how to use Tool Devices and what haptic feedback meant. All test users could finish the task using Tool Devices. All found that the reaction force increased as more music titles were clipped. Seventy five percent of them understood the hardness feedback denoted how many music were sucked up, and 63% found that thermo feedback displayed whether music data were old or new. Most test users commented that the Tool Devices were more enjoyable and entertaining than the mouse or keyboard.

6 Conclusion

We proposed a Tool Device designed as a metaphor of shape and haptic feedback of everyday tools. A Tweezers Device with reaction force feedback and a Syringe Device with hardness and thermo feedback were developed as the examples of the Tool Devices. We also constructed Tool Device applications, where users can manipulate music and text data seamlessly from computer display, CD, or paper to networked computer, speaker or printer. The evaluation experiments showed that the test users could easily understand how to use Tool Devices and what haptic feedback meant.

We believe that a lot of appliances could be targets to be controlled by the Tool Devices. For future work, we are designing other type of the Tool Device and its application.

References

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The PHANTOM haptic interface, from http://www.sensable.com/