Amazing Forearm as an Innovative Interaction Device and Data Storage on Tabletop Display

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ITS'12, November 11–14, 2012, Cambridge, Massachusetts, USA.
ACM 978-1-4503-1209-7/12/11.

Abstract
In this study, we propose interaction techniques that use the forearm on tabletop displays positively. We define the forearm as the part of the arm between the elbow and the hand. On direct input surfaces, users' forearms often create problems such as incorrect recognition and occlusions. Therefore, the forearm is often considered problematic. Conversely, we think it could be possible to use it to create new interaction techniques. We propose new interaction on tabletop displays that use the forearm. In this paper, we describe how users can manipulate menu and data storages by these techniques. Our study offers new possibilities for using the problematic forearm in tabletop displays.

Author Keywords
Forearm; Interaction Techniques; Tabletop Display.

ACM Classification Keywords
H.1.2 [Models and principles]: User/Machine Systems-Human factors; D.4.7 [Operating systems]: Organization and Design - Interactive systems; H.5.2 [Information interfaces and presentation]: User Interfaces - Interaction styles.

Introduction

Many studies have examined direct input surfaces such as tabletop displays. In particular, many researchers have focused on interaction techniques. Wu and Balakrishnan [1] proposed multi-finger and whole-hand gestural interaction techniques for tabletop displays. Weiss et al*.* developed SLAP Widgets, which support input and adjustment of various values on the computer by buttons, knobs, sliders, and a keyboard placed on a tabletop display [2]. Hinckley et al. observed the motion of the non-dominant hand and proposed a new interaction technique that combines a pen device with gestures [3].

Interaction techniques on tabletop displays can be categorized as those in which the tabletop display is touched directly by the hand and/or finger, and those in which real objects such as pens, knobs, or buttons are used as input devices. However, this classification focuses mainly on objects that are being used actively to interact with the system. If we look at the big picture, it is not only the hand or the input device that frequently comes into contact with the tabletop display, but also the user's forearm.

Users often consciously or unconsciously place their forearms on the tabletop display. However, this creates problems such as occlusion and incorrect recognition. In this paper, we propose interaction techniques that make positive use of the forearm. We propose innovative uses of forearm as menu device and data storage. In the menu device, users can display a menu that is arranged around the hand by placing their forearms on the tabletop display. In the data storage the user's forearm is used as data storage where users can store and retrieve digital objects.

In studies [3, 4], operation was improved by using everyday actions. Therefore, we firstly observed everyday motions of users at a desk and designed interactions that use the forearm on the basis of these motions.

Observation and Interaction Design

observation

We observed the motions of participants working with tools frequently used in desk work, such as a pen and paper. We focused on the following points: How often do people place their forearms on a desk? In what situations and for what purposes did people place their forearms on the desk?

To consider a variety of situations, we observed the following two tasks: Reading several documents and classifying them according to a specified condition (four participants). Create a photo album from several photographs by using tools often used in desk work such as a pen and paper (seven participants).

(1) We observed a strong tendency in the participants to place their forearms on the desk when they were working with tools. In this situation, we think that people placed their forearms on the desk to select and pick up their tools or to facilitate their work to complete the required tasks under steadier conditions. (2) We also observed that the participants often placed their forearms on the table while they are thinking about their tasks. They placed their forearms even when they hear our explanation about the required tasks before beginning our observations. In these situations, we think that the participants acted unconsciously. (3) Some interesting usages of the forearm are observed

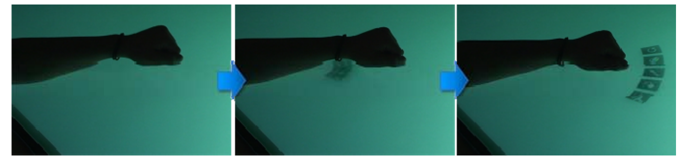
that the participants moved or swept objects with their forearms.

Interaction Design
On the basis of our observations, we conclude that when people are working, they frequently place their forearms on the desk. Judging from the frequency with which this action occurred, we believe that placing the forearm on the work surface is natural.
From the observation (1), we propose interaction techniques using forearm as menu device, where users can select functions as if they select and pick up tools in the real world. From the observation (2) and (3), we propose interaction techniques using forearm as data storage. Placed forearm could become a store space with high accessibility. Additionally, if the forearm became a storage box, many desktop data could be gathered with their swipe action.

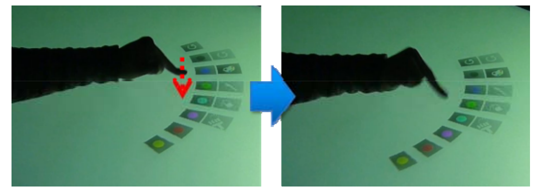
Implementation

(A) Menu
Our first interaction using the forearm is a menu. Bailly et al. [5] proposed the menu displayed by placing a hand on tabletop display. However, placing only the palm and the fingers without the forearm could be tired. We enable users to easily display a menu by placing the forearm on the tabletop display.

Figure 1 shows the interaction with the menu appearing from the forearm. As with Bailly et al. [5], we used a pie menu so that the menu items are located inside users' range of hand motion and users can easily access each menu item. The users can select an item by the touch gesture. To hide the menu, users can simply lift their forearms up from the tabletop display on their elbows or select the "hide" menu located in the top menu. The menu will then be stored in the forearm



a) Display the menu by placing the forearm



b) Rotate the menu

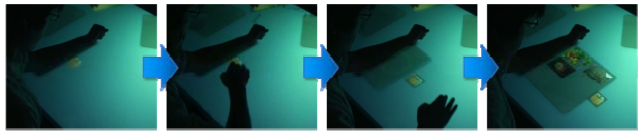
Figure 1. Interaction with a menu appearing from the forearm.

(disappeared under the forearm). The space between the forearm and the menu items is defined as the gesture area. By sliding a finger in this area, users can rotate the menu in the direction of the finger's motion.

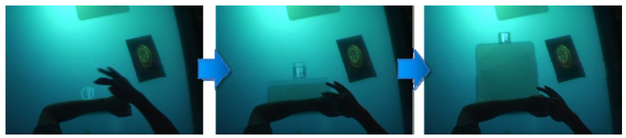
(B) Data Storage
Our second interaction using the forearm is data storage. It can store data such as photos, documents and folders. Figure 2 illustrates how the storage functionality is used.

When users place their forearms on the tabletop display, storage icons are displayed along their forearms. One icon represents one data storage. By tapping the icon, users can open and display the data storage window from the forearm. To hide the window, users tap the icon again.

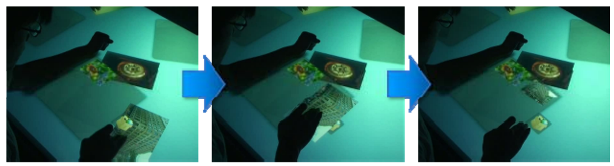
To store data, users drag the desired data into the storage window or into the forearms directly. If several storage icons are aligned along their forearms, users could drag the data close to the desired icon. Another



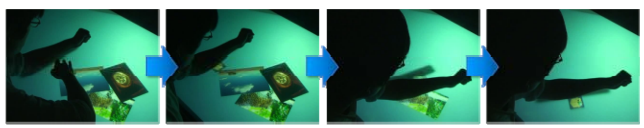
a) Display the storage window (cross direction)



b) Display the storage window (lengthwise direction)



c) Store data to the storage window



d) Interact with collected data by sliding the forearm

Figure 2. Interaction with a data storage in the forearm.

way to store data is to hold the icon a bit longer. This will switch the folder to collection mode. Users can then slide their forearms through on the desired data, and the data is stored automatically.

Users can retrieve the data storage window from the forearm by dragging the storage icon away from the forearm. They can store any data storage window to their forearms by dragging its icon into their forearms.

Conclusion and Future Studies

In this paper, we introduced interaction techniques that make positive use of the forearm on tabletop displays. The data storage can store and retrieve data to the area covered by the forearm by using touch gestures and sliding the forearm. The menu function can display a menu from the area covered by the forearm or store the menu to this area. To change viewpoint, we think that the forearm is not problematic but rather can be used in new interaction techniques.

For our future studies, we plan to create more interaction techniques that users can intuitively use their forearms. For example, when we read books and documents or do some works at desks, we often place our forearms on either side of them. In the same way, if users place their forearms on our tabletop system, a document or an application window on the display could be automatically arranged between their forearms. We also plan to distinguish users' dominant and non-dominant hands to design particularly effective interaction for each hand, and to distinguish forearm user to make the interaction customizable.

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