Multi-User Interaction with Shadows

Tomomi Gotoh[1], Takahiro Kida[1], Munehiro Takimoto[1],
and Yasushi Kambayashi[2]

[1] Department of Information Sciences, Tokyo University of Science, Japan
mune@cs.is.noda.tus.ac.jp
[2] Department of Computer and Information Engineering,
Nippon Institute of Technology, Japan
yasushi@nit.ac.jp

Abstract. Recent mobile devices such as smart phones exhibit performance as good as desktop PCs, and can be used more intuitively than PCs by using fingers. On the other hand, the defect of such a device is its small size. Its display is just big enough for single user, but is too small for interaction of multi-users. In order to overcome the defect, the research of projecting the display with a handheld projector has expanded. Most of the researches, however, do not allow users to manipulate the projected image in a direct manner. In this paper, we propose operations of projected images through shadows. We can create a shadow by shading the light of the projector with a finger. The shadow can be easily scaled by adjusting the distance between the finger and the projector. Also, since the shadow makes good contrast with the white light of the projector, it can be easily recognized through a camera. Using these properties of the shadow, we have implemented a series of operations required on the desktop, and file transfer as a basic multi-users interaction. We show that the users can perform these operations intuitively with the shadow of two fingertips as if they handle a tablet PC through multi-touches.

1 Introduction

Recently advanced handheld devices such as smart phones or PDAs can be also used as projectors with some special attachments. The capabilities of handheld projectors have also begun attracting attentions as one of wearable devices [1–3]. General usage of such a projector is to magnify the small display of a handheld device. Apart from that usage, the researchers begin to investigate the possibility of such handheld device as a multi-user interaction tool have expanded [4–6]. In the latter case, desktop images projected by two users' handheld devices can be used for not only sharing information but also transferring files through making their icons included in the shared area where the two images overlap. The handheld projectors with cameras make such a technique possible, where each handheld device can recognize the two desktop images and their overlapped area from the same position as the projector through the camera. Once the icon

M. Kurosu (Ed.): Human-Computer Interaction, Part IV, HCII 2013, LNCS 8007, pp. 235–242, 2013.

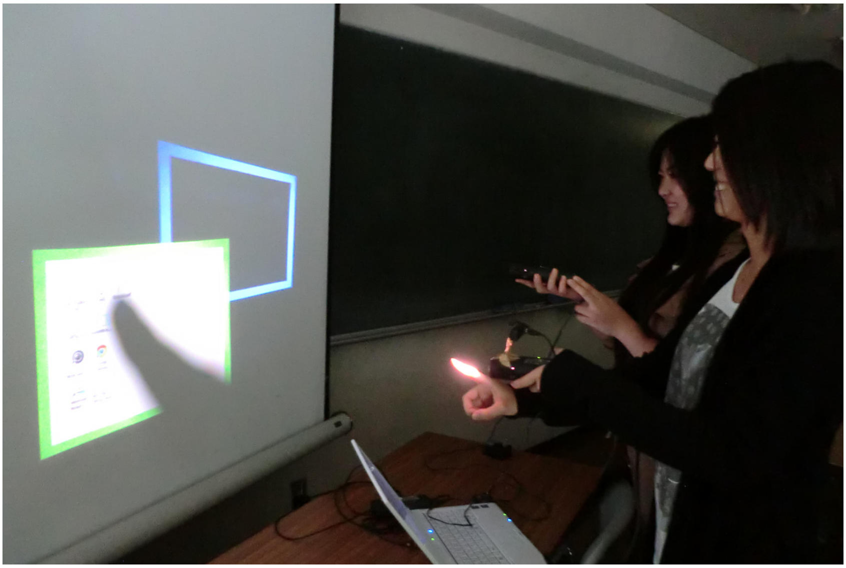


Fig. 1. The projected desktop image with the shadow of a finger

representing a file is recognized, the file can be transferred from one device to the other device, triggered by making the icon move in the overlapped area.

In most cases, these operations are achieved by physically moving the projectors, and therefore thorough operations on the desktop have to be performed at the side of the device. Considering intuitive operations, the direct interaction with projected desktop is preferable rather than operations on the device. It has, however, some problems for practical use. When a user wants to magnify the image projected by his or her handheld projector in order to operate the desktop on a large screen, the user has to look at it from a distance. Since the distance between the projector and the screen is usually longer than human arm, the user cannot touch the projected image directly. Therefore, the user has to utilize a special device such as the laser pointer in order to point a certain object on the screen. Unfortunately, such a special operation is contrary to the intuition augmented by the projector.

In this paper, we propose a set of new desktop operations on projected desktops including multi-user interactions without any special pointing device. Our approach takes advantage of the shadows of fingers on images to operate the desktop instead of real fingers or reflection of laser pointer as shown in Fig. 1. The shadow can be easily created on the projected image by putting a finger between the projector and the screen [7]. Furthermore, the shadow created in this manner can be resized by adjusting the distance of the finger from the projector depending on minuteness of the operation.

Another advantage for using the shadow as an operation tool is that its color and the brightness are relatively stable because the shadow is just a dark area,

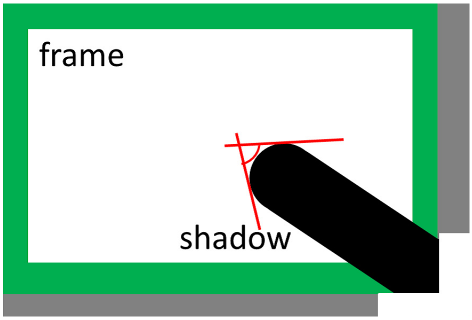


Fig. 2. The shadow of a finger inside a frame

and therefore, it can be easily recognized. Once the black area is recognized, the location pointed by the finger can be also easily detected.

The structure of the balance of this paper is as follows. In the second section, we describe how to recognize the shadows of fingers and fingertips, and then present details of desktop operations using them. In the third section, we show a problem for interactions through the shadow, and then, provide a solution for it. We present the design of our system based on the solution. Finally, we conclude remarks in the fourth section.

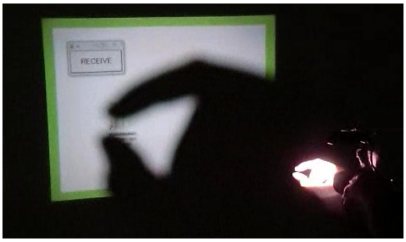
2 Recognition of a Shadow and Operation through It

In this section, we describe how to recognize the shadow of a fingertip, and show how the shadow can be used to operate a desktop. After that, we extend the operation to using two fingers.

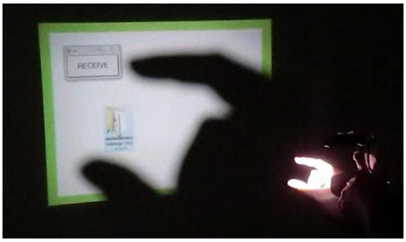
2.1 One Finger Operation

The color and the brightness of a shadow are relatively stable because the shadow is just a dark area, and therefore, it can be easily recognized. Once the black area is recognized and its edge is extracted, the fingertip part of the edge has to be detected. The steps of the detection of the fingertip are follows: 1) draws tangential lines at even intervals, 2) finds neighbor lines such that the angle between them is the smallest, and 3) extracts tangent points between the lines and the finger edge. We determine the location around the tangent points as a fingertip. Fig. 2 shows the smallest angle between tangent lines.

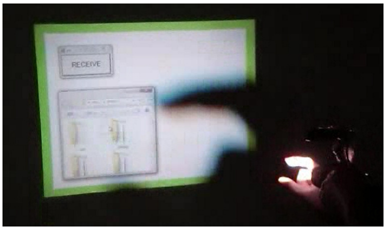
The problem in handling a shadow is that the shadow may be confused with other black objects such as black icons or windows. In order to overcome this problem, we introduce a finger recognition approach based on the frame of a desktop. Notice here that the shadow of a finger has an intersection with the frame. Most other objects on the desktop are inside the frame, and therefore, there is a gap between them and the frame. We identify the black area without



(a) Selection operation with pickup



(b) Open operation with opening fingertips



(c) An opened folder

Fig. 3. Opening a file

such a gap as a finger. As shown in Fig. 2, the shadow created by a finger has an intersection with the frame shown by green border.

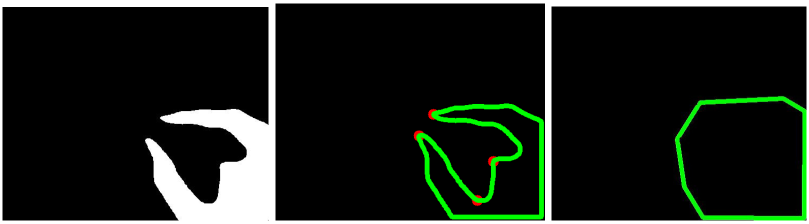
For the first step, we have implemented a series of desktop operations on files by a finger: selection, open, drag, and drop. The selection and open are distinguished by the time period in which the shadow of finger stays on the icon. The required time periods are respectively one second and two seconds for the selection and the open, respectively. The drag is made to be active by moving the shadow immediately after the selection. The drop after the drag is performed one second later after the movement of the shadow in the drag stops.

2.2 Two Finger Operation

The one finger operation works well, but since it has to distinguish each operation based on the time in which the shadow stays on a icon, it takes too much time for practical uses, e.g. it takes two seconds for the selection. If the combination of some operations is required, it would take much more time.

In order to reduce the time taking for one finger operation, we introduces a new operation *pickup* that uses two fingers such as a multi-touch on a tablet. In the pickup, we put two fingers together with a small gap such as picking up something. Each operation can be immediately distinguished by pickup immediately

(a) Recognition of separate fingers



(b) Recognition of connected fingers

(c) Recognition of fingertips

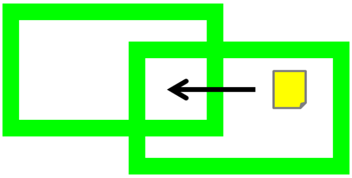
(d) Recognition of the convex hull including fingers

Fig. 4. Recognitions of two fingers

followed by some additional operations. As shown in Fig. 3(a), making pickup held on an icon for a second corresponds to the selection operation. Following it, opening fingers corresponds to the open operation as shown in Fig. 3(b) and (c), or moving fingers holding pickup corresponds to the drag operation.

In order to take advantage of the pickup operation, two fingertips have to be recognized simultaneously. Fig. 2.2 shows the process of recognizing shadows created by two fingers. In Fig. 2.2(a), the shadow looks like two sticks. On the other hand, in Fig. 2.2(b), the shadow looks like a mountain with two tops. We can easily deals with the shadow such as two sticks, because the same recognition technique for one finger can be simultaneously applied to two fingers. On the other hand, it is not easy to recognize the two-top mountain shadow such that shown in Fig. 2.2(c). Red points Fig. 2.2(c) show recognized fingertips in the case of applying one finger recognition technique to the recognized shadow. As shown in the figure, they appear at other than fingertips. That is because the concave angle created by two fingers satisfies the condition of a fingertip.

In order to handle such misrecognized cases, we introduce the technique that identifies the shadow as a convex hull, and ignores recognized points inside the convex hull. For example, the shadow of two fingers shown in Fig. 2.2(b) can be regarded as the convex hull shown in Fig. 2.2(c).



(a) The outline of our file transfer operation

(b) The projected image of a desktop

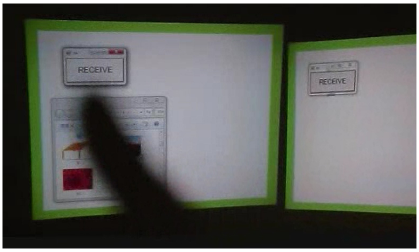
Fig. 5. Interactions of our system

3 File Transfer

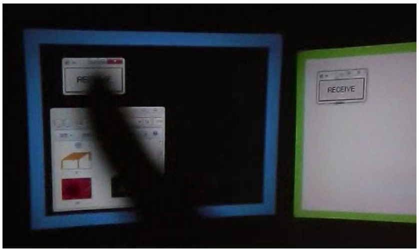
The main contribution of using mobile devices through handheld projectors is that it allows several users to share information. Our desktop operation based on shadow allows several users to interact on projected images. Fig. 3(a) shows an example of transferring a file as the basic interaction. In order to transfer the a file, the users overlap projected desktops, which is used as a shared folder, and then the sender drags the icon of the file to the overlapped area i.e. the shared folder. The file transfer manner, which is similar to the operations on tablet PCs, is preferable because the operation is intuitive. It is, however, difficult to make it work based on the shadow. The shadow of a fingertip is created by blocking off the light projected by sender's projector, and therefore, it disappears in the overlapped area due to the light projected by the receiver.

We mitigate this disappearance problem of the shadow by suppressing the strength of the receiver's light. Fig. 3(b) shows a desktop image of our system. Each desktop has a receive button inside it, which can be pushed by putting the shadow of a fingertip on it. Once it is pushed, the background of the desktop turns to black, which contributes to suppressing the strength of receiver's light.

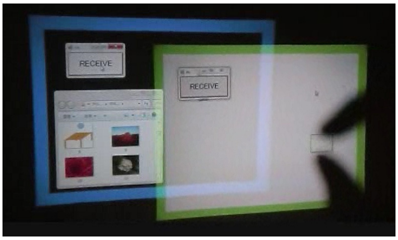
Fig. 3 shows the sequence of the operations for file transfer. As shown in Fig. 3(a), both desktops initially have white backgrounds. Once the receive button on the receiver's desktop is pushed, the background of the desktop turns to black as shown in Fig. 3(b). After that, overlapping a part of the sender's desktop on the receiver's desktop makes receiver's folder allocated to the overlapped area, as shown by Fig. 3(c). Finally, dragging the icon of the file on the sender's desktop to the overlapped area, the file is now transferred to receiver. Notice that the shadow of the fingertip also appears on the overlapped area clearly through turning the background, as shown in Fig. 3(d).



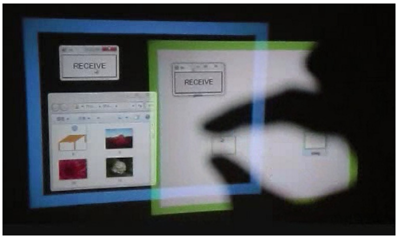
(a) Two desktop images for interaction



(b) Turning the background to black



(c) Creating overlapped area



(d) File transfer through dragging a file to overlapped area

Fig. 6. File transfer

As the last step of the file transfer, the background of the receiver's desktop has to be turned back to white. The background is, however,now black, and the shadow cannot appear on the desktop of the receiver. This means that the button for turning the background back to white cannot be handled by the shadow. Therefore, instead of using shadow, We set the exclusive two kinds of condition where the receive mode is canceled, as follows:

1. The desktops are separated after they are overlapped, or
2. Five seconds passes with keeping the desktops separated.

The first condition naturally realizes the automatic cancellation of the receive mode in a sequence of file transfer operations, and the second condition guarantees that the receive mode is always canceled based on time out.

4 Conclusions

We have implemented a system on which we can operate the desktop using the shadow of fingertips. First, we implemented the operation by using one finger, and then, extended it to the operation by using two fingers. In the one finger actions, corresponding operations have to be distinguished based on the time period in which the shadow stays on the operated icon, but in the two fingers actions, they can be distinguished based on some actions immediately following picking-up action, which contributes to reducing the total of time cost of operations.

Furthermore, we implemented the file transfer as an example of multi-user interactions based on these actions of the shadows. We designed it as a sequence of operations, in which two desktops are overlapped, and then the operated icon is dragged to the overlapped area. Though it is intuitive, and is an natural extensions of multi-user interaction on projected desktop, we observed that it has the problem of disappearance of the shadow in the overlapped area. We then provided a solution for the problem by introducing the technique turning the background of a desktop to black.

The current system is designed for the interaction for two users. We are extending it so that it works for more than two users .

References

1. Cao, X., Balakrishnan, R.: Interacting with dynamically defined information spaces using a handheld projector and a pen. In: Proceedings of the 19th Annual ACM Symposium on User Interface Software and Technology, Montreux, Switzerland, October 15-18, pp. 225–234. ACM (2006)
2. Miyahara, K., Inoue, H., Tsunesada, Y., Sugimoto, M.: Intuitive manipulation techniques for projected displays of mobile devices. In: Extended Abstracts Proceedings of the 2005 Conference on Human Factors in Computing Systems, CHI 2005, Portland, Oregon, USA, April 2-7, pp. 1657–1660. ACM (2005)
3. Yoshida, T., Nii, H., Kawakami, N., Tachi, S.: Twinkle: interface for using handheld projectors to interact with physical surfaces. In: ACM SIGGRAPH 2009 Emerging Technologies. SIGGRAPH 2009, pp. 24:1–24:1. ACM, New York (2009)
4. Cao, X., Forlines, C., Balakrishnan, R.: Multi-user interaction using handheld projectors. In: Proceedings of the 20th Annual ACM Symposium on User Interface Software and Technology, Newport, Rhode Island, USA, October 7-10, pp. 43–52. ACM (2007)
5. Mistry, P., Maes, P., Chang, L.: Wuw - wear ur world: a wearable gestural interface. In: Proceedings of the 27th International Conference on Human Factors in Computing Systems, CHI 2009, Extended Abstracts Volume, Boston, MA, USA, April 4-9, pp. 4111–4116 (2009)
6. Yatani, K., Tamura, K., Hiroki, K., Sugimoto, M., Hashizume, H.: Toss-it: Intuitive information transfer techniques for mobile devices using toss and swing actions. IEICE Transactions 89-D(1), 150–157 (2006)
7. Shoemaker, G., Tang, A., Booth, K.S.: Shadow reaching: a new perspective on interaction for large displays. In: Proceedings of the 20th Annual ACM Symposium on User Interface Software and Technology, Newport, Rhode Island, USA, October 7-10, pp. 53–56. ACM (2007)