Gesture-Based Interactions on Multiple Large Displays with a Tabletop Interface

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Abstract. We like large displays. Also, we love to equip with multiple displays for exercising multiple tasks in parallel. It is not unusual to have multiple large displays in our offices. Therefore, we can see many widgets on multiple large displays and would like to select and manipulate them in more convenient and faster ways. Because the widgets are physically spread in multiple large displays, it is not easy for users to reach them easily. It follows that new interaction techniques must be provided.[1] New interaction techniques for accessing distant widgets on multiple large displays using a tabletop interface called 'u-Table' [2] are proposed in this paper. Hand gestures are mainly used on tabletop interfaces because of their intuitive, non-invasive and easy operations. We incorporate advantages of existing techniques such as intuitiveness of tabletop interfaces, fastness and simultaneity of existing interaction techniques such as Drag-and-pick [10] and Vacuum [11]. The proposed interaction techniques include fetching, sending, and manipulating distant widgets on multiple large displays. We expect our techniques can be applied various interfaces using hand gestures and heterogeneous displays.

Keywords: Multiple Large Displays, Hand Gestures, Tabletop Interfaces.

1   Introduction

A tabletop interface consists of a table-shaped display where displayed objects can be manipulated by touching the display. We extended the concept of the tabletop interface as a ubiquitous multimodal interaction platform, called 'u-Table' [2]. It provides touching interaction by utilizing computer-vision technology with camera under the table combined with the projected visual information from the projector under the table. In u-Table, the tabletop is used as a large touch-able screen. Output images are projected on the tabletop by rear-projection. u-Table also recognizes different devices using specially designed visual tags. The overall system is presented in Figure 1.

Hand gestures are commonly used to interact intuitively on tabletop interfaces [3]. In Augmented Surfaces [4], Hyperdragging can be used to move an object in a
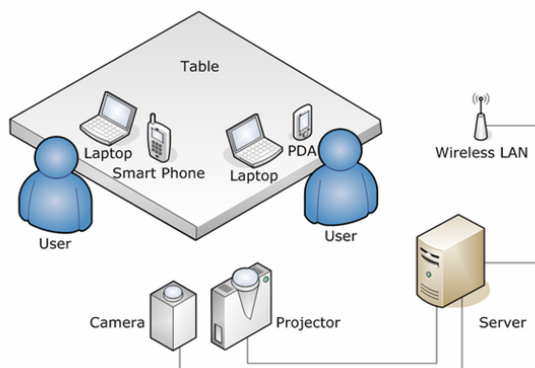

Fig. 1. System overview

notebook to a tabletop or a wall display. Interface Current [5] is a fluid interaction technique to support face-to-face collaboration. To access objects on the tabletop, it provides a controllable flow interface. In this paper, we propose intuitive hand gestures to access distant object.

The displays of tabletop interfaces are getting larger as the tabletop interfaces are considered as cooperative workspace [5][6]. In large display spaces, a user-accessible area is limited. Especially, a user cannot easily interact because of physical boundary problems [1]. On the large tabletop, objects may be placed far from a user when it is needed. When there is another user near the interest objects, the user can request that person to replace the objects to the user using techniques like the Throwing [7][8].

There are many techniques for accessing distant object in large displays. Multiple displays are generally used to make large display. There is a boundary problem with physically separated displays by bezels of each one, for example. Pick-and-drop [9] was used to move an object from a display to another display. Pick-and-drop enables a user to pick up an object on a display and drop it on another display. Throwing [7] can be used to move objects across larger distances. A first short stroke is used to move an object to the opposite direction and a longer stroke is used to correct direction. Drag-and-pop [10] can be used to get distant object with minimal movement. When a user begins to drag an icon to the target icon, icons of the candidate targets are arranged in front of the dragging icon. The user can rapidly drop the dragging icon to the target icon. Vacuum [11] improved Drag-and-pop at accessing multiple objects. A circular widget to make an arc of influence was used to select a target object. The performance of Vacuum was better than Drag-and-pop for selecting multiple targets.

In this paper, we introduce interaction techniques for multiple large displays using hand gestures on u-Table.

u-Table

u-Table is a tabletop user interface for sharing multimedia data in a ubiquitous computing environment [2]. A rear-projected screen is used to display images on

u-Table. The rear-projected screen was chosen because this type of projection does not disturb images on the screen with user's hands and fingers. Most digitalized desk systems have used a front-projected screen. In such a case, hands and fingers of the users could contaminate images on the screen because of their shadows. Another point is that the rear-projected screen can be used as a diffuser which blurs the opposite image. This property can be used to recognize whether user's hands touch the screen or not without stereo cameras. Figure 2 shows various images of u-Table.

The u-Table interface is basically manipulated by fingertips. Multiple fingertips of multiple users are used to interact with virtual objects simultaneously. It can robustly and rapidly recognize users' hand gestures and physical objects using visual tags on the tabletop.

Fig. 2. Implementation of u-Table

3   Interactions

Our interaction techniques presented in this paper, 'Fetching' and 'Sending', are similar to Drag-and-Pop [10] and Vacuum [11]. Different from the conventional Drag-and-Pop or Vacuum techniques, we use hand gestures to reach objects on the
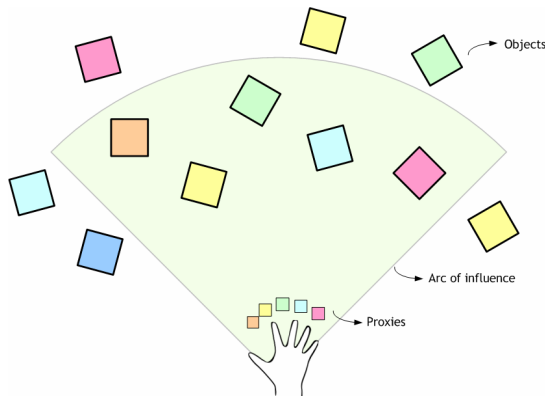

Fig. 3. Basic concept

displays instead of a pen or a mouse. Also, our method uses 'Proxies' and 'Drag Cursors' for fast interactions of fetching and sending widgets on multiple large screens.

The fetching and sending techniques are invoked by hand-gestures of drag-in and drag-out. After the drag-in hand gestures, an arc of its influence is created from the hand. The arc of the influence indicates range of accessible objects. The range can be tuned by adjusting fingers within the same gesture context.

The direction of the arc is decided by fingers of direction. Users can use all of their fingers and the direction is determined by fingers as shown in Figure 4.
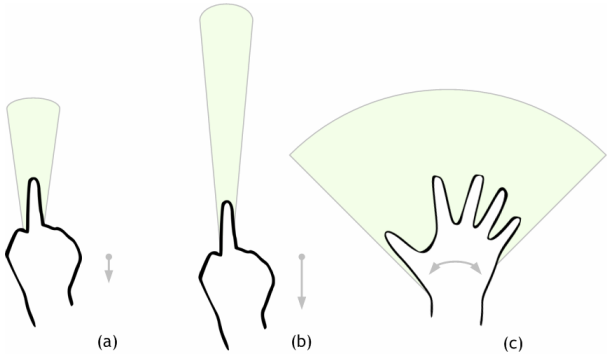

Fig. 4. Ranges set by finger gestures: (a) one finger for default (b) longer distance set by more drag-in actions by the finger (c) wider angle set by more (five in this example) fingers

The distance of the arc can be adjusted by amount of drag-in gestures. Figure 4-(b) shows that a user can set a longer range by more drag-in finger actions than 4-(a). The range can be multiplied to movement of the hand. The angle of the arc can be adjusted by angle of the hand. The angle of the arc can be changed as the number of fingers and the angle between the fingers are changed.

Proxy is a kind of hyperlink to a distant object. After a hand gesture to set an arc, objects in the arc are copied and appeared as proxies in front of the hand. The layout is similar to Drag-and-Pop and Vacuum but more convenient to hands. The proxies are laid as a shape of an arc as shown in Figure 5.
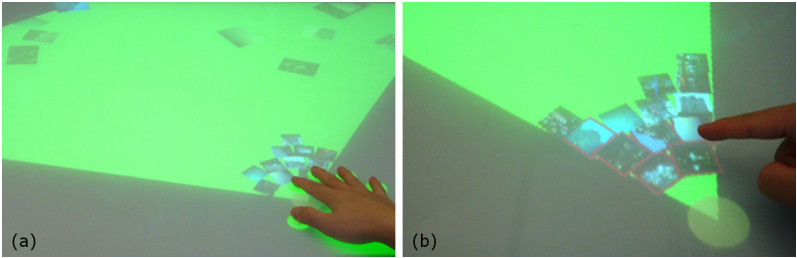

Fig. 5. Proxies: (a) Layout of proxies (b) selection of proxies by the fetching operation

The sending operation is a reverse operation of the fetching operation. It is used to move objects to a specific position on a display. The target position could be either other users or other devices on the table. The sending operation is invoked by drag-out. To indicate the position, a cursor of the target position is required. We implement the cursor using Hyperdragging [4]. The cursor is manipulated by hand gestures.

Figure 6 shows a cursor which represents a target position. Figure 6-(a) and Figure 6-(b) show process of adjusting distance by using drag-out gestures. The distance is illustrated by the cursor, the green dot at the end of the line. Figure 6-(c) and Figure 6-(d) illustrate an example of selecting range of the proxies.
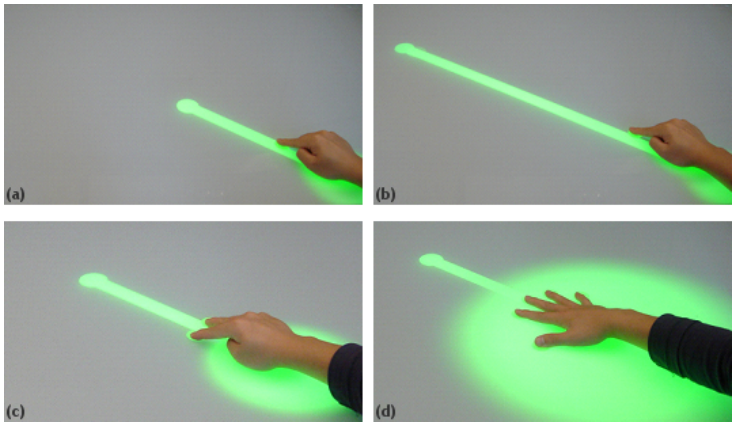

Fig. 6. Sending a widget with hand gestures

Proxies of the sending technique are selected by angle of the hand as shown in Figure 7. The user can easily adjust the position of the cursor and range of the proxies. After selection of the proxies, all of selected objects are transferred to the cursor position at once.
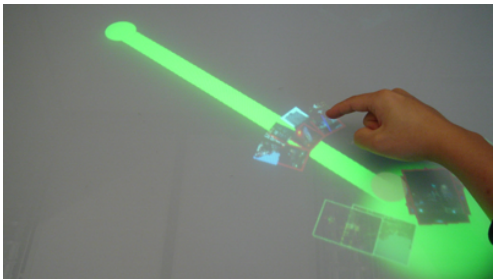

Fig. 7. Selection of proxies on sending

4   Applications

The fetching and sending techniques can be applied to various environments. In physically separated large displays, using the proposed techniques, users can easily move any object on various sized and located display even those displays are not controllable. Figure 8 shows an example of this case. A large wall display is located in front of the tabletop interface. Each display is physically separated but logically connected using these techniques. Users can fetch any object on the front display and send objects near the users to the front display as shown in Figure 8.
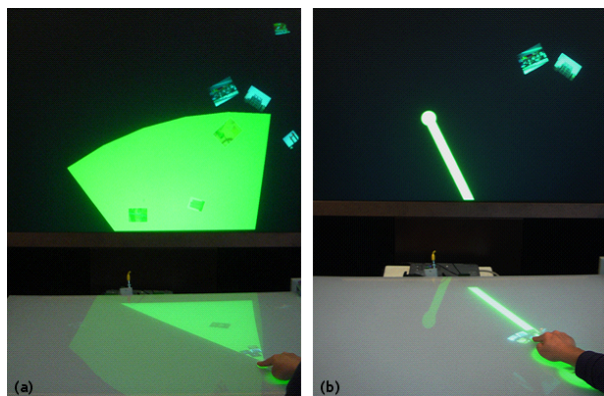

Fig. 8. Fetching and sending with multiple displays: (a) fetching objects from the front display (b) sending objects to the front display

When users want to manipulate a distant object, users can apply these techniques of fetching and sending. It is faster than physical movements, but still involves additional actions compared to the direct manipulation.

5   Conclusions

We introduce enhanced fast access techniques for distant objects. Users can easily send an object on the tabletop to another position using inertial widget. When a user wants to move entire objects, the user can use transformable tabletop. As an improvement to the inertial widget and transformable tabletop, we propose proxy-based enhancement for fetching and sending. The user can also manipulate the distant object directly using the direct manipulation technique on the proxy.

As future works, we are trying to apply the techniques to complex work processes, for example, classifying multimedia data along certain types and collaboration about data processing. We expect that our techniques can improve the performance of tabletop interfaces included large information displays environments. In addition to the proposed mechanism, we are investigating aspects of multi-user environment. In

the multi-user environment where interaction counterpart can react intelligently, the interaction metaphor could be further simplified but with more interactivity on the task.

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