Depth Based Shadow Pointing Interface for Public Displays

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Figure 1: Users' virtual shadows are overlaid on display contents. Using detected pointer (green circle), users interact with the contents.

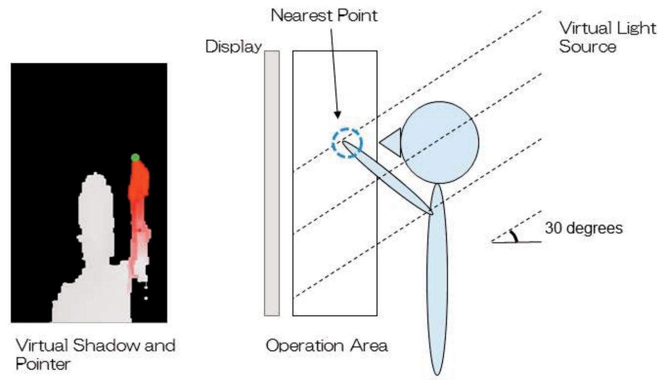

Figure 2: Our virtual shadow is generated as if there is an angled virtual sun light from behind. The nearest point to the display is interpreted as a pointer.

ABSTRACT
We propose a robust pointing detection with virtual shadow representation for interacting with a public display. Using a depth camera, our shadow is generated by a model with an angled virtual sun light and detects the nearest point as a pointer. The position of the shadow becomes higher when user walks closer, which conveys the notion of correct distance to control the pointer and offers accessibility to the higher area of the display.

Author Keywords
Large display; depth based interaction; pointing interface.

ACM Classification Keywords
H.5.2. Information interfaces and presentation: Input devices and strategies

INTRODUCTION
We demonstrate a robust pointing interface for a public display, such as digital signage. A touchless interface is effective for large display especially in the case when people cannot reach the display. Using a depth image sensor, our system shows virtual shadows of users on the displayed content and supports interaction by the shadow with a control pointer (Figure 1). A unique feature of our virtual shadow is that it is generated as if there is a virtual sun light from behind of the person (Figure 2). This makes the position of shadow becomes lower when the person is far from the display, and becomes higher when the person gets closer. This feature has benefits of awareness of distance from the display and accessibility to the higher portion of the display.

Some existing work also propose showing shadows or silhouettes of users for interaction on a large display. Multiple persons' shadows naturally provide feedback for each person's operation [2, 3]. And displaying shadows has the effect of gaining attention of others around a digital signage in a street [1].

Our shadow technique conveys a suitable distance to interact with the display content from. When users are too far from the display, no shadow is shown on the display. It can prevent users from getting outside the field of view of the sensor. We also offer a depth based pointing control, which detects the nearest point of an object from the display as the pointer. As Figure 2 shows, we defined an operation area at a certain distance from the display, and part of the

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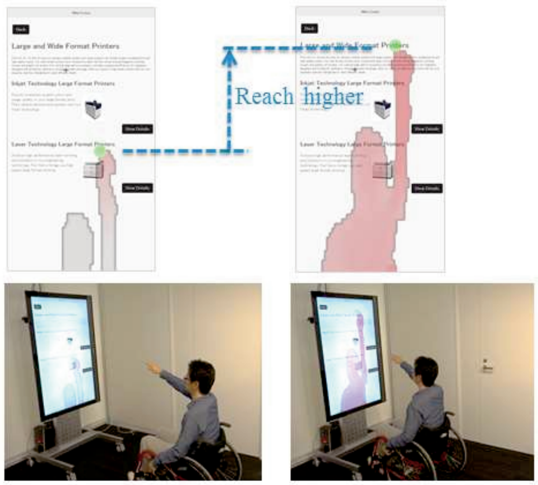

(a) (b)

Figure 1: Our shadow is displayed lower when the distance is far like (a), but gets higher when it is closer as (b). Even a short height user, like a person on wheel chair, also be able to control with the same settings.

shadow inside of the area is shown in red color. Users can notice the invisible operation area with the color. By putting a hand inside of the area, users can interact with contents using the detected pointer, which is shown as a green circle.

Our shadow has the feature that the position of shadow becomes higher when the user is closer. As Figure 3 shows, even at a low height, the user is able to reach the high parts of display by going closer. This is similar to [3], although they use a perspective light source behind the user and the shadow becomes larger when the user steps back from the display.

SYSTEM DESIGN

We implemented the shadow pointing UI to control buttons on a large display for navigating the contents.

Hardware Settings

Our display (50 inches) is setup in portrait mode. A Kinect® for Windows®[1] depth sensor is placed on it. We calibrated the 3D position and angle of the sensor. The sensor is connected to a PC, which creates and shows the shadow and control pointer on the displayed contents.

Generating Shadow

From the sensed depth image, the shadow graphic is created as following:

[Step 1] The captured depth image is converted into 3D point cloud in world coordinates by the position/angle of the sensor.

[1] Microsoft and Kinect are either registered trademarks or trademarks of Microsoft Corporation in the United States and/or other countries.

[Step 2] As Figure 2 illustrates, the 3D point cloud is transformed and projected onto display surface plane as if there is a virtual sun light from behind. The light source is angled 30 degrees from horizontal. The shadow image is vertically offset by a constant value, which is determined by a designed distance to the display.

[Step 3] The pixel color of the shadow image is determined by the distance from the display. When it is in the operation area, the color becomes red (it is gray otherwise).

[Step 4] For the pixels inside of the operation area, the closest pixel to the display becomes the pointer. A green circle pointer is added on the shadow image.

[Step 5] The shadow and pointer is transparently overlaid on the display contents.

Display Contents with Swipe Action Buttons

We created sample contents to be controlled by our shadow pointing UI. The content pages are information of products with button based navigation, which have a "Show More Details" button for each item and a "Go Back" button. Our button interprets a horizontal swipe action as a clicking event. When the pointer is placed over a button, a left or right arrow graphic is shown. Then the user moves the pointer to left/right to activate the button.

PRELIMINARY TEST AND DEMONSTRATION

We tested the system in our lab. We confirmed that users can find a correct position to interact and control the swipe button with the pointing UI easily. Our pointing detection simply takes the nearest point and worked robustly with multiple users, because it does not need human body or hand detections, which can be unstable with crowded situations.

As found in [1], a user who actively interacted is positioned in front of the display, and audiences usually stood behind her/him. Because the audiences' shadows are shown at a lower position than the interactor's, the interaction is not disturbed by the audiences' shadows. Although currently only one user can control the display at the same time, by moving closer or stepping back, changing of an interactor in groups can take place smoothly.

For our demonstration, attendees can experience shadow pointing UI with the prototype system.

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