Dart-It: Interacting with a Remote Display by Throwing Your Finger Touch

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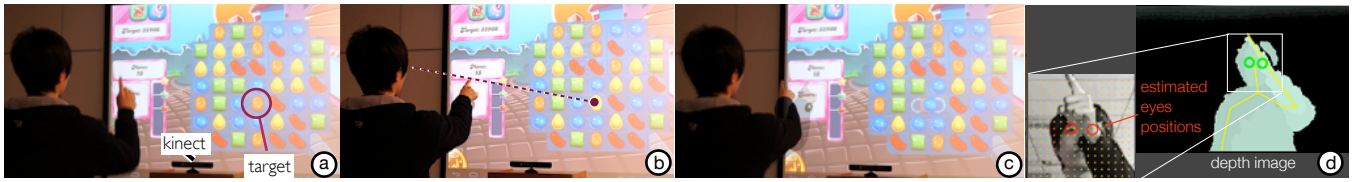

Figure 1: *Dart-It is a lightweight system that allows users to throw their finger touch to a remote display. In the matching game, a user can (a) lift his arm and (b) rapidly select a target without a cursor, and then (c) swipe to make a match. (d) Occlusion-free eye-tracking based on optical-flow.*

1 Introduction

Hand tracking technologies allow users to control a remote display freely. The most prominent freehand remote controlling method is through a body-centric cursor, e.g. Kinect. Using that method, a user can first place the cursor to a rough position on the remote display, move the cursor to the exact position, and then commit the selection by a gesture. Although controlling the body-centric cursor is intuitive, it is not efficient for novel users who are not familiar with their proprioception. Inaccurate cursor placement results in long dragging movement, and therefore causes consequent arm fatigue problems.

Perspective-based pointing [Pierce et al. 1997] is another freehand remote pointing method that allows users to select a target on a remote display by directly pointing at where they see. When a user points at an on-screen target, the remote pointing position is defined by the ray casting from the user's dominant eye to his/her fingertip. Perspective-based pointing is efficient because users are allowed to aim the target accurately with their eyes. Nonetheless, since it requires reliable face and fingertip tracking, it usually needs extra cameras and motion trackers in real-world deployment [Banerjee et al. 2012], which is too heavyweight for general usage. Hence, we present *Dart-It* (Figure 1), a lightweight system that uses only one RGBD camera to enable perspective-based remote direct-pointing on any deployed remote display.

2 Implementation

A Kinect sensor (Figure 1(a)) is used to extract the users' 3D eye positions, fingertips, as well as the skeleton information. If the user steadily points at a remote screen for a 100-ms moment, a selection can be confirmed. The short dwell time form the user a sense of "throwing" a finger touch to the position where he/she is looking at. Our main technical challenge is hand occlusion. When performing perspective-based pointing, the user's hand pointing at the remote display may occlude his/her eyes making the tracking invalid. To mitigate this issue, we designed an optical-flow-based occlusion-free eye-tracking method (Figure 1(d)). Once the occlusion occurred, our system calculates the optical flow of the user's head. Based on the skeleton information, our algorithm first excludes the background and user's occluding hand from the depth image, and then calculates the remaining pixels' optical flows, which are mainly caused by the movement of the user's head. Based on the results, we can correct the previous valid eyes' positions until the eyes are not occluded anymore.

Using GPU, the computational performance of our system is consistently at 30 fps. A 12-participant user study also indicates that, by using our method, users are able to select 13.1cm-width on-screen targets with 95% accuracy, when they were standing or sitting at arbitrary positions in 1.6m $\sim$ 2m away from the display.

3 Application: A Matching Game

We use a matching game, *Candy Crush Saga*[1], as an application to demonstrate the usefulness and possible generalization of this technique. The object of this game is to make lines of three candies by selecting one candy and swapping it toward an adjacent one. An 7×7 grid of 15cm-width targets are shown on an 100-inch 4:3 projection screen with a Kinect sensor placed on its center bottom.

In this game, a user first selects a desired target by simply lifting his arm (Figure 1(a)) and then pointing at it (Figure 1(b)), as if throwing his finger touch to the display. Once a target is selected, the user can swipe the selected target toward its adjacent one to make the match (Figure 1(c)). No cursors and additional committing gestures are required during the selection. During playing this game, the user can freely move his position or sit down for more comfortable control. The user also can further alternatively use his another hand or even bi-manually use both hands for better performance. Multiuser interaction is also supported in this game.

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References

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[1] http://about.king.com/games/candy-crush-saga/