One-Handed Interaction Technique for Single-Touch Gesture Input on Large Smartphones

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ABSTRACT

We propose a one-handed interaction technique using cursor based on touch pressure to enable users to perform various single-touch gestures such as a tap, swipe, drag, and double-tap on unreachable targets. In the proposed technique, cursor mode is started by swiping from the bezel. Touch-down and touch-up events occur at the cursor position when users increase and decrease touch pressure, respectively. Since touch-down and touch-up event triggers are different but easily performed by just adjusting the touch pressure of the thumb from low to high or vice versa, the user can perform single-touch gestures at the cursor position with the thumb. To investigate the performance of the proposed technique, we conducted a pilot study; the results showed that the proposed technique is promising for one-handed interaction technique.

CCS CONCEPTS

• **Human-centered computing → Human computer interaction (HCI)**; *Interaction techniques*; Gestural input.

KEYWORDS

cursor, thumb interaction, touch pressure, force, touch screen

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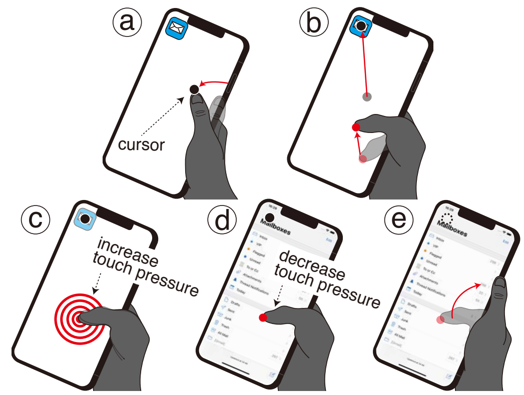

Figure 1: The proposed one-handed interaction technique. a: The cursor appears at the center of the touch area when users swipe from the smartphone bezel. b: The cursor moves when users move the finger. c/d: A touch-down/up event is generated when users increase/decrease the touch pressure. e: The cursor disappears when users release the finger.

1 INTRODUCTION

When users interact with a smartphone using only one hand without changing the grip on the smartphone, unreachable areas exist on the screen. To resolve this problem, various one-handed interaction techniques have been proposed (e.g., [1, 2, 4, 5]). However, because these techniques were designed for selecting (tapping) unreachable targets, single-touch gestures other than tap for unreachable targets have not been explored. As gestures commonly performed using one finger (referred to as single-touch gestures) on a smartphone, swipe, double-tap, and drag are often used in addition to tap.

To allow users to perform these single-touch gestures on unreachable targets, we propose a pressure-based one-handed interaction technique (Figure 1). With this technique, users can perform a single-touch gesture on unreachable targets using the cursor. Therefore, for example, users can easily access a control center, which requires a swipe from the top bezel on the smartphone, using the thumb without changing their grip on the smartphone.

2 PROPOSED TECHNIQUE

Users of the proposed technique start cursor mode by swiping a finger from the bezel (Figure 1a). When the finger is dragged across the screen, the cursor moves three times faster than the finger (Figure 1b). Touch-down events occur at the cursor position when users increase the touch pressure (Figure 1c); touch-up events occur when users decrease the touch pressure (Figure 1d). Our technique also provides haptic feedback by vibrating the smartphone when a touch-down event is generated. Cursor mode continues until the finger is released from the screen. When cursor mode ends, the cursor disappears from the screen.

Since triggers of touch-down and touch-up events are different but easily performed by adjusting the touch pressure of the thumb from low to high or vice versa, the user can perform single-touch gestures at the cursor position with the thumb. For example, if the finger is dragged at high touch pressure, a swipe or drag is performed at the cursor position; if the finger rapidly switches from high to low touch pressure, a double-tap is performed at the cursor position.

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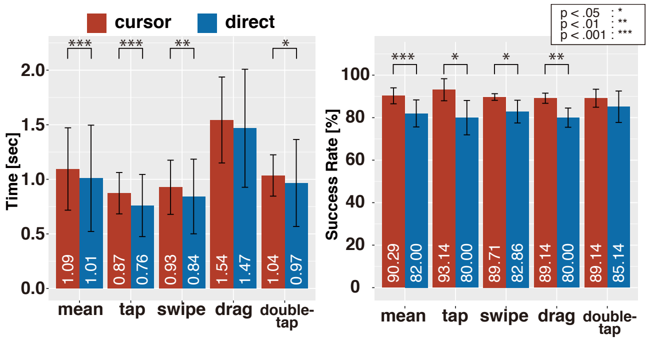

Figure 2: The results of our pilot study. For each gesture and method, the left graph shows the time, and right graph shows the success rate.

3 PILOT STUDY

To investigate the performance of the proposed technique, the first author (23 years old, right-handed, male) performed tap, swipe, drag, and double-tap actions via the proposed technique (cursor) and direct touch. The used smartphone was iPhone XS Max. The screen was divided into 180 cells (9×20) with no gaps between cells. The cell size was 7.1 mm $\times$ 7.0 mm, which is as close as possible to the Apple recommended minimum target size [3] (6.9 mm$\times$6.9 mm) for a cell layout without gaps.

For each gesture, a target was randomly selected among 175 cells, excluding the five cells in the notch area. In each session, the participant performed a single gesture 35 times; five consecutive sessions were performed for each gesture for a total of 175 performances of each gesture, once for all the cells. For the drag task, the participant dragged a target marked "S" to a target marked "G"; each cell was designated the "S" target once, in random order. The "G" target was randomly selected among 174 cells, excluding the "S" target. The participant performed all the four gestures with direct touch and then using the cursor. In total, we collected the data for 1,400 trials (1 participant $\times$ 35 trials $\times$ 5 sessions $\times$ 4 gestures $\times$ 2 techniques).

Mean times and success rates for each gesture are shown in Figure 2. Although the mean time taken to perform gestures with direct touch (1.01 s) was shorter than that using the proposed technique (1.09 s), the success rate of our technique (90.29%) was higher than that of direct touch (82.00%). We detected significant differences in both results (Welch's t-test; $p < .001$). From these results, while the proposed technique was only 0.08 s slower than direct touch, it could be more accurate than direct touch.

Mean time differences between the proposed technique and direct touch for all gestures for all cells are shown in Figure 3. Although the cursor was slower on average than direct touch, the cursor was faster than direct touch in the top left and bottom left cells, such that direct touch was faster for cells near the thumb (center of the right side), and the cursor was faster for cells that the thumb could not reach (all four corners of the smartphone).

4 FUTURE WORK

In the pilot study, only an author familiar with our technique participated. When used by experts, the proposed technique was shown to be promising as a one-handed interaction technique; however, it is unclear how long a user must practice to become familiar with

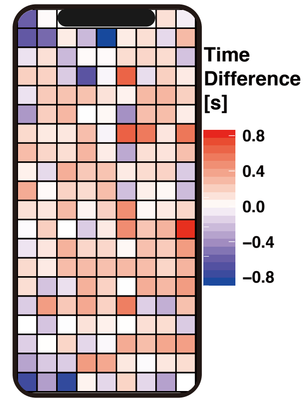

Figure 3: Time differences between cursor and direct touch for all cells. Blue fill indicates that cursor was faster than direct touch; red fill indicates that cursor was slower than direct touch.

cursor operation using the proposed technique. Therefore, it is necessary to investigate the speed and accuracy of the proposed technique among novice users.

5 CONCLUSION

In this paper, we proposed a pressure-based one-handed interaction technique using a cursor. The proposed technique allows users to perform single-touch gestures on an unreachable target using the cursor. We investigated the performance of our technique by conducting a pilot study to compare the speed and accuracy of the proposed technique with those obtained by direct touch. Our results indicate that the proposed technique is a promising one-handed interaction technique.

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