Reaching Targets on Discomfort Region Using Tilting Gesture

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ABSTRACT
We present three novel methods to facilitate one hand targeting at discomfort regions on a mobile touch screen using tilting gestures; TiltSlide, TiltReduction, and TiltCursor. We conducted a controlled user study to evaluate them in terms of their performance and user preferences by comparing them with other related methods, i.e. ThumbSpace, Edge Triggered with Extendible Cursor (ETEC), and Direct Touch (directly touching with a thumb). All three methods showed better performance than ThumbSpace in terms of speed and accuracy. Moreover, TiltReduction led users to require less thumb/grip movement than Direct Touch while showing comparable performance in speed and accuracy.

Author Keywords
Touch screen; one-handed interaction; tilting gesture

ACM Classification Keywords
H.5.2 [Information interfaces and presentation]: User Interfaces - Input devices and strategies

INTRODUCTION & RELATED WORK
Large smartphones makes some parts of the screen unreachable when interacting with only one hand. It is difficult for a thumb to reach a far-target on a large screen while maintaining a safe one hand grip of the device. Since people prefer one hand interaction even when both hands are available [2], large screen sizes introduced a new set of challenges in one hand interaction design.

There have been several attempts to address this issue. ThumbSpace [3] utilizes a miniature semitransparent space placed in a comfortable region that maps relative positions of all components in the screen. Edge Triggered with Extendible Cursor (ETEC) [4] is another approach which makes use of an offset cursor. The cursor is triggered with a bezel swipe and moves faster than thumb's moving speed, which helps reach a target outside the thumb's range.

We noted that people use the strategy to tilt the devices towards the thumb, so that a far-target gets closer to their thumbs. GripSense [1] exploited such behavior to identify the handedness of a user. We collected the magnitude of tilt when users directly touch targets on an 8x14 grid (Fig. 2), and confirmed that users actually tilt the device towards the thumb more when they have to touch targets farther away.

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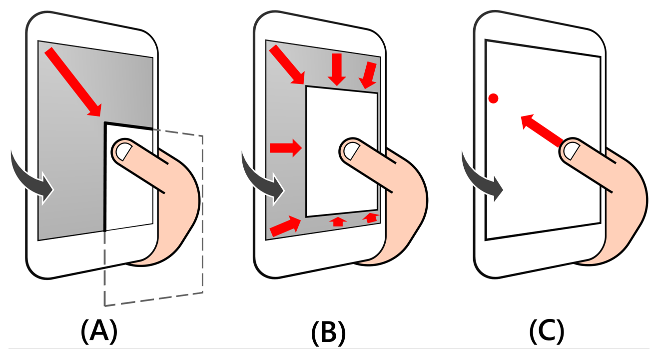

Figure 1. Three methods triggered with a tilting gesture are designed for reaching targets on discomfort regions. TiltSlide (A), TiltReduction (B), and TiltCursor (C).

ONE-THUMB INTERACTION BASED ON TILTING
We designed three novel methods for one-handed target acquisition in large smartphones; TiltSlide, TiltReduction, and TiltCursor, to be triggered by a tilting gesture.

TiltSlide (TS) When a user tilts a device, the screen slides to the tilting direction (Fig. 1A). There are eight sliding directions; right-down, right, right-up, up, left-up, left, left-down, and down. The screen slides until any of the edges hit the center of the physical screen.

TiltReduction (TR) When a user tilts a device, the screen shrinks to fit in a customized comfort region (Fig. 1B). We determined the region as a rectangle that users draw by diagonally dragging their thumb (from top-left to bottom-right) while previewing shrunk sized screen. They were allowed to draw a rectangle repeatedly until they could comfortably reach the entire rectangle whose aspect ratio is maintained to that of screen to avoid distortion.

TiltCursor (TC) While a device is being tilted, a cursor appears on the position where the user starts a swipe gesture (Fig. 1C) and it moves faster than thumb to help reaching a far-target.

STUDY DESIGN
We hypothesized that our tilting methods will be faster than ThumbSpace, since ThumbSpace needs additional cognitive effort to determine the relative position of a target on the semitransparent space **(H1).** Because the initial position of

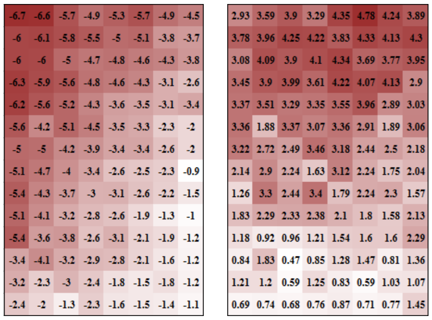

Figure 2. Gyroscope values for x-axis (left) and y-axis (right) when acquiring targets on screen. Negative values for x-axis denote tilting to the right, and positive values for y-axis denote tilting down. The darker the color, the more tilted the device.

the cursor is closer to the target compared to that of ETEC, TC will be faster than ETEC **(H2)**. TR will be less accurate than DT and TS, since it reduces the target size when whole screen shrinks to fit to the comfort region **(H3).**

We conducted a user study to evaluate the three methods against DT (directly touching with a thumb), ThumbSpace [3] and ETEC [4]. We recruited 18 participants (10 females, 8 males, average age = 24, all right-handed). Participants held a large smartphone (Samsung Galaxy Note 3 with 5.7" screen) in their right hands and performed target acquisition tasks using each of six methods for 5 trials. One trial contained 30 target acquisition tasks with targets at randomly activated regions on an 8x14 grid ($7\,mm^2$ as target size) while maintaining the same total thumb-travel distance for each trial. We used a Latin Square design for eliminating ordering effects and completed the experiment with survey questionnaires.

RESULTS AND DISCUSSION

We analyzed results using a repeated-measures ANOVA and found significant effects for task completion time ($F_{5,85} = 24.59,\ p < .01$) and error rate ($F_{5,85} = 9.65,\ p < .01$). We used Bonferroni correction for post hoc analysis.

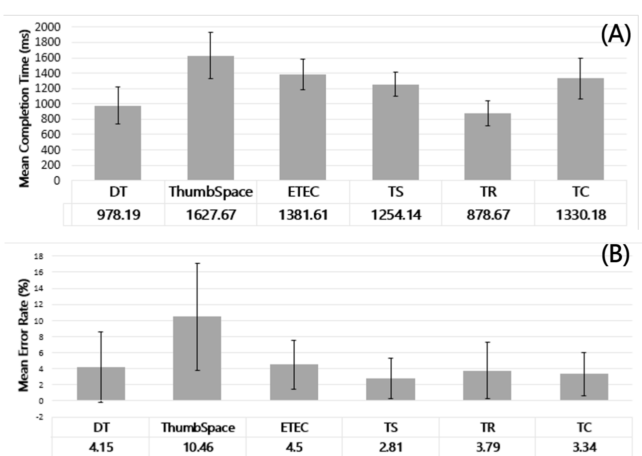

Figure 3. Mean completion time (A) and mean error rate (B) of all six targeting methods. Error bars denote standard deviation.

All three tilting methods (TC, TS, and TR) were significantly faster than ThumbSpace (all $p < .01$), confirming H1. We could not confirm H2 since TC showed no significant difference from ETEC. Other noteworthy result was that TR was significantly faster than ETEC ($p < .01$). Moreover, TR had no significant difference from DT, while other methods were significantly slower than DT. In terms of accuracy, ThumbSpace showed significantly more errors than all other methods ($p < .001$). TR did not have any significant difference compared to DT, rejecting H3.

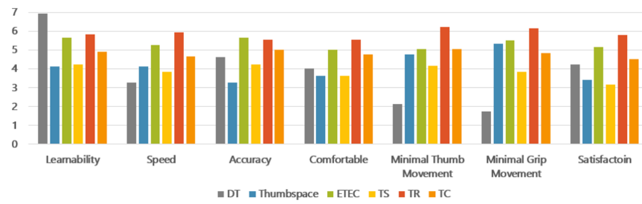

Figure 4. Questionnaire results (means)

Questionnaire results showed that TR had no significant difference from DT about learnability. In terms of thumb/grip movement, there were significant effect between DT and the other methods ($p < .001$). In summary, compared to DT, TR showed a promising result that it required less thumb/grip movement while showing comparable performance in speed and accuracy.

CONCLUSION

We proposed three methods to help reaching discomfort regions when using only one hand. We applied the tilting gesture to trigger our methods since the gesture is naturally used when reaching far-targets. We validated our methods through a user study by comparing other three related methods. All three methods showed better performance than ThumbSpace in speed and accuracy. Especially, TiltReduction led users to require less thumb/grip movement than Direct Touch without showing any significant differences in speed and accuracy.

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