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Comparison between Ring and Flicking Scrolling Techniques for Document Navigation in Touch-based Mobile Devices

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Abstract

This study is to evaluate the performance of ring scrolling and flicking scrolling techniques for document navigation in touch-based mobile devices. Three input methods, including pen input, finger input (thumb and index finger) were used to perform these two scrolling techniques. Experimental results showed that flicking scrolling performed better than ring scrolling for each of three input methods regardless of the distance between two targets or the width of the frame.

Keyword: HCI, touch-based interfaces, pen, finger, document navigation

1. Introduction

Scrolling up and down documents in mobile devices is a common task that most users perform while reading documents. In touch-based mobile devices, ring scrolling and flicking scrolling are two commonly used scrolling techniques. A number of studies were conducted to evaluate the performance of various scrolling techniques [1, 2]. However, the comparison between ring scrolling and flicking scrolling for document navigation in touch-based mobile devices has never been studied.

The purpose of this study is to quantitatively analyze the performance of flicking scrolling and ring scrolling for document navigation in touch-based mobile devices. The design of the experiment was based on how users manipulate mobile devices i.e., by thumb, by index finger, and by pen.

2. Ring Scrolling and Flicking Scrolling Techniques

Ring Scrolling. When ring scrolling, the user can scroll a document by making continuous circular movements. Ring scrolling is based on the approach proposed by Yin and Ren [2]. Vertical scrolling, up and down, can be achieved by moving clockwise or counter-clockwise, respectively.

Flicking Scrolling. Flicking scrolling allows the user to scroll a document by flicking. The document can be scrolled up and down by swiping the user's finger up and down, respectively. Meanwhile, the distance and the direction of the document movements are the same as those of the finger movement.

3. Experiments

3.1 Participants

Twelve participants (11 males, 1 female, and average age 25), 7 of them had approximately one year experience using touch-based mobile devices while the others did not have any such experience.

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3.2 Design

A Windows Mobile smart phone was used as the experimental apparatus. The experiment was a within-subjects design with three input methods: thumb, index finger, and pen input (Fig. 1). The two techniques to be compared in the experiment (flicking scrolling and ring scrolling) were counter balanced. Each block consisted of 6 trials while each trial contained 9 combinations (distance of target line (3) x frame width (3)). Each combination consisted of ten repeated phases.

The ring scrolling and flicking scrolling with each of the three different input methods were examined and compared by means of the touch-based mobile device. A Latin square was used to balance the experimental results for the same input method of each group. In brief, the design of the experiments is input method (3) x scrolling technique (2) x distance (3) x target width (3).

Fig. 1 Three input methods

In our study, we used an experimental setup similar to that used by Hinckley et al. [1]. As shown in Fig. 2, the document consisted of 288 lines with a line height of 21 pixels. The line numbers were shown at the beginning of each line. A thick vertical line was located on the left side of the text window. The width of frame covered 3, 6, and 12 lines. There were two kinds of target lines, blue and red target lines of the same 21 pixels height. Additionally, the distances between the blue and the red target lines were 20, 60, and 200 lines.

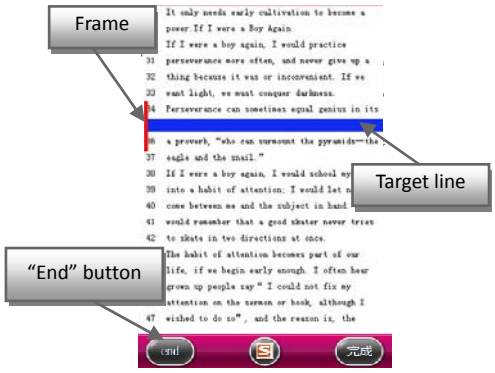

Fig. 2 Experimental interface

3.3 Procedure

Prior to conducting the experiment, all participants were required to understand the instructions and to become familiar with the experimental setup and tasks by taking short practice runs for each of the two scrolling techniques with all conditions and the three input methods. The participants were required to move the document up and down vertically between the two targets. They had to click the end button at the lower left corner of the mobile device when the target line had been moved into the frame. The participant did the experiment in two blocks with at least one hour rest after finishing the first block. In total, the participant spent approximately 150 minutes to complete the experiment.

4. Results

Repeated measures ANOVA showed that for each input method, scrolling technique had a significant main effect on movement time, $F(1, 11) = 40.78$ for pen, $F(1, 11) = 196.19$ for index finger, $F(1, 11) = 115.43$ for thumb, all $p < 0.001$..Fig. 3 shows that for each input method flicking scrolling always led to shorter movement time than ring scrolling. Also, Repeated measures ANOVA showed that for each technique, input method had a significant main effect on movement time, $F(2, 22) = 31.66$ for flicking scrolling, and $F(2, 22) = 23.71$ for ring scrolling, all $p<0.01$. As illustrated in Fig.3, for flicking scrolling, two-handed input produced shorter times than the other two input methods, and for ring scrolling, pen input resulted in shorter times than the other two input methods.

As one would expect, for each of the three input methods, movement time increased as distance between targets increased, $F(2, 22) = 59.745$ for flicking scrolling, and $F(2, 22) = 147.86$ for ring scrolling, all $p<0.01$. As illustrated in Fig. 4, the index finger input produced larger movement times than the other two input methods as distance between targets increased. On the other hand, for each input method, movement time increased as width of frame decreased, $F(2,22) = 776.124$ for flicking scrolling and $F(2,22) = 662.105$ for ring scrolling, all $p<0.01$.

Regarding subjective evaluation, participants were asked to finish a questionnaire after the experiment. It was found that most of the participants did not like one-hand input; they stated that it was tiring to perform the task with this input method.

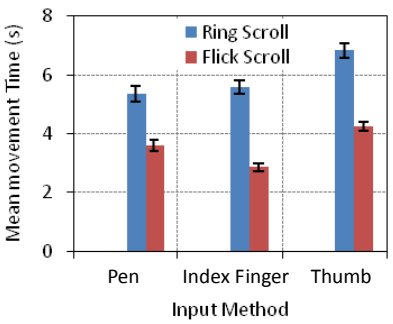

Fig. 3 Mean movement time for each of three input method for two scrolling techniques. Error bars represent 0.95 confidence interval.

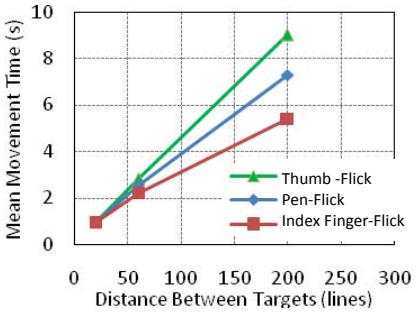

Fig. 4 Mean movement time for each distance between targets (D) using flicking scrolling technique.

5. Discussion

This paper presents a quantitative analysis of flicking scrolling and ring scrolling with three different input methods on a touch-based mobile device.

Based on experimental results, flicking scrolling was found to be more efficient than ring scrolling for each of the three input methods regardless of distance between two targets and regardless of the width of frame. This might be because users can flick the finger or the pen more comfortably than they can draw a circle on the screen.

In ring scrolling, pen input performed better than thumb and index finger input. It seemed that when drawing circles on the screen, participants felt more comfortable with the pen than with the finger. This was due to the fact that drawing a circle on the screen with the finger was hindered by the friction between the screen and the finger. By flicking scrolling, index finger input had better results than thumb input and pen input. This was because it is more comfortable to flick the index finger on the screen than to move the thumb, despite the occurrence of friction between the screen and the finger. All participants also complained that the thumb input method made them more tired compared to other input methods. In the case of pen input, users needed to move their hands to move the pen on the screen which required more energy and made them more tired compared to the index finger input method.

This study provides an insight for document navigation UI design in touch-based mobile devices. As there are plenty of factors that can influence scrolling performance, we would like to conduct future experiments to discuss the effect of postures, such as walking or standing.

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