Usability Evaluation of Flicking Gesture Area for Effective Page Shifting of a Smart Phone

Sangeun Lee¹, Kimin Ban¹, Jiwon Jung², Eui S. Jung¹
¹ Department of Industrial Management Engineering, Korea University, Seoul, Korea
² Business School, Korea University, Seoul, Korea
sangeun89@korea.ac.kr

Abstract
The recent improvement of wireless communication technology has triggered an increase in the frequency and diversification of the information process through smart-phones. Accordingly, interest in the efficient page shifting process based on user convenience is increasing. This study focuses on the use of the flicking gesture to derive the efficient touch area that reflects the features of the individual finger input when user shifts pages. The experiment was conducted with 4 types of alternatives obtained from a full factorial design according to four degrees of difficulty level (3.58/4.64/5.66/6.68). The dependent variables were used to measure completion time and error rate. And the subjective variable was measured with the comfort level of experiment participants. For the testing apparatus, Apple’s I Phone 5S was used. The results showed that significant differences with respect to the alternatives and page shift methods through SNK post hoc analysis differed greatly. For the analysis, ANOVA was used, and optimal proposal was derived. As a result this study suggests a practical approach that is necessary for designing an efficient page switching method on the touch interface.

Keywords: Flicking, Flicking gesture, Touch interface, Efficient page designs

Introduction
Recently, mobile devices based on touch interface such as smartphones and tablet PCs are quickly distributed to users. Touch interface has an advantage of providing simple and fast interaction among users because users can manipulate the interface more intuitively, using their fingers [1].

Some weaknesses of the touch interface are its limited display space and input method [2]. In order to overcome these weaknesses, multiple input methods such as Scrolling, Paging, List, and Grid make various information appear on a limited space. Moreover, various display methods such as Tap, Double tap, Hold (press), Flick, Drag & Drop, Pinch & Spread are used to overcome the limits of input method.

Many studies suggest intuitive interface [3]. An intuitive interface means a natural interface based on user experience through touch and gesture, considering the characteristics of human nature and body convenience. And among touch gestures using the finger, flicking gesture is most preferred [4]. Flicking gesture means when the user swipes the touch screen into a certain direction with the finger, the screen changes accordingly to that direction. [5] Page shift using flicking gestures has a working capability 26% faster than page shift using icons, and is an effective page shift method that better reflects user experience. However, smartphones with the current capacitive touch screen recognize the center point of touched area as the actual touched area, resulting more errors in relatively small control areas. This is because the touched area on the touch screen becomes bigger due to the softness of users’ skin. Figure 1 illustrates a feature of finger input.

Previous studies on existing flicking show that for many page shift methods in mobile devices using touch screen such as web browser, music list, contact list, settings, and text messaging, flicking similar to dragging is preferred. Therefore, in this study we investigate using behavior based on user characteristics [7], touch distance and time using flicking gestures in smartphone interaction [8], evaluate user satisfaction on flicking gestures and satisfaction on optimal flicking time interval. Recently, a study predicting human performance on the touch screen through GOMS model was published [9]. However, studies on touch area design for page shift based on usage assessment (i.e. task completion time, error rate) have not yet been sufficiently developed.

For that reason, this study focused on reflecting user input features and developing a more effective control area when it comes to page shift in smartphones using flicking gestures.

Method
Participants
A total of 12 people, 6 men and 6 women, participated in the experiment whose age is between 24 to 29 years old. They had on average 2 years of experience with mobile touch screen device and smartphones. All the participants had no problem with hand and arm muscles.

Figure 1. Finger input character on touch screen (adapted from [6])
Apparatus
For the apparatus, an iPhone 5S was used. iPhone 5S has a capacitive touch screen of 1135 * 640 pixels. Apple’s X-code was applied to create 4 alternatives, derived from completely factorial design, in relation to levels for each page shift type. Figure 2 shows the experiment apparatus.

![Figure 2. Experiment apparatus (Apple’s iPhone 5S)](image)

Experiment Design
An independent variable was set according to the page shift level. Page shift means the shift of page depth and breadth. It is divided into edge control for shifting between pages (depth change) and center control for shifting inside pages (breadth change).

Independent variables were calculated from the ID through the Fitts's law. Fitts's law is the scientific law that predicts the time required to rapidly move to a target area is a function of the ratio between the distance to the target and the width of the target. [10] Fitts's law is used to model the act of pointing, either by physically touching an object with a hand or finger, or virtually, by pointing to an object on a computer monitor using a pointing device.

For the definition of distances, the one side of the seat width (width change) and 10.1mm horizontal flicking gesture in terms of length, with an average distance of 125 pixels needed (total horizontal width: 51.7mm, 640-pixel basis) were set and the degree of difficulty was measured equidistant intervals. Table 1 shows the independent variables of this experiment.

| Table 1. Independent variable |
|-------------------------------|
| Independent Variable          | ID  | Level (mm) |
| Level (Unit: Bits)            | 1.47| Width 5.7  |
|                               |    | Distance 10.1 |
|                               | 1.96| Width 3.5  |
|                               |    | Distance 10.1 |
|                               | 2.48| Width 2.0  |
|                               |    | Distance 10.1 |
|                               | 2.95| Width 1.5  |
|                               |    | Distance 10.1 |

Table 2. Dependent variable

| Dependent Variable | Detail |
|--------------------|--------|
| Objective Measures |        |
| Total Time (S)     | The total time to perform tasks for each alternative. |
| Error Rate (%)     | Total error rate that occurs when performing tasks for each alternative. |
| Subjective Measures| Discomfort (7 point - Likert - scale) Subjective discomfort feeling when task performing. |

Table 2 shows the dependent variables of this experiment.

Among dependent variables, task completion time and error rate were selected with objective measures, and discomfort was selected with subjective measures. Task completion time is the total amount of time spent on operating each alternative, and error rate is the total error occurred while operating tasks for each alternative. Discomfort, one of the subjective measurements, was assessed using 7-point Likert scale. With 1 being no uncomfortable and 7 being the most uncomfortable.

Based on 4 levels of difficulty of page shift type, a total of 8 experiment alternatives were constructed. Participants were given 2 screens, and conducted a total of 16 experiments. The experiment was presented once with either direction and once with random direction on the two-way task. Figure 3 shows tasks for the experiment.

![Figure 3. Experiment task](image)

Experiment Procedure
There were four steps in this experiment; preparation stage, practice stage, experiment stage, and evaluation stage. In the preparation stage, participants were informed of the purpose and procedure of the experiment, and instructions. In the practice stage, participants were given the opportunity to practice enough in order to eliminate contamination from the learning effect. In the main experiment, alternatives of the experiment and tasks on the handle were randomly presented in order to remove contamination from the procedure sequence or the handle. Finally, in the evaluation stage, participants evaluated their subjective discomfort on different tasks. There was a short break of 30 seconds after each alternative.
Results

Task completion time

The result of ANOVA as for total task completion time of page switching type shows significant difference in level of difficulty (P<0.001) with the level significance being 0.05 Student-Newman-Keuls (SNK) post hoc analysis was conducted in order to check the differences in response among difficulty levels as to performance completion time. The group which took the shortest time was 1.97 bits, 1.47 bits and 2.48 bits for 7.692, 8.124 and 8.6304 sec, respectively. 2.95 bits took 9.527 sec, recording the longest time.

Accordingly, the case which had width of flicking touch area from 2.2mm to 5.7mm had shorter shifting time than the one with its width as wide as 1.5mm. The result of SNK post hoc analysis as to total task completion time is shown at figure 4.

Error rate

As the result of ANOVA as to total error rate of page shifting type, show significant difference in degree of difficulty (P<0.001) at the level significance of 0.05. Student-Newman-Keuls (SNK) post hoc analysis was conducted in order to check the differences in response among difficulty levels as to total error rate. The group with less mistypes recorded 2.48 bits for 2.039 % and 1.97 bits for 2.069% and the group with the most mistypes recorded 2.95 bits for 3.125 % and 1.47 bits for 3.492%. Accordingly the case which had width of Flicking touch area from 2.2mm to 3.5mm had higher accuracy than the one with its width narrower than 1.5mm and wider than 5.7mm. The result of SNK as to total error rate is shown at figure 5.

Discomfort

The result of ANOVA as for total task completion time of page shift type shows significant difference in degree of difficulty (P<0.001) at the level significance of 0.05. Student-Newman-Keuls (SNK) post hoc analysis was conducted in order to check the differences in response among difficulty levels as to total task complete time. As a result of SNK, as the group which had the shortest completion time, 2.48 bits recorded 6.462 point, 1.97 bits 7 point thus having the lowest discomfort and 1.47 bits recorded 8.769 point, 2.95 bits 9.385 point as having the highest discomfort. Accordingly, the case which had width of flicking touch area from 2.2mm to 3.5mm had lower discomfort than the one with its width narrower than 1.5mm and wider than 5.7mm. The result of SNK as to total discomfort is shown at figure 6.

Discussion and Conclusion

This study analyzed the speed, accuracy, and subjective discomfort of page shift in order to figure out the effective gesture area that reflects the input feature of our fingers when shifting pages in smartphones by using flicking gesture. According to ANOVA, the change of difficulty based on the type of page shift showed statistically meaningful effect on three dependent variables time taken to complete the page shift, error ratio, and conversion inconvenience.

Page shift by using flicking gesture in smartphones can be categorized as inter-page shift for depth change and intra-page shift breadth change. Therefore, for more practical approach, integrated analysis is required rather than respectively analyzing each variable. In this study, we have conducted integrated analysis of the types of page shift using dependent variables. As a result, flicking gesture area which is 2.2mm wide was faster in page shift than the flicking gesture area which is 1.5mm wide. Flicking gesture area with width of 2.2mm~3.5mm was more accurate than that with width less than 1.5mm or more than 5.7mm. Moreover, width of 2.2mm~3.5mm also showed less inconvenience than the flicking gesture area with width less than 1.5mm or more than 5.7mm. If the flicking gesture area is narrower than 1.5mm, error and inconvenience in inter-page shift for depth change were shown to be high.
Therefore, considering these results, flicking gesture area with width of 2.2mm~3.5mm turned out to be the most effective. Figure 7 shows the effective flicking gesture area.

![Effective Flicking Gesture Area](image)

Figure 7. Effective flicking gesture area

This study categorized page shift using flicking gesture as inter-page shift for depth change and intra-page conversion for breadth change, and has taken into account both page conversions. A limitation of the study is that it did not consider the frequency of page conversions and different sizes of smartphones, which can affect the effective flicking gesture area. Hence, further studies should include analysis on users’ frequency of page conversion and different sizes of smartphones.

References

[1] Lee J. and Lee D.: Effect of mapping functions for one-handed flicking on a touch-screen phone, Journal of the Korean Institute of Industrial Engineers Autumn Conference, 23-32, 2011
[2] Kim H.: Guidelines for Satisfactory flick performances in touch screen mobile phone, JESK (Journal of Ergonomics Society of Korea) 29, 541-546, 2010
[3] Tajika J.: Intuitive page-turning interface of e-books on flexible e-paper based on user studies, Proceedings of the 16th ACM international conference on Multimedia, 793-796, 2008
[4] Aliakseyeu D. and Irani. P: Multi-flick an evaluation of flick- based scrolling techniques for pen interfaces, In Proc, Press 1689-1698, 2008
[5] Kane and Haun K.: Making mobile touch screens accessible to blind people using multi-touch interaction techniques, In Proceedings of the 10th international ACM SIGACCESS conference, 73-80, 2008
[6] Lim Y. and Jung E.: Analysis of Touch Interaction for the Control of Smart Phones", The 15th Japan-Korea Joint Symposium on Ergonomics, Nihon University, Chiba Japan, June 1, 2013
[7] Lim J. and Rye T.: Comparing Elder Users" Interaction Behavior to the Younger, JESK (Journal of Ergonomics Society of Korea) 31.2, 413-419, 2012
[8] Kim J. et al.: A Research on distance and time of touch for Flick function in touch phone Interaction, Korea HCI, 586-589, 2010
[9] Choi et al.: Extracting Flick Operator for Predicting Performance by GOMS Model in Small Touch Screen, JESK (Journal of Ergonomics Society of Korea) 32.2, 179-187, 2013
[10] Johnny Z., Shumin.A: More than dotting the is foundations for crossing-based interfaces, Proceedings of ACM CHI 2002 Conference on Human Factors in Computing Systems, 73–80, 2002