Development of a two-step touch method for website navigation on smartphones☆

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ABSTRACT

The touch method for hyperlink selection in smartphones can often create usability problems because a hyperlink is universally smaller than a finger contact area as well as visually occluded by a finger while pressing. In this study, we developed a two-step touch method (called *Press and Flick* method) and comprehensively examined its effectiveness using the goals, operators, methods, and selection rules (GOMS) model and user testing. The two-step touch method consisted of finger press and flick motions; a target hyperlink was selected by a finger press motion, and a finger flick method was subsequently conducted for error correction if the initial interaction (press) failed. We compared the two-step touch method with the current touch method through the GOMS model and user testing. As a result, the two-step touch method was significantly superior to the current touch method in terms of error rate and subjective satisfaction score; however, its superiority in terms of number of interactions and touch time was vulnerably affected by error rate. The two-step touch method developed in this study can improve the usability and user experience of website navigation using smartphones.

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1. Introduction

Use of the internet through smartphones has become more common in modern times. The proportion of smartphone users has approximately reached 50% of total mobile phone users; it continues to increase even now (Wikipedia, 2013a; Korea Communications Commission, 2013). Also, 77% of smartphone users access the internet every day, and 51% prefer to use the internet through a smartphone instead of a personal computer (Korea Internet and Security Agency, 2011). Thus, using the internet through mobile phones may be considered a part of daily life among smartphone users (Ericsson, 2011).

Three interaction methods using a finger are commonly employed for website navigation through smartphones (Wikipedia, 2013b; Negulescu et al., 2012). The *Touch* method uses a finger to press a hyperlink displayed on a touch-screen. The *Swipe* method moves a website along with the trace of a finger swiping motion. Lastly, in the *Pinch* method, the thumb and index fingers are typically used in order to zoom in (pinch open) or out (pinch closed) on a website. Thus, these three interaction methods are strongly tied up with advance of usability and user experience design for smartphones (Jung and Jang, 2013).

However, many researchers argue that the touch method may likely impede a smartphone's usability for website navigation, due to the small size of a hyperlink and lack of an immediate error correction process. On average, the hyperlinks are too small to touch, so they are easily occluded by a finger (Vogel and Baudisch, 2007). Also, the finger contact location is not informed specifically before pressing the touch-screen (Albinsson and Zhai, 2003; Benko et al., 2006). Thus, after touch errors, a user must return to the original website without any given intervention for error correction and perform the touch motions repetitively in order to select the intended hyperlink. In order to avoid these inconveniences, a user must pay more attention to perform the precise interaction, which may result in mental stress.

To improve the usability of the touch method, many researchers have introduced new interaction methods employing a cursor. *Bubble Cursor* (Grossman and Balakrishnan, 2005) formed a circle encompassing a finger contact point and helped a user choose one target close to the centroid of the circle. *Take-off Cursor* (Potter et al., 1988) provided a crosshair cursor above a finger contact point and allowed a user to select a target by moving the cursor. Lastly, *Shift*

Cursor (Vogel and Baudisch, 2007) placed a copied image of the screen occluded by a finger above a finger contact point and allowed a user to select a target by moving a cursor on the copied image.

The abovementioned interaction methods have pros and cons in terms of touch accuracy and time. Bubble Cursor improves touch speed by reducing a user's mental load from a precise interaction; however, it may unintentionally activate the object near the target. Take-off Cursor and Shift Cursor greatly improve touch accuracy; however, the touch time increases dramatically because they require a subsequent task to locate a cursor to a target (Vogel and Baudisch, 2007).

The GOMS model and user testing can be applied simultaneously for the comprehensive evaluation of a mobile interaction method. The GOMS model can qualitatively analyze the characteristics (e.g., action sequence) of user interaction as well as quantitatively predict the execution time for each operator (Rose and Bearman, 2014; Kim and Myung, 2013; Hamilton and Clarke, 2005; Chi et al., 2000; Chi and Chung, 1996). Despite its strengths, learning effect, error rate, or subjective response cannot be analyzed through the GOMS model (Hochstein, 2002; Olson and Olson, 1990). On the other hand, user testing is popularly used to measure task completion time, error rate, and subjective responses by an experiment (Jung, 2014; Wu et al., 2014; Bergstrom et al., 2013). However, user testing cannot determine the analytical characteristics or execution time for a unit interaction (e.g., mental act) which are helpful for understanding the nature of interaction. Therefore, a combination of the GOMS model and user testing can create synergy, and be useful for evaluating comprehensive aspects of an interaction method.

In this study, we developed a two-step touch method for smartphone website navigation, and examined its performance based on the combination of GOMS model and user testing. The new touch method was developed by analyzing users' website navigation behaviors while using smartphones. The new touch method consisted of two sequential interactions of *Press* and *Flick*: 1) a target hyperlink was selected by a finger press motion, and 2) a finger flick motion was subsequently conducted for error correction if necessary. We comprehensively examined the effectiveness of the new touch method through the GOMS model and user testing, and compared it with the current touch method.

2. Development of a two-step touch method

A two-step touch method was developed according to the following three steps: 1) observation of user behaviors, 2) characteristic analysis of user behaviors, and 3) design of a new touch method. In the first step, we observed user behaviors while navigating mobile websites for 10 min with their own smartphones. Ten college students (female: 5 and male: 5) participated in this step, and their mean age was 23 years (SD: 2).

In the second step, three characteristics of the current touch method were determined based on the visual observation in the first step. First, the number of touch errors increased as the size of a target hyperlink shrank. Secondly, a touch time elongated as the size of a target hyperlink shrank, since a small hyperlink required more precise interactions. Thirdly, most of the touch errors occurred due to touching a neighboring hyperlink of the target.

In the third step, we designed a press and flick method (hereafter, PF) in order to reduce 1) the touch error and 2) the mental load resulted from a small hyperlink. The PF consisted of the two interactions, press and flick (Fig. 1). In the initial interaction, a user pressed a target hyperlink with a finger. If the user accurately selected the target, then they would release his/her finger; otherwise, the user flicked his/her finger toward the target to reselect. Therefore, the subsequent interaction (flick) can provide an effective restoration when a user mistakenly presses a neighboring hyperlink of the target.

3. GOMS analysis

3.1. GOMS model

We used three categories of the GOMS operators (physical operator, mental operator, and system operator) in order to analyze
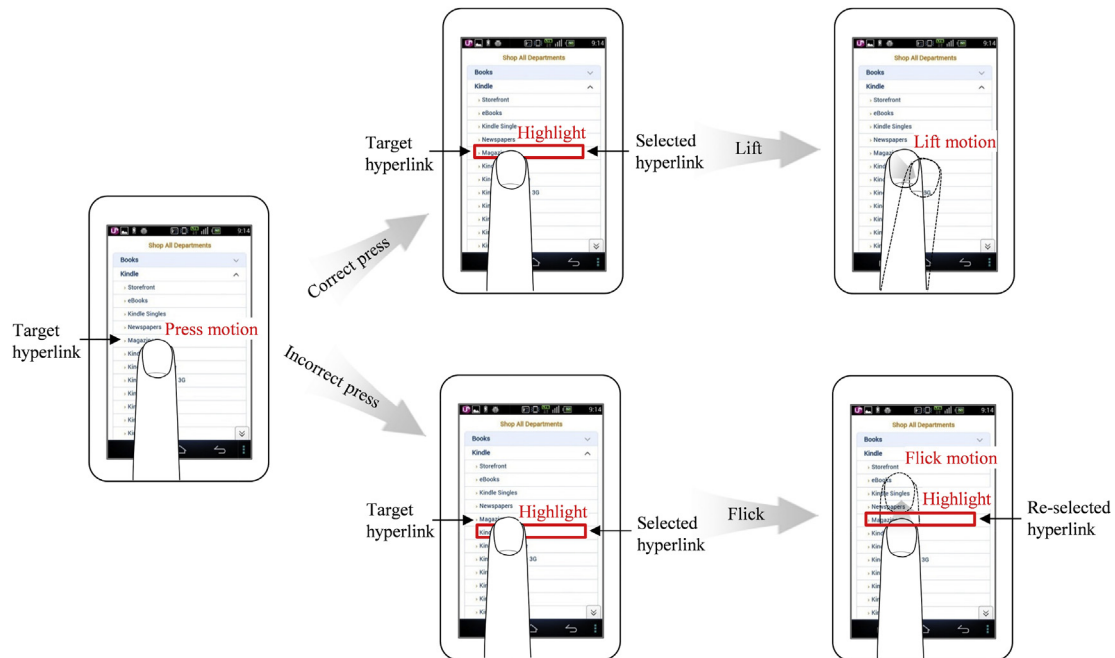

Fig. 1. Illustration of touch interactions using the two-step touch method (A user presses a target hyperlink with a finger. If he properly selects the target, then he lifts his finger; otherwise, he flicks his finger in the direction of the target).