Applied Ergonomics 52 (2016) 232–241

Contents lists available at ScienceDirect

Applied Ergonomics

journal homepage: www.elsevier.com/locate/apergo

Using analytic network process for evaluating mobile text entry methods

Lanndon A. Ocampo [a, *], Rosemary R. Seva [b]

[a] Department of Mechanical Engineering, University of San Carlos, Cebu City, 6000 Cebu, Philippines
[b] Department of Industrial Engineering, De La Salle University, 2401 Taft Avenue, Manila, Philippines

ARTICLE INFO

Article history:
Received 9 June 2014
Received in revised form
8 May 2015
Accepted 26 July 2015
Available online 10 August 2015

Keywords:
Text entry method
QWERTY
Analytic network process

ABSTRACT

This paper highlights a preference evaluation methodology for text entry methods in a touch keyboard smartphone using analytic network process (ANP). Evaluation of text entry methods in literature mainly considers speed and accuracy. This study presents an alternative means for selecting text entry method that considers user preference. A case study was carried out with a group of experts who were asked to develop a selection decision model of five text entry methods. The decision problem is flexible enough to reflect interdependencies of decision elements that are necessary in describing real-life conditions. Results showed that QWERTY method is more preferred than other text entry methods while arrangement of keys is the most preferred criterion in characterizing a sound method. Sensitivity analysis using simulation of normally distributed random numbers under fairly large perturbation reported the foregoing results reliable enough to reflect robust judgment. The main contribution of this paper is the introduction of a multi-criteria decision approach in the preference evaluation of text entry methods.

1. Introduction

Amplified market competition and the rapid progress of mobile technology enable advanced applications such as web browsing, electronic mail messaging, gaming, computing and advanced media services to be incorporated with the basic call and text messaging services in mobile phones. With the increasing number of functions in a phone maintaining an acceptable level of usability is a constant challenge. While product-related design requirements (e.g. basic requirements, physical characteristics, technical features) are widely studied in usability literature, user-related criteria (e.g. functionality, brand choice, customer excitement) are equally considered as part of design decisions (Isiklar and Buyukozkan, 2007).

In designing mobile phones the choice of text entry method is crucial for efficiency and satisfaction of the users. Latest designs of mobile phones allow users to select the preferred text entry method. The choice of method is relevant for creating text messages and other auxiliary services such as searching on the internet, calendar entries, tweeting and other social media. Text messages using SMS that are sent daily are known to be at the order of 1×10^{12} (Bin, 2006). In the Asian region, text messaging draws its success in Singapore, Malaysia and the Philippines (Balakrishnan and Yeow, 2008). This motivated a vast area of research in mobile text entry over the years (Dunlop and Masters, 2008).

Design issues in the area of text entry method include input speed, accuracy, physical form, learning time and cost (Green et al., 2004). Koivisto and Urbaczewski (2005) claimed that these issues could be grouped into two types of usability measurements: performance measurements and preference measurements. The former gathers quantifiable metrics to measure system performance typically that of speed and accuracy while the latter explores subjective preferences and opinion data, which may include physical form or aesthetics, learning time and cost that vary with individual judgments. While performance measurements provide quantifiable basis in design decisions, preference measurements are hardly explored due to the subjectivity of end-users' decision-making despite of their relevance in evaluation (Isiklar and Buyukozkan, 2007). When preference measurements become relevant in design decisions, several criteria must be brought into context. Preference evaluation is highly associated with user experience (UX) evaluation that encompasses user's interaction with a product including perception, feelings, and thoughts (Albert and Tullis, 2013). Furthermore, this is also related to the satisfaction

* Corresponding author.
E-mail addresses: don_leafriser@yahoo.com (L.A. Ocampo), rosemary.seva@dlsu.edu.ph (R.R. Seva).

http://dx.doi.org/10.1016/j.apergo.2015.07.022
0003-6870/

dimensions emphasized by international standards (ISO, 1997) that require subjective measures. MacKenzie and Soukoreff (2002) highlight the importance of preference or subjective measures in addressing broad but highly relevant issues in loosely generated answers. However, MacKenzie and Soukoreff (2002) caution that unless qualitative analyses pass through rigorous empirical validation, results may fail to be reproducible and generalizable. Most scholars tend to construct statistical analyses in exploring preference measurement studies. For instance, Hsiao et al. (2014) provided an empirical evaluation of four miniature keyboards by way of measuring objective and subjective rating using statistical analysis. These intangible issues, such as comfort, ease of use, subjective impression, are often multi-dimensional and qualitative which definitely pose difficulty and complexity in the evaluation process.

This work highlights a methodology in evaluating text entry methods in mobile phones in the context of preference measurements. Since such evaluation requires multiple criteria such as distance between keys, arrangement of keys, number of keys, sizes of keys, popularity and familiarity of users, with inherent interrelationships, a multi-criteria decision method (MCDM) was used. MCDM had been used as methodology in mobile text entry research in particular (Hsiao, 1998; Lin and Hwang, 1999; Isiklar and Buyukozkan, 2007; Chen et al., 2009; Delice and Gungor, 2009; Hsiao et al., 2010). Current approaches in performance evaluation of text entry methods published in literature typically involve the use of Fitts' law (Fitts, 1954), and in some cases an extended Fitts' law that incorporates Hick-Hyman law (Kim and Myung, 2013), to explore speed performance of a method. On the other hand, accuracy performance evaluations rely on the minimum string distance (MSD) method (Koivisto and Urbaczewski, 2005; Soukoreff and MacKenzie, 2001) and the keystroke classification method (KSM) (Koivisto and Urbaczewski, 2005). When speed and accuracy are incorporated with preference measures such as popularity and familiarity of users, little is known on how to integrate objective and subjective results. For instance, the evaluation of Hsiao et al. (2014) using both objective and subjective measures offers separate analysis on these two measures and lacks an aggregated measure that best describes the overall evaluation. Furthermore, exploring the interrelationships of these criteria present in real-life scenario, to our knowledge, has not been accomplished in current literature.

This paper aims to present a platform for evaluation that captures objective and subjective criteria in a robust and reliable process. This study attempts to develop a decision framework which is sufficiently general that could be applied to other evaluations with similar settings. This preference evaluation is significant to fill in our understanding on the role of subjective measurements on the selection of text entry methods. Consequently, gaining insights on these measurements is fundamental to both researchers and practitioners. The contribution of this study is on evaluating text entry methods in the presence of subjective measures in a multi-criteria decision context.

2. Literature review

2.1. Text entry methods

As mobile phones converge to touch screen designs and virtual keypads (Park and Han, 2010), various text entry methods are introduced in the market such as the multitap (M), multitap with disambiguation (MD), qwerty keypad (QW) and handwriting recognition (HR) (Curran et al., 2006). In multitap, one must press one to four times to obtain the desired character. For instance, one must press the number 8 three times for the letter “v” to appear on screen. Such method is relatively slow compared to other input methods. This method on average requires 2.034 keystrokes per character when entering English text (MacKenzie, 2003).

A slightly developed version of Multitap is the T9 technique for disambiguation (MacKenzie, 2003). In this method, users press once on the number representing the letter of interest. The T9 technique then displays the word or words which appropriate the sequence of letters being pressed based on the frequently used words in the English language. It minimizes the number of keystrokes required for a given word compared to the traditional Multitap. However, one shortcoming of the T9 technique is the possibility of appearance of more than one word that goes with the text. T9 technique does not also recognize other languages except the English language.

QWERTY designs, on the other hand, mimic and miniaturize desktop computer keyboards. Keys are pressed once for the desired character. This makes QWERTY performance fast. However, compared to Multitap, QWERTY has more number of keys to display on screen, which naturally reduced key sizes. As such, users have a tendency to make mistakes by tapping on adjacent keys.

Designers had also explored handwriting as text input in order to give more freedom to the user. There are two types of handwriting recognition: the clustered handwriting and the free handwriting. These handwriting recognition styles are embedded in a number of smartphones distributed worldwide (e.g. Samsung™ smartphones). In the clustered handwriting, the keypad is clustered into 4 boxes as in Fig. 1a.

Users write in the upper two boxes (left-hand and short-hand) for alpha texts. The strokes of the letters must be similar to the forms of the texts for them to be recognized. The box in the lower left is used to write numbers in the text. Lastly, the lower right box is used to present symbols and punctuation marks. It is assumed that users are familiar with the forms and keystrokes of the letters, numbers and symbols in using this handwriting style. On the other hand, the free handwriting style is similar to the clustered handwriting but users have to tick an icon beside the handwriting box to select the writing mode. Users can choose between alpha mode, numeric mode and symbolic mode. A sample of the free handwriting recognition style is shown in Fig. 1b. The big box in the lower left represents the input box with the mode on the lower-left side of the box. Users can change the mode from alpha to numeric, alpha to symbolic, numeric to alpha, numeric to symbolic, and vice versa. Users input the keystrokes in the input box and then the transcribed text will be shown.

Among these five text entry methods discussed, current literature focuses on Multitap and QWERTY (Green et al., 2004; Nesbat, 2003; Pavlovych and Stuerzlinger, 2004; Karlson et al., 2006; Balakrishnan and Yeow, 2008). Green et al. (2004) developed a reduced QWERTY keyboard for mobile text entry and Nesbat (2003) developed a rearrangement of multitap design based on

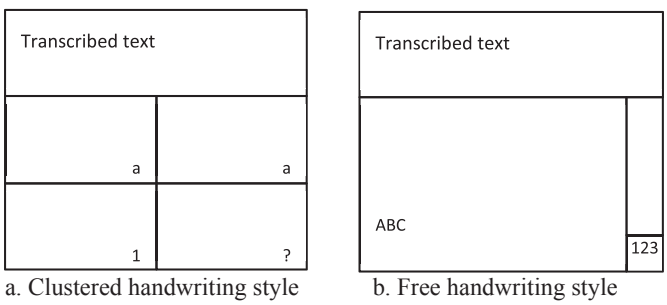

Fig. 1. Types of virtual handwriting styles.