One Line Soft Keyboard with T9-keys Layout Proposal on Smartwatch Touch Screen Device

Eka Prakarsa Mandyartha¹, Pratama Wirya Atmaja¹, Henni Endah Wahanani¹, Made Hanindia Prami Swari¹

¹Department of Informatics, Faculty of Computer Science, Universitas Pembangunan Nasional Veteran Jawa Timur, Surabaya, Indonesia
eka_prakarsa.fik@upnjatim.ac.id

Abstract. A smartwatch is a mini-sized digital computer device that functions apart from being a watch and can also perform intelligent computing tasks. Due to screen size limitations, a smartwatch requires special design techniques on its input and output to allow interaction with its users. Text entry is often required by many applications, but because the smartwatch screen is small, text entry techniques commonly used on personal computers are impractical when applied to smartwatches. In this study, we introduce a design concept proposal for a soft keyboard called One Line Soft Keyboard with T9-Keys Layout. The soft keyboard design concept is expected to reduce the space on the keyboard on the smartwatch screen, along with the use of widely used button layouts that are familiar to users.

Keywords: smartwatch, one line soft keyboard, soft keyboard, text entry, text input

1. Introduction

The development of portable touch screen devices, making the text entry mechanism a very important component in meeting the daily needs of its users, ranging from adding the contents of the diary, writing a meeting schedule, to writing comments on social networks, also writing emails and complex documents. This makes the researchers interested in developing technology in the field of text entry on mobile devices. There are two main challenges that must be accommodated in developing text entry techniques [1]. First, most importantly, the text entry technique must be comfortable and accurate on small mobile devices. Second, besides having to be comfortable when it's used, ideally it should also be familiar to users.

A smartwatch is a mini-sized portable touch screen device embedded in the wrist. Besides having the function as a watch, it can also perform intelligent computing tasks. Until now, smart watches provide access to a variety of applications installed on smartphones, such as e-mail, messaging, calendar and social networking, directly from the user's wrist. Users can interact with their smart phones without touching them. Smartwatch devices have now been produced and marketed such as Apple iWatch, Samsung Gear, Xiaomi Amazfit, and LG Watch Urbane. The launch of the smart watch was successfully sought after by the public, but without the text entry feature, interaction with its users was limited [2].

In this study, we propose a soft keyboard layout design concept that combines the advantages of modern layouts with the efficient space and keys layout that are familiar to many users. This layout is expected to accommodate accurate text entry methods, user familiarity and minimum adaptation learning time.
2. Previous Keyboard-based Text Entry Technique on Smartwatch

The traditional technique of text entry is to use a keyboard. The challenge in implementing text entry on small devices, especially smartwatches, is to create a keyboard layout that is smaller than a normal keyboard, such as those used on mobile phones, by reducing the keys that will be used, as small devices have screen size limitations. The performance of the text entry technique is evaluated based on three criteria, they are learning time, text entry speed, and text entry accuracy.

**Learning time.** The more familiar the system design is to the user, the less learning time the user needs to interact with them. Text entry speed. Faster text entry allows users to complete more tasks on their smartwatch. This performance can be measured based on the number of words typed by the user per minute or abbreviated as words per minute (wpm) [3]. Text entry accuracy. Text entry techniques should provide a mechanism or design that does not cause many typos by the user. This is important, for example, to enter a password or an internet site address. Accuracy can be found based on typos found. More practically, to detect typographical errors, an approach to measure the number of keys pressed to type one character or abbreviated as KSPC (keystrokes per character) can be used [3]. Ideally to type one character correctly requires just one key press or the KSPC value is ‘1’ for a QWERTY keyboard [4]. So, for example, if a user wants to enter one character using a QWERTY keyboard, but more than one KSPC is obtained, then there is an indication that the user is typing the wrong character so that it requires correction until the character is entered as desired.

Several studies have developed text entry techniques on small devices, using either a physical keyboard or a soft keyboard.

**H4-writer** [5]. The text entry method using a physical keyboard proposed by MacKenzie et. al [5] is named as H4-writer. The H4-writer is a text entry technique that can be operated using only one finger (thumb) with its layout design having four buttons. Reducing the number of keys pressed as text input can be done using the Huffman coding concept [6]. The Huffman algorithm generates a code tree based on alphabetic symbols and then calculates the probability or frequency of each alphabet occurring on the vocabulary list. If symbols appear more frequently in the vocabulary list (higher frequency of occurrence), the Huffman binary code length is shorter, and vice versa. In the case of the H4-writer, the Huffman binary code for each alphabet symbol is obtained based on a list of English vocabulary from the British National Corpus (BNC) dataset. Then the frequency of appearance of each alphabet is calculated based on the BNC dataset, a code tree is created, and finally the Huffman binary code can be determined. The H4-writer keyboard layout design uses a design that has been applied to the LURD-writer keyboard. Actually, the H4-writer method is an extension of the LURD-writer, the difference lies in the coding technique used so that the code sequence (the keys that must be pressed) is different. The H4-writer, which initially only accommodated 26 alphabets along with "space" characters, has KSPC 2.074, which was later improved by adding special characters, numbers, and caps locks which resulted in the KSPC increasing to 2.321 but still lower than the LURD-writer which can reach the KSPC value equal to 3. Furthermore, the user evaluation proved that the H4-writer method's entry speed reached an average of 20 wpm, at the last testing session. This shows that the H4-writer can be a good method for use on small devices such as smartwatches, but in addition to reducing the keyboard keys to four keys being an advantage, users still have to learn the sequence of commands to enter each character, so it requires learning time that is not a moment.

**1 Line Keyboard** [7]. Starting from the idea that the soft QWERTY keyboard found on touch screen smartphone devices takes up too much space making it difficult to apply to smaller touch screen devices, Li, et.al [7] developed a soft keyboard with a design resembling a QWERTY keyboard but has a one-line layout. The basic concept of the 1 Line Keyboard design is to group the alphabets of each column of the QWERTY keyboard into one key, thus forming eight keys on one line, each key containing several alphabets (see Figure 1). In order to determine the layout of the keys, that is, which alphabets are grouped into one key, a small study involving six participants was conducted to understand the spatial distribution of typing in a QWERTY layout. Flick gestures (more like swipe) are used for the characters "backspace" (one finger swipe left), "enter" (one finger swipe right), two finger gestures swipe left to delete a word, and one finger swipe down gestures and upwards to select the desired word from the word suggestion
based on the word disambiguation algorithm. The word list used for word disambiguation comes from the Corpus of Contemporary American English (COCA). To give a space between words, the user must tap the keyboard bezel. The evaluation results of the user, the QWERTY keyboard using the keyboard interface on the iPad, show that the accuracy of 1 Line Keyboard (KSPC 1.31) is almost the same as the performance of a QWERTY keyboard layout (KSPC 1.26). Due to the same basic layout, the participants required short learning time, however the t-paired test showed that the entry speed was much lower when using 1 Line Keyboard (30.7 wpm) compared to a QWERTY keyboard (53.9 wpm). The low entry speed performance is due to the inaccuracy of the spacebar bezel detection algorithm, which causes false positives and false negatives. The word disambiguation algorithm suggests a word that is completely wrong, if the user makes a typo at the beginning of the word. Despite these drawbacks, 1 Line Keyboard succeeded in reducing the size of the keyboard to 60% smaller than the original (QWERTY) size, thus providing more space to interact with devices.

Figure 1. 1 Line Keyboard Layout [7].

Zoomboard [1]. Oney et al [1] proposed a new text entry technique called ZoomBoard. ZoomBoard is a soft QWERTY keyboard adapted for small devices, such as smartwatches, using iterative zooming to make text input, which comes from the user, more accurately. Because its main purpose is besides allowing a QWERTY keyboard to be used on small devices, the mechanism must be familiar to the user, and the learning time for the user must be minimum, this is the reason ZoomBoard uses a QWERTY keyboard layout design. QWERTY layout design is the most popular method for text input. The ZoomBoard text entry mechanism is to enlarge the area clicked by the user, up to three levels of magnification so that the text input is accurate. ZoomBoard also provides a specific swipe gesture mechanism, namely top swipe for keyboard symbols (numeric characters and special characters), left swipe to delete text and right swipe for spaces. The results of ZoomBoard evaluations on user participants show that the performance of the ZoomBoard keyboard entry speed is achieved an average of 7.6 wpm and 9.3 wpm in the last testing session. These results show lower entry speed performance when compared to other systems such as the H4-writer, because the H4-writer is a system that uses large keys on the keyboard so that this technique does not require enlargement on the keyboard, thus reducing the time required to input, or type a word. However, zooming soft keyboard has a fairly high accuracy with KSPC 2.15, it should be noted that with the minimum zoom system, the KSPC 2 is obtained, thus implying that ZoomBoard is an efficient method for text entry. The advantage of this ZoomBoard allows extra space on the screen so that more text can be displayed. ZoomBoard’s weakness lies in the fat finger problem, so that if the user’s finger is fatter it is difficult to tap the button with precision.

Drag Keys [8]. DragKeys [8] is a soft keyboard for smartwatch proposed by Hyeonjoong Cho et al, with a new approach, different from other soft keyboards. The idea for its development originated from previous research that developed a soft keyboard with a virtual key-based technique, meaning that the user had to tap right on the desired key area so that the user had to be very careful so that the tap did not hit adjacent areas that were not the desired key. DragKeys takes a different approach, allowing the user to enter text by tapping in almost any area on the touch screen because this text entry technique determines character input based on the drag directions of the finger. DragKeys has a layout of eight circular keyboard keys and each button consists of two array levels (two levels of drag gesture direction). Actually, the eight buttons only define the rules for the sequence of finger drag gestures to distinguish certain characters. This is different from other soft keyboards, such as ZoomBoard [1], which displays a QWERTY keyboard layout on the screen in order for the user to tap a button on the screen to enter text. The DragKeys text entry technique addresses the fat finger problem, where if the user’s finger is thicker then the text entry can be done accurately. With constant learning, users who are very familiar with the rules of the sequence of gestures can enter text without having to look at the screen (eyes-free contact).
Flickey [9]. Flickey [9] is a flick-based soft QWERTY keyboard, where you tap your finger to trigger key selection and flick it. This mechanism allows the user to select small keys on a small keyboard more easily than with one tap. The text entry mechanism using Flickey is described as follows. First, the user selects the button column by tapping his finger. If the selected column is not what is intended, the user can change the selected column by moving his finger right or left. The user selects a button by lifting a finger to enter a character or scrolling to select another key.

3. Proposed Soft Keyboard Layout

Based on previous works, regarding the text entry method on a smartwatch, it is known that the ZoomBoard [1] has the best performance, although the 1 Line Keyboard [7] soft keyboard based on the evaluation results should have the best performance. The best performance is obtained because 1 Line Keyboard uses the popular QWERTY layout by compressing the QWERTY keyboard layout, by combining several characters into one key so that it only uses one line on the screen. The main problem arises, 1 Line Keyboard relies heavily on word suggestion, the user taps a button containing a group of characters, then the system predicts the word the user wants using the word disambiguation algorithm. The algorithm is trained in English vocabulary only, so it cannot be applied to other language environments. In addition, writing errors or often called typos in the initial characters, result in the word disambiguation algorithm making fatal mistakes in predicting the words entered.

In contrast, ZoomBoard is very robust against this noise. However, because ZoomBoard adopts a soft QWERTY keyboard layout design, many characters are displayed on the screen so that the screen space is mostly used by the soft keyboard.

3.1. A Design Concept

The development of this text entry technique was inspired by the ZoomBoard [1] soft keyboard method, by modifying the soft keyboard layout and gesture interactions. The concept used is one line because it doesn't take up too much screen space. The zooming keyboard concept is maintained. In accordance with the basic idea of ZoomBoard, the layout used is a popular keyboard layout. However, the use of a QWERTY layout is not possible. Because the concept adopted is One Line, the key layout used is the T9 concept, which was also popular before QWERTY was introduced.

3.2. Keyboard Keys-Layout

In addition to the popular QWERTY keyboard layout, the T9 keyboard layout is widely used due to the limited dimensions of mobile phones in the form of both physical space and screen space. The Sony Xperia Mini smartphone is one of the touch screen smartphones that applies the T9 soft keyboard concept due to the limited size of the touch screen (its size is smaller than the average touch screen smartphone). See Figure 2. Because the T9 keyboard reduces the use of keys, of course there are several characters merging into a key. Because the use of the T9 layout design is also familiar to users, the concept of grouping characters in one button (keys) layout adopts the T9 button grouping layout. Figure 2 shows the T9 keyboard design, characters A, B, and C combined in one key. Likewise with D, E, F and so on.

![Figure 2](image-url)
3.3. One Line Keyboard with T9 Keys Layout

The soft keyboard design concept "One Line Keyboard with T9 Keys Layout" adopts the 1Line Keyboard [7] prototype. The advantage of a one-line layout is that it takes up less screen space than a QWERTY layout. We combined the advantages of the one line concept, keyboard zooming, and T9 button grouping. The design concept is shown in Figure 3.

![Figure 3. One Line Keyboard with T9 Keys Layout Soft Keyboard Design Concept.](image)

The text entry mechanism is that the user taps the button containing the character to be entered, the keyboard then zooms the button pressed to provide a group of characters in it, finally the user selects the desired character by tapping. The swipe gesture interaction command is used, which is defined by Figure 4. To add a space character, the swipe gesture to the right in the text area (1), the “backspace” character uses the left swipe gesture in the text area (2), and to move the next key is used. swipe gestures left and right on the keyboard area (3). To give a special character, it can be done by tapping the “& @” button, the numeric character of the "123" button, and changing the capital letter with the up arrow key.

![Figure 4. Swipe Gesture One Line Keyboard with T9 Keys Layout.](image)

4. Conclusion

In this study, we propose a soft keyboard design concept that combines the advantages of one line layout, zooming keyboard and T9 button grouping layout. This design concept is called One Line Keyboard with T9 Keys Layout. It is expected to reduce the space for the keyboard on the smartwatch screen with a button layout that has been widely used so that it is familiar to users.

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