



7th International conference on Intelligent Human Computer Interaction, IHCI 2015

ETAO Keyboard: Text Input Technique on Smartwatches

Rajkumar Darbar^{a,*}, Punyashlok Dash^a, Debasis Samanta^a

^a*School of Information Technology, IIT Kharagpur, West Bengal, India*

Abstract

In the present day context of wearable computing, smartwatches augment our mobile experience even further by providing information at our wrists. What they fail to do is to provide a comprehensive text entry solution for interacting with the various app notifications they display. In this paper we present ETAO keyboard, a full-fledged keyboard for smartwatches, where a user can input the most frequent English alphabets with a single tap. Other keys which include numbers and symbols are entered by a double tap. We conducted a user study that involved sitting and walking scenarios for our experiments and after a very short training session, we achieved an average words per minute (WPM) of 12.46 and 9.36 respectively. We expect that our proposed keyboard will be a viable option for text entry on smartwatches.

© 2015 The Authors. Published by Elsevier B.V.

Peer-review under responsibility of the Scientific Committee of IHCI 2015.

Keywords: Text entry; smartwatch; mobile usability

1. Introduction

Over the past few years, the world has seen a rapid growth in wearable computing and a demand for wearable products. In recent-times, smartwatches have gained a lot of public attention as one of the most popular wearable device. In 2001, IBM introduced WatchPad¹ which was the first prototype of today's commercially successful smartwatches like Samsung Galaxy Gear S, LG G Watch, Motorola Moto 360, Apple Watch and so on. Smartwatches allows users to access several applications (messaging, email, calendar, maps etc.) running on smartphones directly from their wrists, without the need to touch their smartphone. Although applications are instantly accessible on the watch, users face difficulties to immediately reply as there is normally no text entry method on the same device.

Text input is an integrated part of our daily digital activities. For desktop computer, hardware keyboard is used to enter text. Whereas, Qwerty keyboards have become the dominant text input modality for mobile devices like smartphones and tablets. However, in case of wearable devices like watches, glasses, bracelets and jewelry, it is difficult to fit traditional Qwerty keyboard, due to the tiny touchscreen and 'fat finger' problem². Most present day ultra-small smartwatches either do not offer a virtual keyboard as a text entry mechanism or have methods like short-hand gestures which take lengthy user training sessions to get accustomed to. The 'speech to text' mode is supported

* Corresponding author. Tel.: +91-9635118040;
E-mail address: rajdarbar.r@gmail.com

by most modern smartwatches which run on Android Wear¹², Tizen¹³ etc, but there are certain limitations of voice typing such as privacy³, noise in crowd and pronunciation.

Here we present ETAO keyboard, a technique that supports faster and less erroneous text input on ultra-small interfaces of smartwatches. It supports all English alphabets, numbers and most symbols that we use on a daily basis. Using our proposed keyboard user-interface (UI), user can select most frequent characters (i.e. E, T, A, O, I, N, S and R) with a single tap and remaining characters, numbers and symbols with two taps. It supports faster typing with minimum key strokes per character (KSPC). We use two swipe gestures for delete and space. Here, we consider ‘tap’ as the prime input method because it is really easy to perform when walking in a street. However, this layout easily eliminates fat-finger problem by providing keys with bigger buttons. We conducted a user study to demonstrate the effectiveness of our proposed prototype. The user evaluation shows that a novice user takes only a few minutes to learn the keyboard and can achieve a relatively high typing speed while sitting or while walking.

2. Related Work

Text-input in wearables can be done through various methods like speech, bluetooth keyboard etc. However as soft-keyboards are popular methods of text-input in most mobile devices, we are interested to see their performance on wearables like smartwatches. S.Oney et al. proposed ZoomBoard⁵, that uses a miniaturized version of the conventional Qwerty keyboard. The user has to focus on a particular area of keyboard and then tap for zooming into that area. The user can also zoom in further depending upon the number of zoom levels set. Once the zooming is done the user selects the appropriate key by tapping. Although this mechanism seems favorable to the user because of the familiar layout, it still requires two or more careful taps to zoom and select a key. Text entry rates suffer because of these excessive tapping tasks.

The Swipeboard⁶ divides the traditional Qwerty keyboard into nine regions and to enter any character, user requires two swipes. Using first swipe, user specifies the desired character’s region and the second swipe selects the particular character within that region. H. Cho et al. developed DragKey⁷ prototype for text entry in wrist-worn watches with tiny touchscreen. It allows a user to input letters using drag directions regardless of careful touched locations. A user needs lot of time to learn this layout. Furthermore, making continuous drag gestures is quite difficult in walking situations and it is also slower than tapping.

M. Dunlop et al.⁸ proposed alphabetic ambiguous-key approach to text entry. Here, they used tapping and few swipe gestures as input method. Overall, it is a nice concept, but a user may face difficulties while trying to enter password and urls. Moreover, commercially available prediction based text input techniques like Minuum¹⁴, Swipe¹⁵, and Fleksy¹⁶ also suffer from similar kind of problems. M. Funk et al.⁹ developed linear and multi-tap touch-sensitive wristband for text input. But, it demands external hardware which is not available in the existing commercial smartwatches. D. Y. Huang et al.¹⁰ presented TouchSense which provides additional touchscreen input vocabulary by distinguishing the areas of users finger pads contacting the touchscreen. They showed its applicability in a calculator and a text editor application, but not in text input purpose.

Recently, Jonggi Hong et al. developed SplitBoard¹¹ which is a variation of the Qwerty keyboard. Here, the Qwerty layout is split into a few layers. The user sees one layer of keys and has to swipe left or right to press keys present in other layers. It is intuitive to use as it doesn’t require a steep learning curve. But, the key-size of SplitBoard is not large enough to avoid ‘fat-finger’ problem.

Most of the earlier research-works related to text entry on smartwatches tried to fit traditional Qwerty soft-keyboard in an intelligent way and also used touch sensitive wristband for typing. The existing virtual keyboards, which provide good typing accuracy, are slow in nature and keyboards which support faster typing, are error-prone. Our aim in this work is to develop a keyboard which will try to establish a trade-off between typing speed and error rate.

3. ETAO Keyboard Prototype

3.1. Design

The area provided by a smartwatch is really small (only 1.65” screen diagonal) for any conventional keyboard to fit in entirely. Hence, in our proposed ETAO keyboard, we apply the concept of key layering where certain

keys appear in one layer and the rest appear in other layers. The size of each key has been made to be 40dp in width and height with the exception of two middle keys in the first row which are set to 50dp each (Fig.1(a)). This size has been chosen after certain trial and error tests as smaller key sizes made viewing a little difficult and larger key sizes hampered the key layout. ETAO keyboard supports all English alphabets, numbers and most symbols that we use on a daily basis. The design layout consists of two-layers of input modes where user can access most frequent letters (i.e. E, T, A, O, I, N, S and R) with a single tap and remaining characters with two taps. The first layer i.e. main-screen is divided into two regions. The top most region has a text field where typed characters will appear. The remaining area of the screen is divided into three rows. This region is known as ‘button region’. The first row of the button region has four grid keys. Each grid key has different functions and when tapped, open a new layer. The opening of a new layer acts as the second layer of input mode. The functionality of each key of the first row is described below.

The left most (first) grid key is used for numeric entry. This grid has been customized to behave a little differently from the other grid keys. After typing a single character from the other grid keys, the intent changes and the user is taken back to the main screen. But, in the case of the numeric grid (Fig.1(d)) this would prove tedious to the user as one generally inputs several digits at a time instead of a single digit. To solve this issue, the numeric grid’s intent remains fixed and does not change till the user taps the back button. On tapping the back button the user is taken back to the main screen.



Fig. 1. ETAO keyboard layout: (a) home screen (b) intent layout of the second button of first row (c) intent layout of the third button of first row (d) digit's intent and (e) special symbol's intent.



Fig. 2. ETAO Keyboard prototype running on LG W100 smartwatch.

The second and the third (grid) buttons are used to enter the remaining English alphabets which are not mentioned separately in the second and the third row. Each of these grid keys house 9 buttons of 40dp each. The second grid has the letters B,C,D, F,G,H and J,K,L arranged alphabetically (Fig.1(b)). The third grid key comprises M,P,Q, U,V,W, and X,Y,Z also arranged in alphabetical sequence (Fig.1(c)).

The right most (fourth) grid button is used to enter special characters such as symbols and punctuation marks. Most commonly used 15 such special symbols are included in 11 buttons (Fig.1(e)). There are four buttons that contain two symbols each. For example, the opening and closing parenthesis ‘(’ and ‘)’ are present on a single key. To enter the opening parenthesis, the user just needs to tap the button and in order to enter the closing parenthesis the user has to long press the same key. The text field always remains on top of the screen irrespective of the layers we type in. This enables the user to be able to visualize the characters he/she types at any instant of time.

The second row in this region has four buttons specifying the characters 'E', 'T', 'A', 'O', and the last row has the characters 'I', 'N', 'S' and 'R'. These eight characters are arranged on the basis of most frequently occurring English alphabets, starting with highest frequency character 'E' to the relatively less frequent 'O'. Note that, these eight letters cover almost 65.04% of all letter frequency occurrences in English¹⁷.

A special back button is provided in all the four grid keys present in the first row. In case the user unintentionally opens a grid and realizes that the key he/she wants is not present there, the user can get back to the main screen of the application by tapping the back button directly. Two swipe gestures are designed for space and delete key. To input a space the user has to swipe down by tapping either of the two grid buttons present in the middle of the first row and similarly, to delete a character the user has to swipe left by tapping on either of these grid buttons. Tapping a key displays the character in the text-field. Long pressing the key makes the character capitalized. When a key is pressed it provides a haptic feedback via 100 msec vibration to the user.

3.2. Implementation

We use the 'LG W100 Watch' and the 'Android Wear' platform for implementing our ETAO keyboard (see Fig. 2). The G watch comes with Android Wear as the native OS, hence development of the app had to be done on Android 4.4W API which is compatible with Android Wear. This API fully supports the gestures that we incorporated in our application. The watch has the screen size of 30mm × 30mm. The home screen has all the buttons on 25mm × 25mm layout which includes all the three rows of the 'button region'. We used a keypad size of approximately 20mm × 20mm in a grid (the second layer of input) and placed nine keys with a return button in this grid. This translates to about 6.6mm × 6.6mm for each key and this area is big enough to avoid most fat-finger problems. To compare the key-size, we consider few other keyboards' key-size. For example, the size of the ZoomBoard key is 2.9mm × 2.9mm when not zoomed and in the zoomed state is 5.8mm × 5.8mm. The area of each key of the SplitBoard is 4.8mm × 6.5mm and is a little larger for space and backspace key.

4. Evaluation

4.1. Method

To evaluate the feasibility and practicality of ETAO keyboard, we performed some text entry tests and compared it with three existing keyboards like Qwerty, ZoomBoard and SplitBoard. Ten university students were recruited (6 male and 4 female), all aged between 20-28 (Mean = 24). The participants were primarily post-graduate students in our university's Information Technology department. None of them had any previous experience with smartwatches, but they are all well experienced with smartphones. All of them were given a compensation of Rs. 500 for their time.

Before the beginning of the tests, the participants were shown the interface and were informed of the gestures that were built into the keyboard. A demo session was conducted to educate them about the keyboard layout. In the demo session, each participant were asked to type in their names, surnames, addresses and telephone numbers with our keyboard. This was done to familiarize the participants with the keyboard layout further, on a personal level.

For actual evaluation purposes, a total of 45 phrases were selected at random from the MacKenzie and Soukoreff⁴ texts and were grouped into three sets of 15 each (i.e. Phrase_Set_1, Phrase_Set_2 and Phrase_Set_3). These three groups were categorized as short, medium and long. Short phrase group had all phrases less than or equal to 23 characters in length. The medium phrase group had phrases less than or equal to 32 characters in length and the long phrase group had phrases more than 32 character in length. During the experiment, phrases were displayed to the users on a desktop screen. The participants were requested to input text with their dominant hand, while they wore the smartwatch on their non-dominant hand.

There were two scenarios taken into consideration. The first one was a sitting scenario and the second was a walk inside the lab. The participants were asked to perform three sessions in both the testing scenarios, each session included two trials and they had to write 15 phrases (we chose 5 phrases randomly from each of our three existing phrase-sets) in each trial. We conducted the sitting environment tests first for all the participants and it spanned across three days. A gap of two hours was strictly maintained between each session. After the completion of the sitting environment tests, the walking tests were conducted. These tests also spanned three days and the participants had to

type in exactly the same phrases as they had typed in the sitting environment. Participants were instructed to correct any errors they made during the typing session but a constraint was imposed upon them. The constraint being that they were allowed to correct an error, only if they observed it at the time of committing the mistake. So, if they typed along and realized later that they had made an error in a previous word or the beginning of the word they were typing, they weren't allowed to rectify the mistake. Note that, we also followed the same experimental-setup protocol for the other keyboards.

4.2. Text Input Performance

In the experiment, we recorded the corrected WPM measure and not the raw WPM measure as it would have included incorrectly typed characters during the calculation. To analyse the WPM and error-rate of different keyboards, we used repeated measures ANOVA and a pairwise-comparison. As the Qwerty keyboard showed significantly higher error rates, we removed it from our ANOVA measures and considered only three remaining keyboards (i.e. ZoomBoard, SplitBoard and ETAO Keyboard). This removal was important as the inclusion of Qwerty would have given unnecessarily given higher values in ANOVA and would not have helped in proper analysis of results.

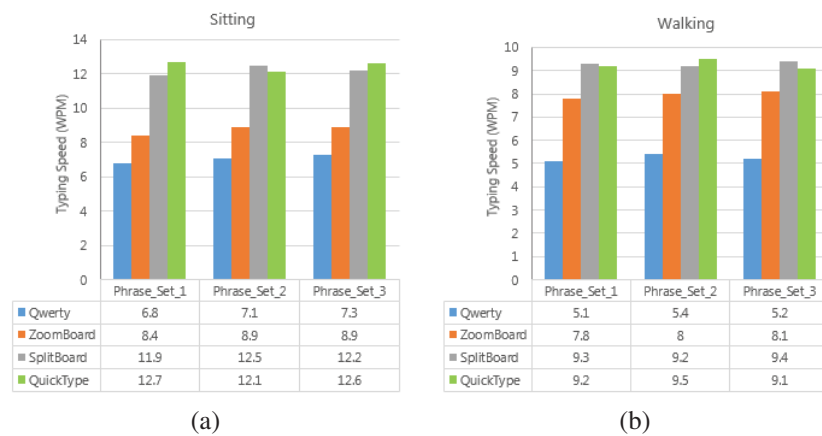


Fig. 3. Typing speed in words per minute: (a) during sitting (b) during walking.

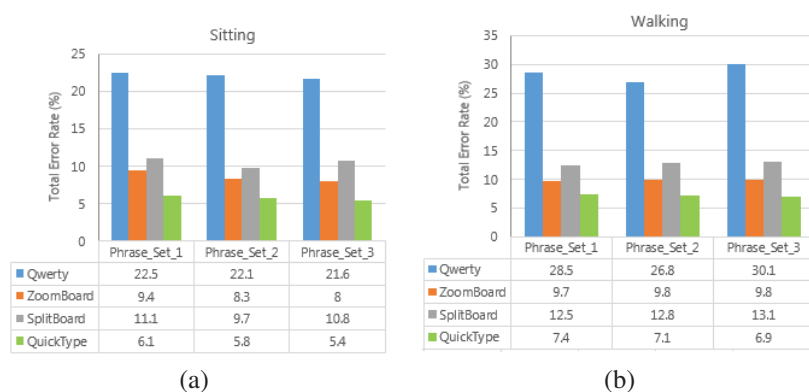


Fig. 4. Total Error Rate: (a) during sitting (b) during walking.

There was a major effect of the keyboards on WPM in sitting experiment ($F(2,18) = 60$, $p < 0.05$) and during a walk ($F(2,18) = 47.227$, $p < 0.05$). Using ETAO keyboard, participants were able to enter the phrases with 12.46 WPM ($SD = 0.71$) in sitting situation and 9.36 WPM ($SD = 0.59$) in walking scenario respectively. The Fig. 3(a) and 3(b) represent the text entry speed of different keyboards during sitting and walking. The ETAO was faster than the

Qwerty ($p < 0.001$) and the ZoomBoard ($p < 0.05$). However, there was no significant statistical difference between ETAO keyboard and SplitBoard when we compared their text entry rates ($p = 0.05$).

A similar effect was also seen on the Total Error Rates (TER) during the sitting experiment ($(F(2,18) = 72.18, p < 0.05)$) and while walking ($(F(3,27) = 80, p < 0.05)$). As can be seen from Fig. 4(a) and 4(b), the Qwerty caused the most number of errors when compared with the remaining keyboards. This was observed in both the sitting and walking conditions. The ZoomBoard had an error rate lower than that of SplitBoard and Qwerty ($p < 0.05$). In our experiment, ETAO keyboard was the most accurate keyboard to enter text efficiently in both sitting and walking scenarios.

The average UER (Uncorrected Error Rates) were 0.74% for the Qwerty and was 0.61% for the SplitBoard. The ZoomBoard had an UER of 0.48% while the ETAO keyboard had the least UER at 0.41%.

The participants were asked to order the keyboards on the basis of ‘learning-time’ involved. Most participants favored the Qwerty citing that it had the most common key layout and hence it was easy to guess the location of a character, even though it was cumbersome to type text with a small key size. The next favorite keyboard was ZoomBoard as its interface was similar to Qwerty with zoom-in and zoom-out features. The SplitBoard was their third preferred choice as it is a scrolling Qwerty keyboard and immediate learning is possible. Next they voted for ETAO keyboard. Participants suggested that it took some time getting used to the different layers involved, but after the initial learning effort it was the easiest to type with. They also mentioned that after getting accustomed with our keyboard, they felt that ETAO keyboard achieved the best trade-off between error rate and typing speed.

5. Conclusion

We introduced ETAO keyboard, a text entry technique for smartwatches with tiny touchscreens. It allows a user to access eight most frequent English letters with a single tap, while others including digits and special symbols by double tap. Here, we used two swipe gestures for ‘delete’ and inserting ‘space’. This layout easily eliminates the ‘fat-finger’ problem by providing enough key-size and space between keys. User requires few minutes of training to be accustomed with this keyboard. In this study, we didn’t consider any dictionary-based features and focused only on the key entry efficiency of the keyboards. This is a clear shortcoming of this study. Now-a-days, every modern touchscreen keyboard uses a language model. For more practically meaningful results, we would like to compare these keyboards after they are augmented with a dictionary based text prediction feature.

References

1. Narayanaswami C. et al., IBMs Linux Watch: The Challenge of Miniaturization, IEEE Computer 35(1), 2002, 33-41.
2. Siek K.A. et al., Fat Finger Worries: How Older and Younger Users Physically Interact with PDAs. INTERACT 2005, 267-280.
3. Sawhney N. and Schmandt C., Nomadic Radio: Speech and Audio Interaction for Contextual Messaging in Nomadic Environment, ACM Trans. Comput.-Hum. Interact. 7(3), 2000, 353-383.
4. MacKenzie I. S., Soukoreff R. W., Phrase Sets for Evaluating Text Entry Techniques, In CHI 2003, 754-755.
5. Oney S., Harrison C., Ogan A., Wiese J., ZoomBoard: A Diminutive QWERTY Soft Keyboard Using Iterative Zooming for Ultra-Small Devices, In CHI 2013, 2799-2802.
6. X. Chen, T. Grossman, G. Fitzmaurice, Swipeboard: A Text Entry Technique for Ultra-Small Interfaces That Supports Novice to Expert Transitions, In UIST 2014, 615-620.
7. H. Cho, M. Kim, K. Seo, A Text Entry Technique for Wrist-worn Watches with Tiny Touchscreens, In UIST 2014, 79-80.
8. M. D. Dunlop, A. Komninos, N. Durga, Towards High Quality Text Entry on Smartwatches, In CHI 2014, 2365-2370.
9. M. Funk, A. Sahami, N. Henze, A. Schmidt, Using a Touch-Sensitive Wristband for Text Entry on Smart Watches, In CHI 2014, 2305-2310.
10. D. Y. Huang, M. C. Tsai, Y. C. Tung, M. L. Tsai, Y. T. Yeh, L. Chan, Y. P. Hung, M. Y. Chen, TouchSense: Expanding Touchscreen Input Vocabulary Using Different Areas of Users’ Finger Pads, ACM CHI’14, 189-192.
11. J. Hong, S. Heo, P. Isokoski, G. Lee, SplitBoard: A Simple Split Soft Keyboard for Wristwatch-sized Touch Screens, In CHI 2015, 1233-1236.
12. Google Android Wear, <http://www.android.com/wear/>
13. Samsung Tizen Operating System, <https://www.tizen.org/>
14. Minuum keyboard, <http://minuum.com/>
15. Swipe keyboard, <http://www.swype.com>
16. Fleksy keyboard, <http://fleksy.com>
17. Frequency of English alphabets, <http://www.math.cornell.edu/~mec/2003-2004/cryptography/subs/frequencies.html>