Two New Mobile Touchscreen Text Entry Techniques

Ahmed Sabbir Arif* Mauricio H. Lopez† Wolfgang Stuerzlinger‡

Department of Computer Science & Engineering, York University, Toronto, Canada

ABSTRACT

This article introduces two new mobile touchscreen text entry techniques. One is timeout-based and the other is pressure-based. Also, this work examines the effects of tactile feedback on text entry techniques. Empirical comparisons between conventional and proposed techniques show that the new techniques, as well as tactile feedback, enhance overall text entry performance.

KEYWORDS: Text entry, error prevention, touchscreens, virtual keyboard, delay, timeout, pressure.

INDEX TERMS: H.5.2 [User Interfaces]: Haptic I/O

1 INTRODUCTION

Recently, touchscreens have become one of the dominant interaction modality for handheld devices. Many of these devices replace physical keyboards with virtual ones, which permit larger displays, less weight or size. It also enables adaptation to different layouts and orientations. However, virtual keyboards are more error prone [3], mainly due to smaller key sizes [8] and the absence of tactile feedback [8], . To counteract these issues, we present two new techniques that are timeout-, respectively, pressure-based. We also examine if providing synthetic tactile information can improve overall text entry performance.

2 RELATED WORK

MultiTap is the dominant technique for standard 12-key keypads on mobile devices. In MultiTap, keys are pressed repeatedly until users get the intended character. Then, one can proceed to the next character, assuming that it is on a different key. If not, users have to either wait for a *timeout* for the system to accept a character on the same key, or have to press a predetermined *kill* button.

McCallum *et al.* [6] introduced a pressure-based technique for 12-key mobile keypad with three pressure levels. Their technique was shown to have higher *expert* entry speed compared to MultiTap, but at the expense of higher error rates. Likewise, Tang *et al.* [10] developed a 3-key chorded keyboard with three pressure levels, which again yielded higher error rates. Hoffmann *et al.* [2] designed a physical keyboard that used pressure to prevent errors. This reduced mistyped characters by 87% and correction attempts by 46%. Brewster and Hughes [1], used pressure-based techniques to switch between upper and lower case. This technique was faster and more accurate than standard touchscreen techniques.

3 NEW TECHNIQUES

The main idea of this work is to generate a list of potential next characters based on the preceding input in real-time. Then we identify those letters including space characters that have less than .01% probability of appearing after the preceding input. Such unlikely characters are then made to be more difficult to enter. In practice, we use a digram frequency table [5] for letter-pairs of the English language to calculate the probability ρ of a character C_n's appearance given the preceding character C_{n-1}, using Equation (1):

$$\rho(C_n \mid C_{n-1}) = \frac{Total(C_{n-1}, C_n)}{Total(C)} \qquad (1)$$

There, *Total* (C) is the total number of characters including space and *Total* (C_{n-1}, C_n) is the total number of a specific digram ($C_n \mid C_{n-1}$) in the table. We use digrams mainly for simplicity here. However, *n*-grams, a dictionary, or grammar rules could also be used to identify less probable characters more accurately.

In the timeout-based technique, we force users to press unlikely keys longer than 0.5 seconds, to make them harder to input. In other words, users will have to press-hold those keys for longer than usual. In the pressure-based technique we use pressure and users will have to apply more force on keys that are unlikely.

4 MEASURING PRESSURE WORKAROUND

All present handheld touchscreen devices do not provide hardware support for measuring pressure. Therefore, we detect pressure by measuring the movements of the touch centre over time, which identifies different levels of contact force [7], .

4.1 Pilot Study

We created an application with the iPhone SDK on an Apple iPhone 3G at 320×480 pixel resolution for our pilot study. The application's virtual Qwerty keyboard was practically identical to the default one, see Figure 1, and provided users with auditory and visual feedback via clicks and highlighting during a press.

Three participants aged from 22 to 24 participated in the pilot study. One of them was female, two of them had prior experience with touchscreens, and all of them were right-hand mouse users.

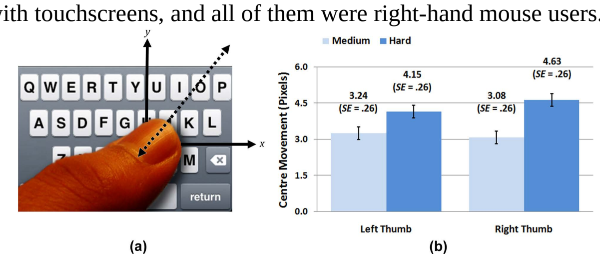

Figure 1. (a) Illustration of movement with contact force. (b) Touch centre movement during *medium* and *hard* presses.

During the pilot, participants entered all the characters on the keyboard holding the device in the portrait position. Two pressure levels, *medium* and *hard*, were tested. During the *medium* condition participants entered all characters using regular force from the top-left to the bottom-right, and then from the top-right to the bottom-left; using at first their *left* and then the *right* thumb. During the *hard* condition, participants repeated the same tasks, but applied more force than usual. We recorded the distances between the *initial* and the *release* touch centres. In total we

* e-mail: asarif@cse.yorku.ca
† e-mail: cs241053@cse.yorku.ca
‡ e-mail: wolfgang@cse.yorku.ca

recorded 3 participants × 2 sessions (pressure levels) × 2 blocks (thumbs) × 27 keys (including space) = 324 presses.

An ANOVA showed that there was significant effect of different pressure levels on touch centre movements ($F_{1,2} = 21.19$, $p < .0001$). However, there was no significant effect of different thumbs ($F_{1,2} = 0.36$, ns). On average *left* and *right* touch centres moved 3.16 pixels ($SE = 0.19$) during the *medium* and 4.39 pixels ($SE = 0.19$) during the *hard* presses.

5 An Experiment

For our experiment, we used the same apparatus and software as for the pilot study. Based on the pilot results, we used a threshold of 4.4 pixels on touch centre movements to identify *hard* presses.

Twelve participants aged from 19 to 34, average 26 years, took part in the experiment. Five of them were female, four of them were touch-typists, and all of them were right-hand mouse users.

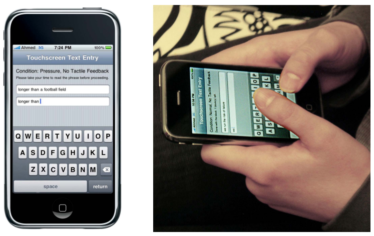

Figure 2. Screenshot of the application used during the user study.

5.1 Procedure and Design

We tested 3 conditions, namely the *regular*, *timeout-based*, and *pressure-based* techniques. Each condition was tested *with* and *without* synthetic tactile feedback. For the synthetic tactile feedback we activated the iPhone's vibration motor for 500 ms.

Participants were asked to enter a set of short English phrases [4], all in lowercase, as shown on the display. They held the device in a portrait position and were asked to take the time to read and understand the phrases, to enter them as fast and accurate as possible, and to press the *Return* key after completion of a phrase to see the next. Timing started from the entry of the first character and ended with the last. Participants were informed that they could rest between sessions, or before typing a phrase. They were asked to work normally, that is, to correct their errors as they noticed them. However, they had to use the *Backspace* button, exclusively, for editing. Based on the 3 × 2 = 6 techniques, we used a within-subjects, 6 × 6 balanced Latin Square design for our experiment. In summary the design was: 12 participants × 6 sessions (techniques) × 20 phrases =1440 phrases.

5.2 Results and Discussion

An ANOVA for the techniques showed that there was significant effect of entry techniques on *WPM* ($F_{5,11} = 3.21$, $p < .01$). There was, however, no significant effect of tactile feedback ($F_{1,11} = 0.12$, ns). The ANOVA on the *Total ER* also showed that there was a significant effect of entry techniques ($F_{5,11} = 2.38$, $p < .05$) and tactile feedback ($F_{1,11} = 7.57$, $p < .01$).

Deeper analysis showed that the *regular with tactile* (16.27 *WPM*, 9.46 *Total ER*) and *pressure with tactile* (16.08 *WPM*, 9.24 *Total ER*) conditions had better overall performance with higher text entry and lower error rates. *Timeout with tactile* was the slowest of all (14.91 *WPM*, $SE = 0.28$). A Tukey-Kramer test revealed that it was significantly slower than *regular with tactile* and *pressure with tactile*. However, it was, at the same time, the most accurate (8.0% *Total ER*, $SE = 0.70$).

From the results it is clear that tactile feedback reduces *errors* for all techniques without reducing the speed in a significant manner. The results also confirmed that pressure-based techniques have the potential to offer higher performance. We believe that with proper training the advantages will increase even more, as previous studies [6], , showed that response time increases with practice for different pressure levels.

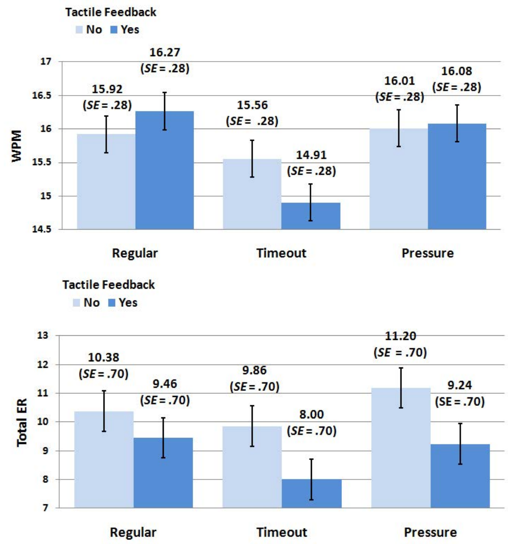

Figure 3. Average *WPM* and *Total ER* for different techniques.

6 Conclusion

Here, we presented and evaluated two new mobile touchscreen text entry techniques: one timeout-based and one pressure-based. The pressure-based techniques had better overall performance compared to the conventional one. Our results also showed that synthetic tactile feedback significantly reduces errors.

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