A Smart-Restorable Backspace to Facilitate Text Entry Error Correction

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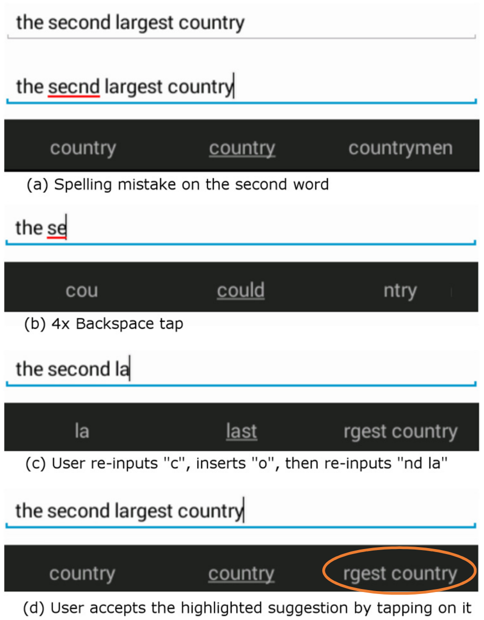
Abstract
We present a new smart-restorable backspace approach to facilitate error correction on touchscreen tablets. A pilot study involving transcription of short English phrases revealed that users generally like the new technique, but performance is not substantially different from the conventional one. Our results indicate that free-form and longer text entry tasks may reveal the differences better. We briefly discuss our plans to investigate this further.

Author Keywords
Text entry; touchscreen; error correction; backspace; smart and restorable; predictive text; input devices and strategies.

Introduction
Based on recent market research, many predict that tablet computers will overtake desktop and laptop computers in the near future [3]. Tablets have become lighter and smaller over the years, with substantial advances in power, functionality, and performance. Nowadays, one can be productive with tablets for tasks that previously required the "power" of a desktop or a laptop. However, text entry with tablets is still relatively difficult due of their smaller screen sizes and the absence of a physical keyboard. Researchers have addressed these issues by developing numerous new and improved text entry techniques, mostly predictive, for tablets [2]. Many have also worked on error prevention [2] and text editing techniques [4]. Yet



(a) Spelling mistake on the second word
(b) 4x Backspace tap
(c) User re-inputs "c", inserts "o", then re-inputs "nd la"
(d) User accepts the highlighted suggestion by tapping on it

Figure 1. Four stages in a sample correction attempt: (a) the user makes a spelling mistake on the second word. (b) S/he taps backspace four times to delete the text after the cursor position in (b), i.e., the correction position. This deletes a total of 19 characters here. (c) S/he corrects the mistake and re-inputs two characters. Our system then suggests the correct portion of the deleted text (see the right candidate). (d) S/he accepts the suggestion simply by tapping on it.

almost no work has improved the users' error correction process—which involves navigating to the position where a mistake was made by using cursor control or the backspace key, and then correcting the mistake by replacement, insertion, and/or deletion. The only major development in this area is a feature that is now default in almost all virtual predictive keyboards: it enables users to restore the original text by pressing the backspace key immediately after an auto-completion/correction. To provide users with a more coherent text entry experience, we see a need for more efficient and smarter correction approaches.

The New Smart-Restorable Backspace

We present a new smart and restorable backspace technique to facilitate error correction on touchscreen-based tablets. We focus on backspace, as previous work showed that about 99% of all error corrections are done with it [1]. The new technique keeps a record of all likely spelling mistakes in a text entry session, and then enables users to correct those with fewer keystrokes than the default backspace method. The user can discard the inclusion of a non-dictionary word (highlighted with a red underline) into the record either by selecting it from the prediction panel (the first candidate always shows the original text inputted by the user, see Figure 1) or by tapping on it (similar to adding a new word into the dictionary). The smart-restorable backspace acts like the default backspace for three repetitive taps to accommodate immediate error corrections. This is based on a prior finding that showed that about 90% of all times users correct their mistakes within three characters from the error [1]. In such cases, users can quickly make the corrections necessary and continue with text entry. But if the text contains misspelled word(s) and the backspace is tapped more than thrice, the system identifies the last misspelled word, determines the earliest position within the word where an inclusion, deletion, or replacement is necessary via the Levenshtein distance [6] (called the correction position), and deletes all input following that. Using the earliest position accounts for words with multiple mistakes. If the text contains multiple misspelled words, the user can keep tapping on the backspace key. Then, on each fourth tap, the system will have moved the cursor back to the previous correction position. This reduces the number of backspace presses needed for error correction.

Yet, one issue with this approach is that users have to then re-input the correct portion of the deleted text. To address this and following [5], the system keeps a separate record of the deleted text and later suggests the correct portion of the text on the prediction panel when the user attempts to re-input it (i.e. inputs at least two characters following the correction that match previously entered text). The system removes a misspelled word or a deleted chunk from the record as soon as the user corrects or re-inputs it, to avoid recurrences. Figure 1 illustrates a sample correction episode. Similar to most recent predictive keyboards, our technique permits users to replace an auto-completed/corrected word with the originally inputted text by backspacing immediately after the occurrence. In such cases, the smart-restorable feature is also trigged on the fourth backspace tap.

Predictive System

We developed a simple prediction system using the most frequent 10,000 English words [8]. As the default Android word prediction, it displays a panel above the keyboard to suggest three candidates—the original text in the left, the most probable prediction in the centre

Figure 2. The device and the application used during the study.

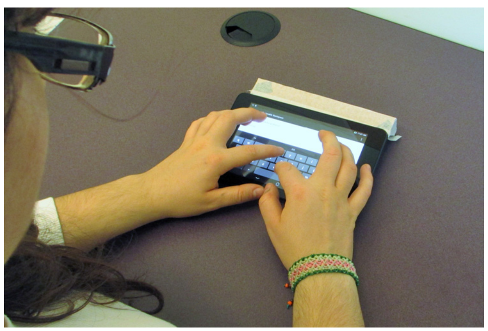


Figure 3. A participant inputting text using the custom application during the pilot study.

(highlighted with underline), and the second most probable one in the right. See Figure 2. It allows users to input a predicted word by pressing the space key, which will input the highlighted candidate, or by tapping on the intended word in the panel. In case of a likely misspelled word, the system autocorrects it with the most probable correct one (i.e. the underlined candidate), unless the user override this by tapping on the original text in the panel (i.e. the left candidate). Users can also replace an auto-completed/corrected word with the original one by pressing the backspace key immediately after the prediction was entered. We informally tested our system with several experienced Android users and none of them noticed differences between our custom and the default prediction.

Pilot Study

Apparatus and Participants

We used a custom application developed with the Android SDK on an ASUS MeMO Pad HD 7, 196.8× 120.6×10.8 mm, at 800×1280. It used the default Google Keyboard and logged all interactions. See Figure 3. The device was attached to a desk with a dock to tilt it to a comfortable 15° typing posture. Twelve participants, aged from 19 to 38 years, average 23, participated in the pilot. Seven of them were female and one was left-handed. They all owned a tablet for at least a year and frequently used it for text entry. All received a small compensation for participation.

Procedure and Design

We used a within-subjects design. The two factors were the conventional and the smart-restorable backspace. During the study, participants were asked to enter short English phrases using both techniques. These phrases [7] were shown in random order on the display, all in lowercase. We instructed participants to read and understand the phrases in advance, then to enter them as quickly and accurately as possible. When finished, participants had to press the enter key for the next phrase. Error correction was forced. Users had to correct all mistakes or the system made a "ding" noise to notify them of existing errors. Misspelled words were highlighted with red underlines. They were asked to exclusively use backspace for error correction. They could use any comfortable posture in landscape position. Most of them, 92%, used both hands. They were provided with two practice phrases before each condition to ensure that they were moderately familiar with each technique and the protocol. They could extend this practice period on request. Participants could rest between conditions, blocks, or trials. Timing started from the entry of the first character and ended with the last. In summary, the design was: 12 participants × 2 techniques (counterbalanced) × 3 blocks × 12 short phrases = 864 phrases in total.

Results

We used repeated-measures ANOVA for all analysis.

Words per Minute (WPM): The ANOVA failed to find a significant effect of technique on entry speed ($F_{1,11}$ = 0.58, ns). On average entry speed with conventional and new were 23.5 (SD=5.4) and 22.7 WPM (SD=5.2), respectively. We filtered the data for cases where users committed at least one spelling mistake (64% of the data), but failed again to identify an effect ($F_{1,11}$=0.04, ns). The average WPM with conventional and new were 20.5 (SD=3.8) and 19.2 (SD=2.9), respectively.

Total Error Rate (TER): An ANOVA failed to identify a significant effect of technique on TER ($F_{1,11}$ = 2.19, p <.05). On average TER for conventional and new were 9.72 (SD = 4.7) and 8.15 (SD = 2.8), respectively.

External Validity

To enhance the external validity of the pilot, we conducted an informal survey to identify the most used text entry positions and predictive features on touchscreen-based tablets. The survey involved 24 experienced users who owned and frequently used tablets for text entry. Ages were from 18 to 38 years, average 23.5 (SD=5.7). 62.5% of them were female. Results revealed that about 92% use word prediction and 79% use auto-correction.

Also, about 96% users input text by placing the device on flat surfaces, i.e. a table, and input text using their index fingers (54%), thumbs (29%), or all fingers but thumbs (8%). The remaining 9% hold the device with their hands and input text using their thumbs. Based on this during the study we placed the device on a table but allowed users to input text using their preferred posture. Similarly, as the survey showed that almost all users use word prediction and auto-correction, we enabled these features.

There was also no significant effect for cases where users committed at least one mistake ($F_{1,11}$= 1.12, p <.05)—the average TER for conventional and new were 14.4 (SD=5.2) and 13.3 (SD=3.9), correspondingly.

Backspace per Phrase (BSPP): There was no significant effect of technique on BSPP ($F_{1,11}$ = 2.59, p >.05). On average BSPP for conventional and new were 3.37 (SD=2) and 2.7 (SD=1.2), respectively. There was also no significant effect for cases where users committed at least one mistake ($F_{1,11}$= 1.41, $p < .05$)—the average BSPP for conventional and new were 6.5 (SD = 2.3) and 5.6 (SD = 1.6), correspondingly.

User Feedback: About 60% users really liked the new technique, found it easy to use, and wanted to keep using it. About 17% users were impartial, while the remaining 23% disliked it or found it difficult to learn.

Discussion and Future Work

Results showed that there was no significant difference between the new and the conventional technique in terms of entry speed, accuracy, and backspace use. Analyzing even deeper we found indications that users had (too) few occasions to use the smart-restorable feature while transcribing short English phrases (only 29% of all phrases). This was also apparent in the post-study interviews, where the "impartial" users commented that they did not notice any difference between the new and the conventional technique. Also, due to the immediate visual feedback on (probable) spelling mistakes, almost all mistakes were either immediately corrected by the users or auto-corrected by the system. Nevertheless, we hypothesize that our technique will perform better with free-from and longer text entry. In such tasks, it is more likely for users to make spelling mistakes and miss or intentionally ignore those mistakes until later to avoid interrupting their flow. Overall, we do not believe that the new technique will immediately improve users' text entry performance, but will enhance their overall text entry experience. We intend to test this hypothesis in the future.

Conclusion

We presented a smart-restorable backspace to facilitate error correction on touchscreen tablets. Although users generally liked the new technique while transcribing short English phrases, statistically it was not different from the conventional one. In the future, we intend to test this technique in longer text entry tasks.

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