SmartKey: A Multi Purpose Target Expansion Based Virtual Keyboard

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ABSTRACT
SmartKey is a new virtual keyboard animation for handheld devices designed to make key selection easier for people with situational and motor impairments. The nearest key to cursor expands in four directions using the available space of nearby keys. Target expansion is accomplished with an occlusion factor of 0% and without any sideways motion. The two studies conducted with able-bodied and motor-impaired users showed that subjects performed better with SmartKey than with traditional virtual keyboard.

Categories and Subject Descriptors
H.5.2 [**Information Interfaces and Presentation**]: User Interfaces – *input devices and strategies.*

General Terms
Design, human factors, experimentation

Keywords
Text input, accessibility, handheld devices, target expansion.

1. INTRODUCTION
Nowadays, the personal communication products like PDAs, smart phones and Ultra Mobile PCs, are becoming smaller and smaller in size. Besides, they are seen more and more equipped with functionalities, applications and services (office, messaging, etc.) so they almost serve as a desktop computer. These devices are especially suitable for people with motor and situational impairments having a shorter travel distance of pointing device and being light weight and mobile. However, new technologies are often being created without considering people with disabilities and other special needs, rendering unnecessary barriers for them. Designing a text entry method for mobile devices doesn't only require finding the quickest and most accurate one, but also other aspects such as user situations, abilities and needs should be considered. The on-screen keyboards of handheld devices are small and the keys can be difficult to acquire even for able-bodied users. Motor symptoms include a loss of the motor control leading to more difficult acquisition of tiny target. In addition, the study of Lin et al. [1] suggests larger keys are required if user is under mobility conditions for target selection task.

Handwriting recognition systems can help to overcome the screen-space constraint, but they are still inherently limited by making their gestures smoothly and accurately. These requirements create a huge barrier for people with situational and motor impairments.

In this investigation our main priority is to provide an assistive and adaptive text input system, making mobile computing products easier in accessibility and usability for people with situational and motor impairments. McGuffin and Balakrishnan [3] proposed to expand a target of one-dimensional widget to facilitate its selection. We discuss, in this paper, a new solution to improve target expansion applied to virtual keyboard.

2. SMARTKEY VIRTUAL KEYBOARD
We propose a new text input solution called SmartKey primarily targeted towards people with motor impairments and can also be beneficial for able bodied persons, enhancing their text entry efficiency through target expansion.

Keys of virtual keyboard are arranged adjacent to each other in form of an array in order to save the screen space and reduce the travel distance of pointing device. However, expanding key being among nearby keys causes overlap and occlusion between keys. Moving other adjacent keys sideways increases a required screen space and then a travel distance. Finally, expanding some keys, associated with shrinking others, changes their position that may make target acquisition more difficult.

The performance in the selection task depends on a final target size, not an initial one, even after 90% of traversed distance towards the target [3]. Thereby, we have shifted the initial boundary limiting the key to make it larger in size with pointer movement.

The main guidelines to build the SmartKey virtual keyboard are in the following.

For the keys being far away from pointer, we have removed their border or separator in order to benefit from the available space of adjacent keys: upper, lower, left and right keys. Regarding the closest key to pointer, we have rebuilt its border with the available space of nearby keys to have a bigger one as shown in figure 1. Therefore, the proposed animation provides an expanded target with an occlusion factor of 0% and without any sideways motion. In addition, the keys of virtual keyboard can be expanded enough so the expansion factor can be reached up to 150%.

We believe that our design is promising to make target selection easier for other interfaces, in particular for design of buttons, menus or selectable widgets.

We have conducted a user study to verify the following hypothesis: the proposed animation of virtual keyboard may improve user performance for text entry task.

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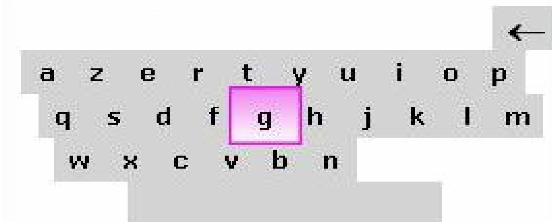

Figure 1. SmartKey animation when the stylus is closest to 'g'.

3. AN EVALUATION OF SMARTKEY

Two user studies were conducted: one with able-bodied users (2 female, 4 male) who ranged in age from 24 to 30 years. The other study was conducted with motor-impaired users who ranged in age from 35 to 58 years: 2 female with Muscular Dystrophy, 2 male with Spinal Muscular Atrophy (SMA). All participants had normal or corrected eyesight, a beginner level in English and were right-hander. The experiment was conducted using Inspiron 6400 Dell laptop running under Microsoft Windows XP attached to a Wacom Cinitiq 21 UX graphics tablet. All users used stylus as a pointing device except one of the two users with spinal muscular atrophy who used his pointing device: Logitech trackball. The two virtual keyboards tested in our study were a traditional AZERTY[1] virtual keyboard without any animation and AZERTY virtual keyboard with SmartKey animation. The both virtual keyboards had a width of 240 pixels and were built with C#.

Mackenzie phrases [2] can be classified according to their length into three packets: short, medium and long sentences. For each virtual keyboard, the program reads two iterations of 6 complex sentences (not memorizable) to avoid user learning: 2 short, 2 medium and 2 long sentences. We opted for the two iterations of the variety of sentences in order to measure the motor fatigue generated from the text entry with the two virtual keyboards.

The experiment consisted of a training session followed by a testing session. The training session consisted of entering the sentence "the quick brown fox jumps over the lazy dog" with two virtual keyboards. The testing session consisted of two blocks. A block was to enter phrases using traditional virtual keyboard, while another block was to enter phrases using SmartKey virtual keyboard. Participants were divided into two-person groups to perform the tasks in a different order. The phrases were the same for virtual keyboards but were in a different order. Participants were instructed to enter the phrases as quickly and as accurately as possible.

4. RESULTS AND DISCUSSION

The variables measured for both virtual keyboards were (1) text entry speed expressed in words per minute (wpm) (2) accuracy or error rate during and after testing session and (3) the motor fatigue generated from the text entry task.

The overall average text entry speeds for able-bodied people were 19.76 wpm with traditional virtual keyboard and 23.94 wpm with SmartKey, suggesting about 21.15% of performance advantage. The difference was statistically significant ($F_{1,10}$ = 16.91, $p < 0.005$). The mean text entry speed by people with motor impairments was 9.93 wpm using traditional virtual keyboard whereas 14.55 wpm with SmartKey, resulting 46.52% improvement. The ANOVA yielded a significant difference ($F_{1,8} = 6.85$, $p < 0.05$).

Error correction while writing was allowed. Thus, two kinds of errors were present in the data: the errors noticed and corrected by participant while others remained uncorrected. Hence error rate was measured using two metrics [4]. The first one is the Corrected Error Rate to compute the errors made during text entry. The average corrected error rate for able-bodied users was 2.64% with traditional virtual keyboard, while it was lower at 0.83% with SmartKey. The difference was statistically significant ($F_{1,10} = 5.00$, $p < 0.05$). The motor-impaired users achieved the test with 1.04% of corrected error rate for traditional virtual keyboard and with 0.27% for SmartKey. The ANOVA yielded a significant difference ($F_{1,8} = 18.45$, $p < 0.01$).

The second metric is the Non-Corrected Error Rate to measure the errors remained in the transcribed string. The average non-corrected error rate for able-bodied users was 1.16% with traditional virtual keyboard, while it was lower at 0.11% with SmartKey. The difference was statistically significant ($F_{1,10} = 18.78$, $p < 0.005$). The motor-impaired users performed the test with 0.37% of non-corrected error rate with traditional virtual keyboard and only 0.05% when using SmartKey. The ANOVA yielded a significant difference ($F_{1,8} = 11.28$, $p < 0.05$).

We introduce a new metric called text entry-generated motor fatigue based on the difference in text entry performance between the two iterations. After analyzing all user data, we found that it depends on the user profile and the task difficulty. Among our users, we had one fulfilling the two requirements: the user with SMA who used his trackball as a pointing device. He achieved the test with 10.79% of text input fatigue for traditional virtual keyboard versus 9.42% for SmartKey.

5. CONCLUSION AND FUTURE WORK

We have shown how a target expansion can be an effective means to improve user performance for text entry task. Currently we are focused on testing SmartKey with wide range of motor-impaired users for small screen. In the future, we will create a version that combines a target expansion with a linguistic prediction system in an attempt to enhance user performance for text entry task.

6. REFERENCES

[1] Lin, L., Goldman, R., Price, K.J., Seras, A., Jacko, J. 2007. How do people tap when walking? An empirical investigation of nomadic data entry. Journal of Human-Computer Studies 65. 759-769.

[2] MacKenzie, I.S. and Soukoreff, R.W. 2003. Phrase set for evaluating text entry techniques. CHI '03. ACM Press, New York, NY, 754-755.

[3] McGuffin, M. and Balakrishnan, R. 2002. Acquisition of expanding targets. CHI '02. ACM Press, New York, 57-64.

[4] Soukoreff, R.W. and MacKenzie, I.S. 2003. Metrics for text entry research: an evaluation of MSD and KSPC, and a new unified error metric. CHI '03. ACM Press, New York, NY, 113-120.

[1] AZERTY is a keyboard layout for French-language computer.