Vector Keyboard for Android Platform-Based Devices

Martin Klima and Pavel Slavik

Czech Technical University in Prague, Faculty of Electrical Engineering,
Karlovo nam. 13, Prague, Czech Republic
{xklima,slavik}@fel.cvut.cz

Abstract. This paper introduces a Vector keyboard for mobile devices with a touchscreen. Typing is produced by simple strokes sourcing from one of four blocks of letters. A user study was made comparing this keyboard with standard QWERTY, ABC and a Mobile keyboards. The study resulted in a comparable performance in terms of speed and typing with all the named layouts but QWERTY. The user preference and subjective evaluation is in contrast to the performance measured preferring the Vector keyboard over ABC and Mobile.

Keywords: vector keyboard, virtual keyboard, touch screen, PDA, QWERTY, ABC.

1 Motivation

The goal of this research is to introduce a new type of keyboard design for touch screen mobile devices, which would be immune to disturbing influence of surrounding when typing in a mobile environment.

There are several commonly used virtual keyboards designed for either mobile phones or handheld devices in general whose performance is degraded when using on small screens. An example of such a keyboard is the QWERTY keyboard, which is present on all smart-phone operating system like Android, iPhone OS, Windows Mobile and others. Such keyboard, when displayed on a small screen, does not scale well with degreasing screen size and its performance drops dramatically. Therefore we designed a keyboard layout which scales well and which should perform better on touch-screen mobile devices. This study is about verification and evaluation of usability of our modified keyboard and about objective performance evaluation and subjective user experience results. We focused solely on comparison of virtual keyboards that make it possible to enter text using fingers only (e.g. no stylus is necessary). No prediction algorithms was used with any of the keyboards measured since we wanted to evaluate the core qualities of the keyboard, not the quality of prediction algorithm used.

2 State of Art

Our research is primarily based on our previous work [1] in this area, which introduced the first version of a vector keyboard for mobile devices. This design used a

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combination of tapping on the touch screen and drawing a vector. Each action (tap or draw) resulted in typing one character.

Fig. 1 shows the layout of the keyboard which consisted of three blocks of alphanumerical characters, each blocks organized in a matrix of 3x3 characters. The blocks can be exchanged for a different set of three blocks by either pressing the shift button (upper left) or by pressing the symbol button (lower left).

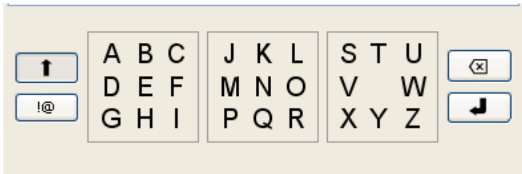

Fig. 1. The layout of vector keyboard designed in [1]

Typing on the keyboard was done by two principles.

- The first and major one was drawing a vector with a starting point within one of the three blocks and heading in a direction which is parallel to a vector starting from the center of the block heading to the character to be typed. The principle is demonstrated in Fig. 2 on typing letter “a”. Please notice, that the starting point of the vector can be anywhere in the area. Such design makes it easy to locate the relatively large block.
- The second one was tapping anywhere in the area which resulted in typing the character in the middle of the block. An example is typing letter “n” in Fig. 2.

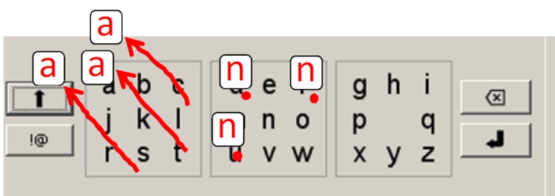

Fig. 2. Typing letters **a** and **n**

The major problem of the approach was that the user often confused tapping and drawing very which increased the error rate. The study as introduced in [1] was carried out on an ultra mobile PC with a resistive display which did not correspond to regular mobile phones in terms of display size, touch screen sensitivity nor the size and weight of the device.

Besides the above introduced technique, there are methods that employ gestures for typing individual characters or whole words. A nice overview is given in Jochen Rick [3] where a number of layouts for virtual keyboards is summarized. Most of them are a variation to tapping QWERTY keyboards and thus not differing from the well known layout. An interesting approach is the Cirrin [4] where the letters are organized in a one circle and word is written by drawing a stroke through all the letters. This approach was later improved by Cechanowicz et al [5]. This approach uses one stroke to type multiple letters at once. Since our primary focus is on a mobile environment where the user might be disturbed in producing long and complicated gestures, we do not find this method suitable. An interesting approach is Quikwriting [9][10] where individual letters are written by drawing gestures starting and ending in the same point. The path of the stroke must follow complicated rules in order to distinguish which of 8 letters in one region should be typed.

The most well know virtual keyboard lately is the Swype keyboard which has the ability to degrade to a standard QWERTY keyboard but can also offer a fast gesture based word typing. Since this method is based on dictionary and language model based algorithm, it is out of scope of our study (same as other well known methods including Dasher).

3 Problem Description

There are several major problems of the existing vector keyboard designed in [1]. Firstly the layout of the three blocks is not suitable for mobile devices like smart phones with their display size (portrait orientation). The three blocks simply do not fit to the display apart from the controlling elements that make the space indigence yet more serious.

Secondly the nature of the typing and the controlling of the other elements - delete, shift, enter, symbols is different. While the typing is done by strokes, the other named actions are made by clicking (tapping). This may confuse the user.

Thirdly there is an internal inconsistency in the way the individual characters are typed. While some are typed using strokes, others are typed using tapping. This fact was identified as a problem in the previous study and users did complain about this.

Our aim was to:

- Redesign the vector keyboard to be suitable for the commonly used smart phones using Android platform.
- Make a qualitative usability study comparing the most common methods of text inputs. These methods should not be based on a language model or dictionary.

4 Solution

Our keyboard layout consists of four blocks, each containing eight different letters (see Fig. 3). A letter is typed by drawing a vector (stroke) from one of the blocks in a direction which is parallel to vector directing from the center of the block to the letter on its border. In contrast to the previous work, there is no letter in the middle of the rectangle, no tapping is ever needed.

All special actions needed for managing the texts are distributed in the blocks. This covers the delete, enter, shift, space and other alphanumeric characters.

In the center of the four blocks, there is a special sliding button for changing the set of typed letters. By dragging this button to the left or right, it is possible to switch to a different set of letters. Dragging the button to the bottom hides the keyboard from the visible screen area.

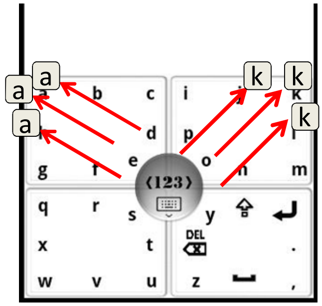

Fig. 3. Vector keyboard layout and usage

The study. We designed our study based on a hypothesis that the keyboard is more error prone than QWERTY and ABC layout keyboard of a comparable size and that the total typing speed will be faster and thus the vector keyboard more efficient. Prior to the study we had two users using the keyboard for a two weeks period who reported better user experience compared to the QWERTY. The reported positive experience was prior to all based on situations where it was not possible to use any prediction algorithm.

The study consisted of comparison of four different keyboard types, namely QWERTY, ABC, 12 buttons cell phone like virtual keyboard (a representative of numerical keyboard of a traditional cell phone) and our vector keyboard. We collected data from 18 users who typed equally difficult texts on each keyboard type. All of the keyboard had built-in logging mechanism which recorded all user actions and timings.

We used four different texts originating from a web site informing about latest financial news. All four of them had equal length of 100 words, equal difficulty and equal frequency of special characters like numbers, parenthesis or quotation marks.

The texts were dictated so that the user did not have to spend time thinking about any grammar and spelling issues. Keyboards and texts were used in a random order, users made pauses between individual typing for at least 10 minutes.

Device used for the test was a HTC Hero with Android OS. Users were sitting during the tests. The style of typing was up to the user whether he/she used one or two hands, left or right.

The users were of age from 16 to 28 (mean 22 and std. dev. 2.76), 6 users had previous experience with typing texts on a touch screen smart phone using QWERTY virtual keyboard, 12 users did not have any previous experience with smart phones. All users were experienced in using regular mobile phones and PC with QWERTY or QWERTZ keyboard.

The test covered the first experience with the vector keyboard, no training except of introduction to the principles of typing was given to the users.

5 Results

We used several metrics for evaluation of the typing performance.

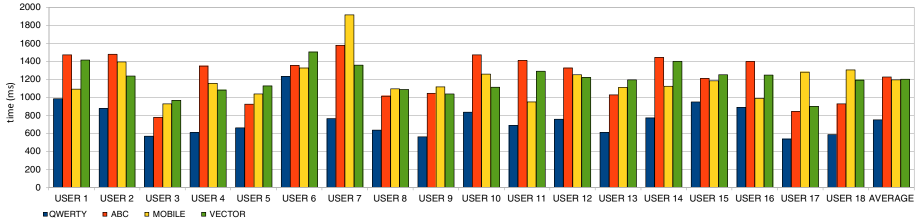

Fig. 4. Raw typing speed including typos and spaces (lower is better)

First a typing speed of a single letter was evaluated with no filtration on typos, pauses between words and first letters in words and is presented in Fig. 4.

QWERTY in this test performed best, probably thanks to the fact that users were familiar with its layout from the PC. The other three keyboards performed equally well in average.

Table 1 shows relative speed compared to QWERTY keyboard as a reference.

Table 1. Relative keyboards speed with no regard to typos (average)

QWERTY	ABC	MOBILE	VECTOR
100%	163%	159%	160%

Second evaluation was performed on a data set, where we extracted only such letters that were inside a word, e.g. starting from the second letter in the word. Spaces and single letter words as well as typos were removed. The reason for such extraction was our observation that users needed extra time for preparation for typing between words rather than in the middle of a word. By excluding the first letter and the spaces from this statistics we subtracted the mental preparation phase for the whole word from the average time needed to type a single letter.

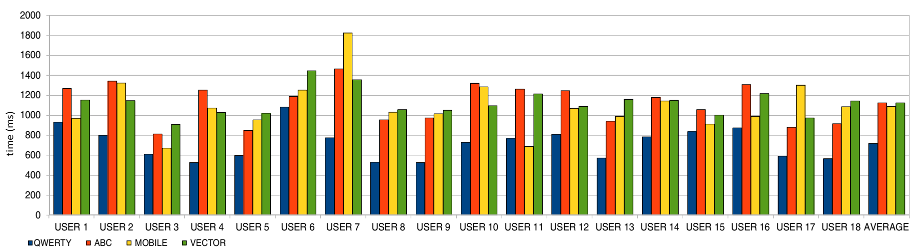

Fig. 5. Typing speed with no typos, spaces and first letters

The relative slowdown of the virtual keyboards compared to the QWERTY is shown in Table 2.

Table 3 shows the difference in results for the named methods. All keyboards exhibit faster times when the major mental preparation phase for typing is excluded. It is a very interesting observation - the QWERTY is the most well know layout and the mental preparation plays significantly smaller role. It is difficult to extract the mental preparation phase between individual characters types in the first experience study. It could be observed in a longer study as a typing speed improvement (learning).

Table 2. Relative keyboard speed with regard to typos (average)

QWERTY	ABC	MOBILE	VECTOR
100%	156%	152%	156%

Table 3. Speed of typing method evaluation

QWERTY	ABC	MOBILE	VECTOR
5%	9%	10%	7%

In contrast to our expectation, the vector keyboard did not perform significantly different from the ABC and Mobile layout. The evaluation of the errors, e.g. typos was done by measuring all initial typos made in a word. In case the user made a typo and continued typing without notifying, than noticed the typo, deleted all characters following the typo and typed everything again, we considered this just as one typo. This way we excluded false typos caused by the nature of individual users.

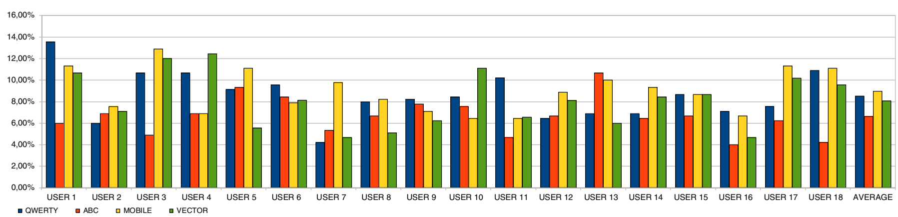

Fig. 6. Error rates

The error rate produced during typing on individual keyboards is displayed in Fig. 6. In average the vector keyboard did not perform significantly better than other keyboards, which did not prove our hypothesis. It is that some users performed very well compared to QWERTY (1,6,8,9,11,16) but for some users the typing philosophy of the vector keyboard was extremely unusual (3,4,10,17) and did not reach a good performance during the short testing period.

Finally we did a subjective evaluation of the keyboards where the users assigned to 1 to 4 (best) points to each keyboard expressing its speed, error proneness and usability. The sums of the points is shown in Fig. 7.

Surprisingly, the results are not in a correlation with the performance measured. Users definitely prefer the QWERTY layout, which also performed best. Despite the fact that the ABC keyboard was performing equally well as the Mobile and Vector

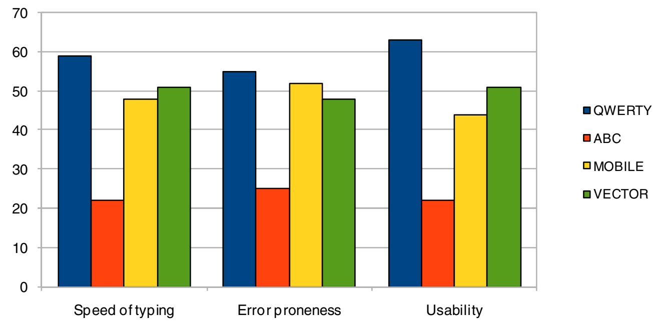

Fig. 7. Subjective keyboard evaluation

keyboard, it was evaluated significantly worse. Subjectively the usability of the Vector keyboard received the second highest score.

As a subjective observation we identified a problem with typing letters in the lower right block of letters when holding the device by right hand and producing stroke in the direction to the right and right bottom. Similarly the same issue arises when holding the device by left hand and typing letters located in the left or left bottom area. This problem is caused by the anatomy of human hand – thumb. We will consider this issue in the next versions and will adapt the system of coordinates to reflect the natural move capabilities of human hand.

6 Conclusion

We measured the real and subjective performance of the Vector keyboard implemented on a smart phone with Android platform. We compared the Vector keyboard with other commonly used layouts (QWERTY, ABC, Mobile) with no typing prediction. Our initial hypothesis that is will naturally perform better than a QWERTY keyboard did not prove true. The keyboard is performing similarly well as the ABC and Mobile keyboards while the QWERTY wins. One of the interesting observation was the fact, that the cognitive load (mental preparation) is significantly higher by all the ABC, Mobile and Vector keyboards, almost a double the value of the QWERTY. The performance is in a correlation with this finding.

The subjective evaluation of speed, error proneness and usability shows that users give priority to the Vector keyboard over ABC and Mobile.

As a possible improvement and a future work we now consider implementation of a language model and a prediction. The user types one letter per stroke and the stroke hits ideally one letter. In the worst case we can consider also the neighboring letters. The prediction can take advantage of this limited set of letter that come in question.

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