Increasing the Efficiency of Text Input in the 8pen Method

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Abstract. The purpose of this work is to improve the 8pen method to increase text input speed. Authors proposed calculation of Layout Factor based on gesture energy cost calculated as number of Curve Drawn Per Character (CDPC) and the cost of transition between two letters neighboring in a text. Then the letters were arranged in four different layouts: alphabetically, using the frequency of unigrams, bigrams and trigrams in English. The best result was estimated for letter order based on bigrams. However, after user evaluation the best results were achieved for trigrams (almost 20 WPM). That underlines the importance of easy transition between letters while entering the text.

Keywords: 8pen · Text entry · Text input · Virtual keyboard

1 Introduction

Text entry is a common functionality of many ICT devices. Although it is easy for most people to enter text, sometimes it is a big challenge for people with physical disabilities. It is very important to offer alternative methods of typing text to support the integration of people with disabilities in society. There are many different physical impairments that cause many obstacles in using smartphones intended for most people. Therefore, to provide access to computer technology, many techniques and methods of interaction are used [7], among others those that facilitate the text input. However, studies in the field of text input is not focused exclusively on the development of new methods and approaches, but also on improving the existing ones.

This article discusses improving the 8pen method to increase its efficiency.

2 Background

The progress of mobile technologies has resulted in many new methods of text input using touch screens. There are several interesting approaches in the area of

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free-hand writing. First should be mention two projects based on straight lines for a single letter composing. First one is the *EdgeWrite* [14], utilized a special template with a square hole and a stylus; a user needed to write the symbols with the stylus along the edges and diagonals of the hole. The second one under the name *GrooveWrite* [1] - instead of a square, used a seven-segment layout. One of the oldest methods (1993) of smooth typing was gesture-based system the *Unistrockes* [4]. Its symbols bare little resemblance to Roman letters. Each letter is associated to a short gesture. The most frequent letters are represented with straight lines. Next one, the *Graffity-stroke* [2] is a text entry system that uses strokes resembles its assigned Roman letters. This was intended to facilitate learning. Another system - *MoonTouch* [5] is a technique based on an enhanced version of the Moon alphabet. It consists of a set of simple symbols made as similar as possible to the Roman alphabet. It should also be mentioned the method of continuous writing Braille code [3], which also leads to various shapes representing single letters. Many methods that use hand movement can be used for touchless writing. There are a lot of studies devoted to the problem of hand gesture recognition described in a literature surveys [6,9,11].

A separate field in the area of text input are studies about thee use of smooth gestures to navigate a specific keyboard layout. Since the spread of mobile devices with touch screens, gestures in the form of swipes on their surface have become widely used. Hence, many solutions for fully swipe keyboards [13], or as support for keys [12] have already been patented. One of the little-known, but very interesting solutions, is the 8pen method, hardly at all described in the literature although its implementations for Android OS are known. So far the 8pen method has been compared to one and two-hand QWERTY-based virtual keyboard, and swipe text input. The study presented its advantage of the 8pen method in a contactless onscreen keyboard interface where these based techniques have been adopted [10].

The purpose of this work is to improve the 8pen method so that it can compete with other virtual keyboards that use swipes on the touchscreen.

3 The 8pen Method

3.1 Concept

The 8pen solution has been introduced for mobile platforms. This text entry technique based on a special virtual keyboard layout. The area that is used for writing is a circle divided into four parts, the letters are located on the edges of the quarters. At the start the user has to touch the central region of the keyboard. Next the user selects one of the four sectors (up, down, right, left) by moving the finger across its area. This limits the number of letters available only to those visible in the selected sector. Next, an expected letter is selected by moving the finger in one of two directions: clockwise (letters: W, P, K, M) or counterclockwise (letters: Q, O, J, N). The direction corresponds to the set of letters where will be selected for an expected letter. The number of sectors crossed in the turn indicates the successive letter on the boundary. Going through

the first border (Fig. 1), the first letter 'Q' is selected from the set, continuing movement until the second border intersects, causes the selection of the second letter 'O' and so until the desired letter is obtained. After reaching the expected letter, the user makes a move inside the circle so that the finger is again in the central region of the keyboard.

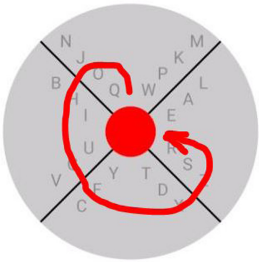


Fig. 1. Selection of "J" on the 8pen layout.

The 8pen method itself is very versatile and can provide acceptable results in terms of speed and precision of text input. However, like all other methods, it uses a certain arrangement of characters that can be random or precisely chosen.

3.2 Gesture Energy Cost

The pointer route (finger on the touch screen) to reach the selected letter, it can be short or long, depending on its location. Considering the trajectory of motion needed to select a sign, a CDPC (*Curve Drawn Per Character*) measure was proposed, i.e. the number of curves drawn for a given letter. This measure will assess the complexity of the moves, which the user will need to enter the text. On the Fig. 2. The CDPC value for entering the letter "Q" equals 3 (on the left), while entering the letter "O" requires 4 moves (on the right side).

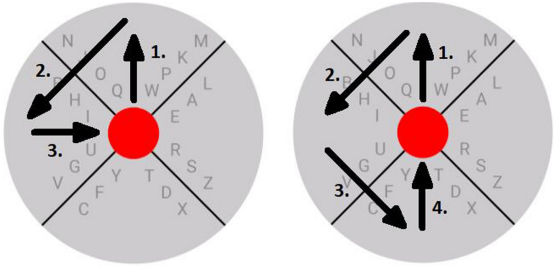
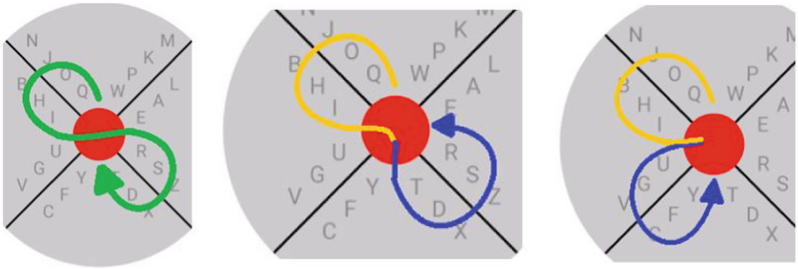


Fig. 2. Calculation of CDPC

3.3 Transition Cost

A characteristic feature of the 8pen method is the use of movements reminiscent of drawing the digit '8' or circles, because they are natural movements and can be performed in one sequence without breaks. Unfortunately, the letter setting and the variety of vocabulary do not allow the user to perform only natural movements. In some cases, the gesture should be stopped and started in the opposite direction. Depending on the sequence of letters entered, the movement may be slower or faster, which affects the writing speed. In this situation, we can introduce the concept of the Transition Cost (TC) needed to start drawing the next letter (Fig. 3).



(a) Low cost (b) Average cost (c) High cost

Fig. 3. Examples of typing character sequences with different energy costs

The following cost values have been assumed in this work (Fig. 4):

1 - for gestures performed in a circle or through the center in a straight line - these are the most natural movements that do not require stopping; in this case, at the end, there is a move to the right or upper sector and a left turn;
2 - when after the gesture the upper sector is selected again, but this time the turn has been made to the right, which causes a slight break in the natural movement of the circle;
3 - when the movement is made to the lower sector, just before the end of the previous selection, the movement slows down or sometimes even stops so that the continuation can take place in the opposite direction to the assumed natural circular movement;
4 - when the next gesture starts from the same sector from which the movement has just ended, which causes a complete stop in the center.

3.4 Layout Factor

The usual approach to testing usability and efficiency of a virtual keyboard relies on practical tests with human users. Unfortunately, such tests are time-consuming. Therefore, the quality of a given layout (arrangement of letters) can

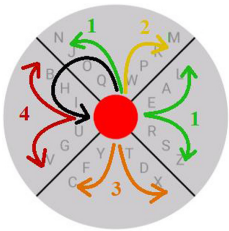


Fig. 4. Gesture energy costs.

be assessed by calculating the appropriate Layout Factor (1) depended on the CDPC and TC values.

$$LF = \frac{CDPC}{NoC} + \frac{TC}{NoT} \tag{1}$$

where:

CDPC - Curve Drawn Per Character;
NoC - Number of Characters;
TC - Transition Cost;
NoT - Number of Transitions.

The calculation of the LF should be made for a representative text of a given national language.

3.5 Arrangement of Letters

The order of letters in the layout was defined in the following steps (Fig. 5):

1. Selection of the sector,
2. Selection of the circle of letters,
3. Selection of the place in the sector on a proper circle

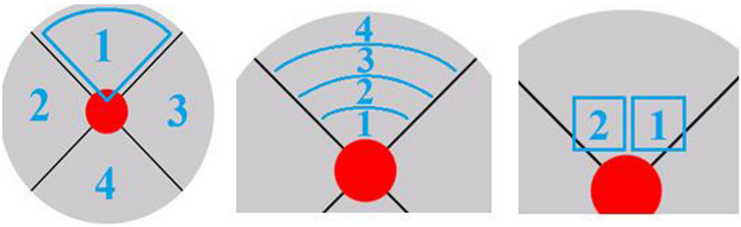
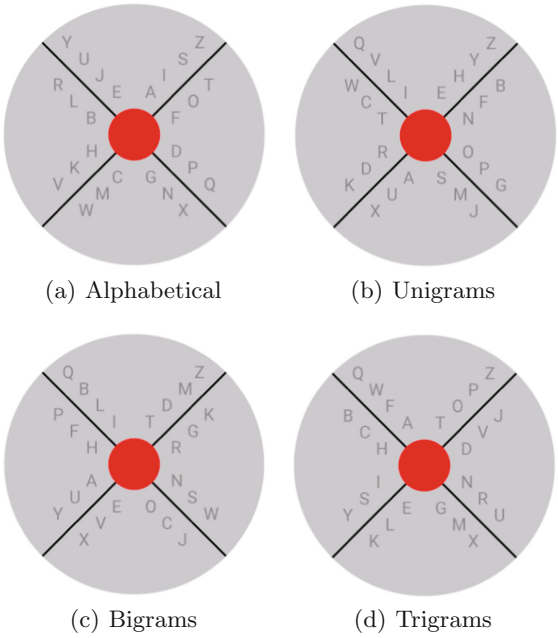


Fig. 5. Steps in the process of inserting letters

Then the letters were arranged in four different sequences: alphabetically, using the frequency of unigrams, bigrams, and trigrams in English (Fig. 6).



(a) Alphabetical (b) Unigrams

(c) Bigrams (d) Trigrams

Fig. 6. Letter arrangement in the layout

3.6 Evaluation

There were used twenty sentences in English taken from [8] to calculate the *LF* indicator for different layouts. Table 1 shows average values of sentence parameters calculated for different letter arrangement in the 8pen layout.

Table 1. Calculated layout parameters

Order	CPDC	TC	LF
Alphabetical	92.85	40.95	6.255
Unigrams	**81.30**	43.15	5.886
Bigrams	82.05	40.50	**5.745**
Trigrams	84.30	**38.50**	5.755

The results obtained show that the use of n-grams in the arrangement of letters has an effect on reducing the energy spent when typing with the 8pen method. The average sum of gesture energy cost in a sentence (CDPC) has the lowest value for the arrangement of characters according to the frequency of occurrence of individual letters (unigrams) in English. The average cost of transition between letters is the lowest for a layout based on trigrams. However, the best LF factor was obtained for a layout using bigram order.

Next, a group of eight volunteers involved in the study evaluated the four proposed layouts. The 8pen method with four different letter arrangement was implemented in the form of mobile application. Each participant had five attempts to enter a chosen test sentence making gestures on the smartphone touchscreen. The illustration (Fig. 7) presents the progress in learning a new arrangements of letters. Learning to write using the 8pen method is not difficult due to the smoothness of the gestures performed. However, the difficulty of the evaluation resulted from the different placement of the letters during the experiments. In general, all results improved as experience grew. The best result was achieved for trigrams, when typing speed has reached the value almost 19 WPM. This means that the cost of transitions between letters is more important than the gesture energy cost when a single letter is entered.

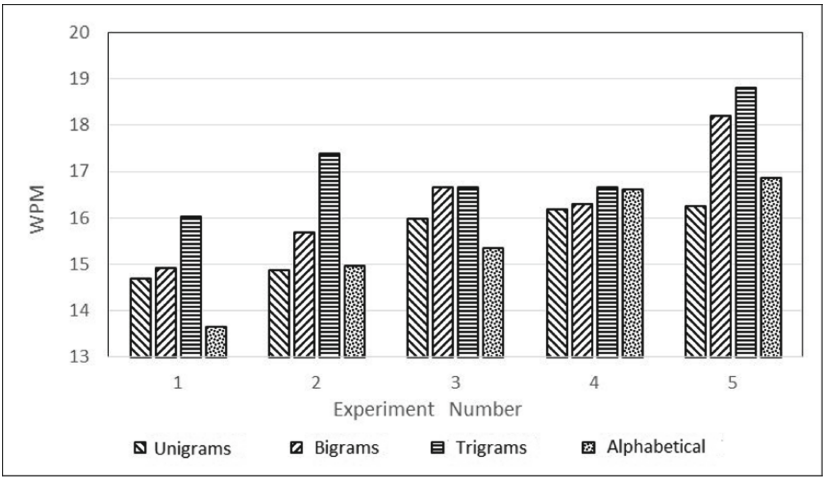


Fig. 7. Results obtained in five trials

4 Conclusions

The paper describes the original method of calculating the layout factor for 8pen method. This parameter based on gesture energy cost calculated as number of Curve Drawn Per Character (CDPC) and the cost of transition between two letters neighboring in a text. The best result was obtained by a layout based on bigrams and trigrams - the result were very similar. The layout using unigrams got worse, while the worst was the alphabetical order. During the user tests, the theoretical assumptions were confirmed, the best results were obtained by layouts using bigrams, and trigrams, although the trigram order gave the best result. This means the fluent transition between entered letters is more important than its complexity represented by single gesture energy cost. This observation

is particularly relevant for all alternative text input methods for people with motor deficits.

In this studies, it was also found that estimates also play a very important role. In a research where many different systems would be tested, a properly defined factor allows to reject practical tests for cases with low performance in calculations.

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