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クメール語携帯電話のための2キーストローク文字入力方法

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12 キーの携帯電話におけるクメール語文字入力は，その文字数が多いことから容易ではない．本論文では，クメール語の特徴に適応させる 2 つのキーを使用する文字入力方法を提案し，その評価について述べるものである．すなわち，下付き文字がキーパッドに割り当てられている手法と割り当てない手法の 2 つのキーマッピングアプローチを提案した．実験結果によると，我々の開発した 2 つのキーを使用する手法（3 キーストローク／文字、エラー発生率：下付き文字あり 10.40%、下付き文字なし 9.96%）は，既存のマルチタップテキスト入力（5 キーストローク／文字、エラー発生率 13.30%）に比べ，文字入力速度（文字／分）に関しては大差なかったが，キーストローク数が少なく，エラー発生率も，非常に低いことが示された．今後はさらに，母音と子音とのマッピング手法について，ユーザにとって使い易さおよび覚え易さに関する評価行うための検討を進める．

Two Keystrokes Text Entry Method for Khmer Mobile Phones

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Text entry into 12-key mobile phone for Khmer language is a challenge task due to the amount of its enormous characters. This paper is to propose a text input method for mobile phone based on Two-key idea adapting to the nature of Khmer language. From this basic concept, we designed two key mapping approaches whose characteristic differs in that the subscripts are spread onto key-pad or not. The experiment shows that our methods use less keystroke for about 3 KSPC compared to the existing Multi-tap text input (approx. 5 KSPC), and that with Two-key method, error rate is quite lower than that of the existing approach in which Two-key with Subscript and without subscript yielded 10.40% and 9.96%, respectively; while the Multi-tap condition had 13.30%. However, there was no significant difference among the three input models in text entry speed measured in character per minute. Survey is conducted to fetch the information on the comfort-abilities, familiarities of the users regarding consonant and vowel mapping concept.

1. Introduction

Short Message Service (SMS) gains its popularity among mobile users probably due to some features: it's low cost; reserves users' privacy from their annoying neighbors; can be responded according to the time of their convenience; and is considered as an effective note; if the address or telephone number are told, users might forget, but it's different in the use of SMS. Anywhere mobile phone can reach; the penetration of SMS can be seen as well. The same situation in Cambodia, SMS in English is widely used in this country short after the presence of mobile phone. However, this service limits SMS usage among the population, since not all Khmer people especially elderly can read and write English.

For localization as well as for the augmentation of SMS usage among local people, Khmer SMS is encouraged to be implemented. Recently, 2 Nokia handsets with Khmer User Interface have been put in

use to local people. However, text input method is still difficult since Khmer language consists of lots more characters than one in English. Thereby, it's a challenge to spread around 74 letters onto only 12-keypad mobile phone. With this amount of characters, each keypad is forced to accept from 5 up to more than 10 letters, which is very inconvenient for users and slow down typing speed.

Every corner should be considered when big amount of letters are encoded onto 12-key mobile phone keypad. Otherwise, it's very difficult for users to search for their desired letter among more than 70 letters. Thus, letter arrangement, grouping is demanded for better digital device and human interaction, and thereby, this papers is to introduce a text entry design for immense character language like Khmer.

2. Related Works

In this section we will discuss some of the current mobile phone text entry method for alphabet language like English.

Multi-tap is a traditional text input method for mobile phone. It's simple and easy. With this approach, a desired character is obtained by pressing the same key one or more times until it displays. For instance, to have the character "b", 2 key is quickly forced down 2 times; on the screen character then cycles through "a" and then "b". However, this method needs time-out or time-out key if users wish to enter the next letter from the same key. The drawback of this method is that when users pause longer than time-out period while cycling, the screen will catch the unwanted character, and when users have gone beyond their wished letter, they cycle another round, which is a waste of time and very slow if many letters are mapped on a keypad.

Linguistic knowledge is added to overcome the problem of ambiguity. For instance, T9 by Tegic Communications Inc. (www.tegic.com). This input method uses only 1 key for each letter, and then the system will guess the intended words by using a linguistic database. Users select their desired words with a key. If the word doesn't pop up on the screen, they require pressing next key one or more times until it views. In this regard, the approach might demand many next key presses if the desired word is not the most-probable. Another problematic point of this method is that if the word itself is a non-dictionary word such as a proper noun, abbreviation, or slang, the system can't find in the dictionary, and users thereby are forced to delete those series of input, and change to Multi-tap mode for keying in their intended word.

Another text entry is Two-key which requires two keystrokes for each character. The first press indicates the main group, while the second keystroke is to select an entity within the main group. In other words, the second key-press is to specify the position of the character within the group. For instance, to enter the character 'e', first the user presses 3 key for 'def', and the second press is 2 key as 'e' is second character in 'def'. The Two-key is a very simple method without timeouts. Each character is gained with exactly two key-presses. The method itself is not popular in Roman alphabets; however, it is very common in Japanese pager to enter Katakana characters [4].

3. Khmer Language

Khmer, an official language of Cambodia, belongs to the Mon-Khmer family of the Austroasiatic phylum of languages, enriched by the Indian Pali and Sanskrit languages. Khmer writing system is from left to right, with characters being placed above, below the main line of writing, leaving no space between words. Khmer contains 33 consonants, 32 subscript consonants with a pair of duplicates, 24 dependent vowels, 12 independent vowels, 2 consonant shifters, and a dozen diacritic signs and other symbols including number sign [1]. Most consonants have reduced or modified forms, called subscripts, when they occur as the second member of a consonant cluster. Vowels may be written before, after, over, or under a consonant symbol. Fig. 1 shows Khmer Characters.

4. Khmer text entry

4.1 Khmer text input history

Text input for Khmer language has a history of 15 years, using a non-Unicode standard, in which the writing system is from left to right in the same order that characters are printed. In 2003 Unicode Consortium released Khmer Unicode standard 4.0 which is the result of making some changes to Unicode 3.0 that introduced ambiguity in the standard order for modern Khmer, allowing different typing order that leads to the same graphic representation.

Since then the Khmer Unicode system has been used to create a wide rage of applications. There is also a hardware Khmer Unicode keyboard on sale in several places in Phnom Penh - the standard NiDA keyboard (National Information Technology Development Authority). And hundreds of trainers have been trained; thousands of computers have been equipped with the KhmerOS system.

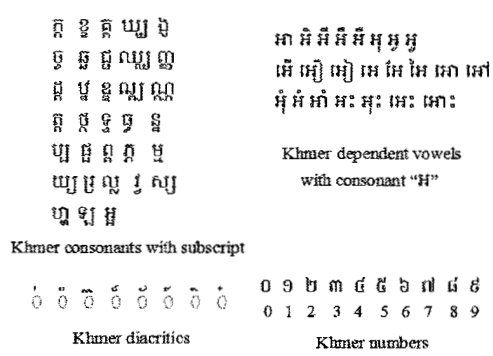

Fig. 1 Khmer Character

4.2 Current mobile phone

Starting from October, 2007, Nokia Company has been doing a promotion on new Nokia Khmer User Interface Handset, Nokia 2760 and Nokia 2630 [2]. The menu guide and SMS can be expressed in Khmer language. It's the first mobile phone that lets Cambodian people enjoy using, reading, and writing in their own native language based on Khmer Unicode.

Key mapping:

The first row, 1 key, 2 key and 3 key are mapped with dependent vowels, consonant shifters, and other diacritic signs, which are categorized into 3 distinct groups : upper group, lower group and in between group [3]. As introduced in section 3, vowels can be placed at any positions around the base consonant. Upper group of Nokia consists of the vowel and signs that stand above the consonant; for example, ◌ិ,◌ី, ◌ុ, ◌ូ, ◌ួ while ◌ុ, ◌ូ, ◌ុំ are the members of lower group and in between is grouped by ◌ា, ◌ៀ, ◌ោះ. From 4 key to 9 key consonants are spread, and each key translates 5 right-order consonants except 9 key with 8 consonants. Independent consonants can be accessed by 0 key. The typing style as in input method of Khmer Unicode keyboard, subscripts are not scattered on the keypad, and instead they can be accessed by pressing a sign which will signify that the next consonant will play a role as subscript.

Fig. 2 Nokia Multi-tap key mapping

Input Method:

Multi-tap is adapted as a text entry method of the above devices. It works as in English alphabet. Users cycle through the same keypad until the desired character appears on the screen. For instance, in 4 key, first key-press will yield consonant "ក" while "ខ" will be shown due to the effect of pressing twice. Because of the big amount of Khmer characters, many letters from 5 to 14 are mapped onto each key, which results in slower speed and inconvenience. Fig. 2 illustrates the key arrangement of Nokia. We will refer Nokia text entry method as Multi-tap in the rest of this paper, as Nokia adapts Multi-tap approach as a text entry technique.

5. Proposed Method

5.1 Two-key method

As our proposed method uses Two-key approach, we first briefly introduce its features. The concept works

well with enormous character syllabic languages because it provides up to 10 separated characters per key with the same key-presses (2 keystrokes) which is considered a less keystroke-consuming approach. For example, if a key is mapped with 10 characters, users require pushing only a constant of 2 keystrokes for every character (even for the last one) of the group. In contrast, users need 10 successive key-presses to get the last character if the method is Multi-tap. Hence, we propose this method in Khmer.

5.2 Khmer language with Two-key method

Time consuming and memory conssuming are the two main factors that should be considered and overcome while around 74 characters need to be squeezed onto only 12 buttons of mobile phone. The idea is simple and easy to remember. We spread 33 consonants from 1 key to 7 key. It is because every Khmer word starts from at least a base consonant; thereby, they should be easily accessed the most. Basically, we mapped each keypad with 5 consonant characters. This way doesn't demand much memory, for from the first grade Khmer students are trained to read five by five characters in a row. Therefore, they might know which consonant is in the first, second and third range of the row. From the basic idea, we design two key mapping layouts namely Two-key with Subscript and Two-key without Subscript. We will discuss in more detail the character mapping of each approach in the following sections.
Differing from Nokia in which 23 vowels are grouped according to the position of the vowels when combining with the base consonant, we refer readers to section 4.2 for vowel grouping of Nokia, we group dependent vowels according to its shape. Vowels are categorized into 3 distinct groups as follows:

1. ◌ា,◌ិ,◌ី,◌ឹ,◌ឺ,◌ុ,◌ូ,◌ួ : "◌ា" group or "A" group

2. ◌ើ, ◌ឿ, ◌ៀ, ◌េ,◌ែ,◌ៃ,◌ោ,◌ៅ,◌ាំ: "◌េ" group or "E" group

3. ◌ំ,◌ុំ,◌ាំ,◌ះ, ◌ុះ, ◌ោះ, ◌ាះ: "◌ំ" group or "O" group (As all vowels have "◌ំ" sign whose shape is as letter "O")

The first, second and third group is mapped in the order of Khmer vowel thereby users can naturally adapt to it easily. Herein, we give the priority to "◌ំ" group or "O" group meaning at the first sight of considering the typing vowel users need to go firstly to this group ("O" group) whenever that word consists of "◌ំ" sign. If not, users need to scan for "◌ៃ" sign, and then go to "E" group. "A" group is the last home to be in, if the desired vowel is composed of neither "◌ំ" sign, nor "◌ៃ" sign. Pseudo-code of vowel selection is as follows:

If "◌ំ" or "◌ុំ" sign (regardless of any other signs coming with "◌ំ" sign such as "◌ា","◌ុ","◌ៃ") then "O" group

else if " ◌ៃ" sign (regardless of any other signs coming with "◌ៃ" sign such as "◌ាំ"...etc) then "E" group

else "A" group

End if

5.3 Two-key with Subscript

Mapping subscript of consonants onto the keypad of mobile phone is the main notion of this approach. Herein, we encode both the basic consonant and its subscript in the same button, aiming to reduce a keystroke in getting subscript consonant compared to the existing method and to help Khmer users not to forget the subscript sign. Fig. 3 depicts the key mapping of Two-key with Subscript.
Table 1 demonstrates key assessment of Two-key method in Khmer. We start the base consonant from 1 key so that it's easy for users to think of the keypad that they are going to access. For example, in 1 key, the first consonant can be accessed by a key-press of 1 key followed by another key-press of 1 key; Consonant "ក" = (1,1). The second consonant will be gotten by pressing 1 key and 2 key successively; consonant "ខ" = (1,2). From (*,6) to (*,0), where * is first key press, users can access to subscript of the (*,1) to (*,5) consonant, respectively. To get subscript "◌ុ" = (1,6) which is the subscript of consonant "ក" = (1,1), and "◌ួ" =(1,7) the subscript of "ខ" = (1,2). With this key-mapping, users can flexibly approach the subscript easily. Starting from 7 key to 9 key,

"A", "E" and "O" vowel group are spread, respectively.

1 key=ក,ខ,គ,ឃ,ង,◌្ក,◌្ខ,◌្គ,◌្ឃ,◌្ង,១
2 key=ច,ឆ,ជ,ឈ,ញ,◌្ច,◌្ឆ,◌្ជ,◌្ឈ,◌្ញ,២
3 key=ដ,ឋ,ឌ,ឍ,ណ,◌្ដ,◌្ឋ,◌្ឌ,◌្ឍ,◌្ណ,៣
4 key=ត,ថ,ទ,ធ,ន,◌្ត,◌្ថ,◌្ទ,◌្ធ,◌្ន,៤
5 key=ប,ផ,ព,ភ,ម,◌្ប,◌្ផ,◌្ព,◌្ភ,◌្ម,៥
6 key=យ,រ,ល,វ,ស,◌្យ,◌្រ,◌្ល,◌្វ,◌្ស,៦
7 key=ហ,ឡ,អ,◌្ហ,◌្អ,◌់,◌៉,◌៊,៧
8 key=◌ា,◌ិ,◌ី,◌ឹ,◌ឺ,◌ុ,◌ូ,◌ួ,ɔ,៨
9 key=◌ើ,◌ឿ,◌ៀ,◌េ,◌ែ,◌ៃ,◌ោ,◌ៅ,ៗ,៩
0 key=◌ុំ,◌ំ,◌ាំ,◌ះ,◌ុះ,◌េះ,◌ោះ,?,០
* key=S,◌៍,◌័,◌៏,◌៌,◌៎,◌់,◌៊,ឥ,ឦ,
ឧ,ឩ,ឪ,ឫ,ឬ,ឭ,ឮ,ឯ,ឰ,ឱ,ឲ,ឳ,
។,?,៖,ៗ,៘,។ល។,ខ្ញុំ,អ្នក,ឲ្យ
key= Change Mode

Fig. 3 Two-key with Subscript key mapping

Table 1: Two-key without Subscript

1st key-press	2nd key-press									
	1	2	3	4	5	6	7	8	9	0
1	ក	ខ	គ	ឃ	ង	◌្ក	◌្ខ	◌្គ	◌្ឃ	◌្ង
2	ច	ឆ	ជ	ឈ	ញ	◌្ច	◌្ឆ	◌្ជ	◌្ឈ	◌្ញ
3	ដ	ឋ	ឌ	ឍ	ណ	◌្ដ	◌្ឋ	◌្ឌ	◌្ឍ	◌្ណ
4	ត	ថ	ទ	ធ	ន	◌្ត	◌្ថ	◌្ទ	◌្ធ	◌្ន
5	ប	ផ	ព	ភ	ម	◌្ប	◌្ផ	◌្ព	◌្ភ	◌្ម
6	យ	រ	ល	វ	ស	◌្យ	◌្រ	◌្ល	◌្វ	◌្ស
7	ហ	ឡ	អ	◌្ហ	◌្អ	◌់	◌៉	◌៊		
8	◌ា	◌ិ	◌ី	◌ឹ	◌ឺ	◌ុ	◌ូ	◌ួ	ɔ	
9	◌ើ	◌ឿ	◌ៀ	◌េ	◌ែ	◌ៃ	◌ោ	◌ៅ	ៗ	
0	◌ុំ	◌ំ	◌ាំ	◌ះ	◌ុះ	◌េះ	◌ោះ	?		

5.4 Two-key without Subscript

The second layout was designed to make it easier to approach the consonants. The main reason is that we are willing to find out the better like of users between subscript spreading and without-subscript spreading onto mobile phone keypad. We refer to this mapping as "without-subscript" layout as the subscripts are not spread on the keypad. Here, the idea is the same as the former both in vowel grouping way and text entry, Two-key. As shown in Fig. 4, from 1 key to 5 key only 5 consonants are translated in each key. Thus, users need to remember only 5 letters per key for consonant, which might lead them to access more quickly to their potential character.

1 key=ក,ខ,គ,ឃ,ង,១
2 key=ច,ឆ,ជ,ឈ,ញ,២
3 key=ដ,ឋ,ឌ,ឍ,ណ,៣
4 key=ត,ថ,ទ,ធ,ន,៤
5 key=ប,ផ,ព,ភ,ម,៥
6 key=យ,រ,ល,វ,ស,ហ,ឡ,អ,៦
7 key=◌ា,◌ិ,◌ី,◌ឹ,◌ឺ,◌ុ,◌ូ,◌ួ,ɔ,៧
8 key=◌ើ,◌ឿ,◌ៀ,◌េ,◌ែ,◌ៃ,◌ោ,◌ៅ,ៗ,៨
9 key=◌ុំ,◌ំ,◌ាំ,◌ះ,◌ុះ,◌េះ,◌ោះ,?,៩
0 key=◌់, ◌៉,◌៊,◌៍,◌័,◌៏,◌៌,◌៎,S,◌្,0
* key=ឥ,ឦ,ឧ,ឩ,ឪ,ឫ,ឬ,ឭ,ឮ,ឯ,ឰ,ឱ,ឲ,ឳ,
។,?,៖,ៗ,៘,។ល។,ខ្ញុំ,អ្នក,ឲ្យ
key= Change Mode

Fig. 4 Two-key without Subscript key mapping

6. User Study

We conducted a user study to learn more about the speed of the system and users' preference on consonant and vowel layout. We recruited five volunteer subjects; all of them are native Cambodians with the age ranging from 24 to 26. All own a cell phone that they use regularly both making call and writing SMS. We are interested in participants who are already familiar with phone and experience in writing SMS either in Khmer or English. Some could type Khmer Unicode while others do not have experience with this typing style.

As described earlier, our approach has two key-mappings ("with subscript" and "without-subscript");

hence, the intent of the user study was to explore the possible mapping layout of consonant subscripts, possible grouping vowel and to investigate the speed of those two prototypes compared with the existing model, Multi-tap.

Subjects were trained before starting the experiment, and thus to familiarize themselves with the method, they were permitted to key in either the practice words or their own words, which took for about 15 minutes. Subjects were told that their typing speeds will be recorded and yet they must correct all of the incorrect typing. Once being able to get started with experiments, subjects were asked to type 5 Khmer sentences used in daily conversation between friends, and composed of most of the consonants, vowels, numbers, and diacritic signs. We tracked the users' time to complete each the whole dialog with which each user was requested to type 5 trials. Fig. 5 is the sentences used in our experiment.

ស្វស្តី!
សម្លាញ់ឯងដឹងទេ គ្នាបានក្លាយជាបុគ្គលិកពេញសិទ្ធិហើយ។
គ្នាសប្បាយចិត្តខ្លាំងណាស់។
ថ្ងៃទី២០ ខែ៨នេះគ្នានឹងបានចូលធ្វើការហើយ។
ជួបគ្នាថ្ងៃក្រោយ

Fig. 5 Experiment sentences

7. Result and discussion

Keystroke per character

We analyzed each of input method to investigate the efficiency for entering Khmer text. To measure the efficiency of text entry, Mackenzie presented Keystroke per Character (KSPC) metric [4]. The equation is as follows:

$$KSPC = \frac{\text{Total Number of Keystrokes}}{\text{Total Number of Characters of Transcribed Text}}$$

We examine the overall Khmer characters (consonants, independent vowel, dependent vowels and diacritics) and the experiment sentences. As shown in Fig. 6, when considering for all Khmer character, Nokia input method needs 5.39 Keystrokes for a character while Two-key with Subscript and Two-key without Subscript need 2.96 and 3.13, respectively. In the experiment sentences, Nokia requires 3.02 keystrokes for a character, and 2.11 and 2.19 keystrokes are needed for Two-key with Subscript and Two-key without Subscript, respectively. KSPC of Two-key with Subscript is less than that of other methods in that with this method there is no extra keystroke to indicate a subscript of the consonant while other two methods, Nokia and Two-key without Subscript do.

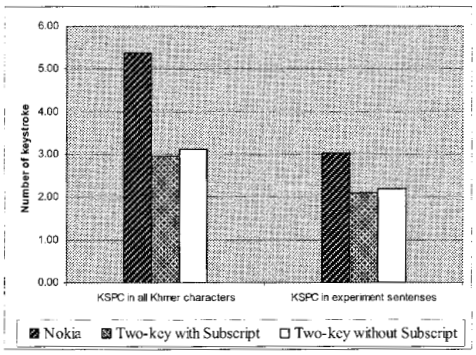

Fig. 6 Keystroke per character

Theoretically, two-key concept needs exactly 2 key-presses for a character; however, in the real implementation the keystrokes is higher because some characters whose position is difficult to be remembered are kept in the table list that users can get by using arrow key. That's because we observed that users may need not only the speed but also joy with the device. Thus, the method demands much more memory for them may not catch their attention much.

Accuracy

For error rate calculation we adapted the equation presented by MackKenzie and Soukoreff (2003) [5]. The equation is as follows:

$$\text{Error Rate} = \frac{MSD(A,B)}{\max(|A|,|B|)} \times 100$$

Where A is the presented text and B is the transcribed text. MSD (Minimum String Distance) of the presented text and transcribed text is the minimum numbers of primitives -- insert, delete or substitute.
From the above equation, [7] simplifies total error rate by the combination of uncorrected error and corrected error. However, as stated earlier, users must

correct the uncorrected spelling thereby we consider only corrected error. We direct users to paper [7] for more detail information on error correction.

There was a quite difference in error rate among the three methods. As illustrated in Fig. 7, all users generated error the most with Nokia method. It was observed that with Multi-tap, users enjoyed pushing the button and thus tended to go further the desired character. In contrast, with Two-key approach users just had to scan for the position of the character thus the chance of error is less. As a whole, Two-key without Subscript yielded the least error rate of 9.96% while the Multi-tap condition had 13.30% and the Two-key with Subscript had 10.40%.

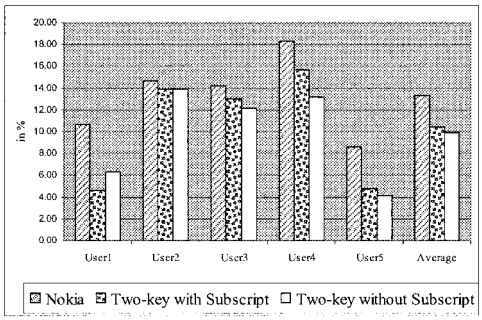

Fig. 7 Error rate

Speed

Generally, words per minute (WPM) is mostly calculated to report the speed of a text entry method in similar papers. The common definition for "word" is a term of 5 characters including spaces (Yamada, 1980). However, in our case, it's not reliable if we focus on WPM as the number character per word of syllabic script and alphabet language might not be the same. We hesitate to measure 5 characters per Khmer word as there is no exact indication source. Therefore, we based on characters per minute (CPM) to demonstrate our text input speed. Herein, we calculate CPM by dividing the transcribed text which consists of 135 characters length with the completion time of each trial of user in minutes.

As depicted in Fig. 8, Two-key with Subscript yielded the least result by almost all users except user1. User1 and user3 typed faster with Multi-tap while user2, user4 and user5 went faster with Two-key without Subscript. In overall, there was no significant difference in entry speed between Multi-tap and Two-key without Subscript in which Multi-tap averaged 20.43 CPM while Two-key without Subscript averaged 20.54 CPM.

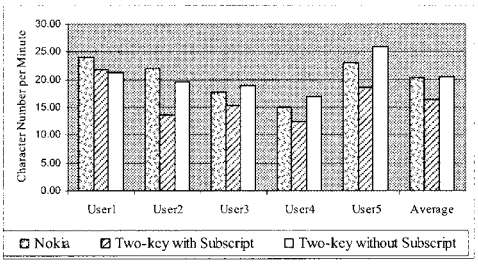

Fig. 8 Speed in character per minute

Discussion

In the experiment, Two-key approach gives better keystroke per character and error rate than Multi-tap, however, regarding speed Multi-tap and Two-key without Subscripts yielded the same result. There might be some reasons hindering the Two-key approach method. This may be because the subjects do not have any experiences with Two-key approach while all of them know exactly Multi-tap input style though they never used with Khmer language, yet with English. Another factor might be that users spend much time to scan for the position of the letter in the group. We were told that none of them remembers the position of the characters. Thereby, time spending to scan for the character is quite lots for the novice users. We strongly believe if they were given more training time the speed should be faster as they don't have to stare at the screen and seek for the position of the desired character.

Critique of the method

The experiment was conducted with only a limited number of users and for a short period, and did not address the long term use. A long term study with more subjects would prove the better performance of the Two-key approach in terms of speed.

The experiment sentences are commonly used in text message by friends and hence they are not representative of all character of Khmer language.

As reported by subjects, Two-key method demands more memory than Multi-tap. Therefore, it may need some training for the first time users since they may find it hard to remember the order of the mapping characters for the vowel grouping. It may need the

attention of the users to recognize subscript consonant since in Two-key with Subscript we spread the subscript consonants on keypad which is different from existing Nokia model (in order to get a subscript one needs to press "្" sign indicating that the next consonant will be the subscript of the cluster, not the base consonant). * key seems to be overflow because we include all of diacritics sign with independent vowels. However, those signs are not usually used and the users can access to this sign by using arrow key.

Questionnaire

Post questionnaire was conducted in order to disclose the subject's preference of the three models in overall and consonant mapping and vowel mapping in particular. We have two types of questionnaire. 1: was asked the subjects to complete right after each method is finished, and 2: was provided after the whole experiment. For the first type, we gave participants four Likert Scales (1-5) to get their feedback in terms of the comfort-ability and user-friendliness of the three methods. Mean and standard deviation of all users can be seen in table2. Generally, all of the methods seem to equally attract the users since they were pointed almost the same rate.

Table 2: Mean (Standard Variation) of each method provided by 5 subjects

Likert Scales (range 1-5)	PG with Trackball	PG with Mouse	Software Keyboard
Difficult-Easy	3.6 (0.55)	3.6 (1.67)	3.8 (1.30)
Painful-Enjoyable	3.4 (0.89)	3.6 (0.89)	3.6 (0.89)
Slow-Fast	3.8 (0.84)	3.8 (0.45)	3.4 (1.14)
Dislike-Like	3.2 (1.3)	3.8 (0.84)	3.8 (0.84)

At the end of the experiment, we again asked users to provide their feedback regarding vowel and subscript arrangement. Surprisingly, less relax and memory-consuming were reported as the drawbacks of Two-key without Subscript compared to Multi-tap, however it was rated as the most like with the reasons that there were fixed in keystroke and less error (no pressing beyond the desired letter as one in Multi-tap), and once they continued and started to remember the character position they find it easier and enjoyable. All subjects prefer to press one key and a consonant key successively to form a subscript rather than recognizing the subscript itself. Of 5 users, 3 rated our vowel grouping method as their preference, for its nature in order, less-confusion and ease in recognizing the group.

8. Conclusion

Two techniques for text entry on mobile phone for Khmer language were evaluated. Multi-tap method is the existing method that is currently utilized by Nokia handsets. Two different key mappings based on Two-key method, uses 2 keys per character. With the experiment, we observed that the Two-key without Subscript yielded better result compared with Multi-tap in KSPC and in error rate. However, there was no significant difference in speed among the three. Though KSPC of Two-key without Subscript is more than that of Two-key with Subscript, it gains more popularity due to the fact that users don't like to search for the subscript sign. We believe that our proposed method as well as proposed vowel grouping is practical with the long-term training. We do hope that this approach could have a good chance of adoption.

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