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ミャンマー語ソフトウェア・キーボードのための LRUDC（左・右・上・下・中心）ボタン

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本論では、ミャンマー語ソフトウェア・キーボードのための LRUDC（左・右・上・下・中心）ボタンすなわち5入力領域ボタンインターフェースを提案する。LRUDCボタン文字入力方式は既に提案した「位置予測」に基づくもので、母音と下付き子音をそれぞれタイプする必要がないため、子音結合（子音＋母音あるいは下付き子音など）の容易な入力が可能である。初回ユーザスタディでは、LRUDCボタンソフトウェア・キーボードプロトタイプを使用すると1文字入力に必要なキーストロークが減少し（KSPC＝0.96）、「Win Myanmar Visual Keyboard Input」に比べてより使い勝手が良いとの結果が出た。また、初心者でも、マウスを使用して最高38.55文字／分で、スタイラス・ペンを使用して最高35.53文字／分でタイプすることができた。さらに、LRUDCボタンインターフェースの概念は、ミャンマー語のみならず、クメール語、ラオ語、バングラ語、タイ語、チベット語、ヒンディー語、ネパール語といった他の音節言語すなわちBrahmic文字群にも適用可能である。

LRUDC (Left, Right, Up, Down and Center) Button for Myanmar Language Software Keyboard

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We propose the *LRUDC* (Left, Right, Up, Down and Center) button or five pressing areas button interface for Myanmar language software keyboard. The text input method or pressing *LRUDC* button is based on our proposed "Positional Prediction" [1], [2]. With *LRUDC* button interface, users can easily type one Myanmar consonant cluster (i.e. one consonant + other characters especially vowels or subscripted consonant) because of no necessity to type combination of exact vowel character(s) or subscripted consonant. The result of the initial user study shows that the current *LRUDC* button software keyboard prototype enables better Keystrokes per Character (i.e. *KSPC* = 0.96) and user friendliness than "Win Myanmar Visual Keyboard Input". Even first time users were able to type at ~38.55 Characters per Minute with mouse and ~35.53 Characters per Minute with stylus pen by using *LRUDC* button interface. And the concept of *LRUDC* button interface is applicable not only for Myanmar language but also for other similar syllabic based languages or Brahmic family of scripts such as Khmer, Lao, Bangla, Thai, Tibetan, Hindi, and Nepali etc. [3].

1. Introduction

In this paper, we propose Left, Right, Up, Down and Center (*LRUDC*) Button text input interface for Myanmar language. *LRUDC* button text input interface is based on our proposed Positional Prediction (*PP*) text input method [1], [2]. *PP* is the prediction method of possible combinations of a consonant and vowels (i.e. a consonant cluster) based on positional parameter of vowels or characters for Myanmar language. *PP* text input method is designed for Myanmar language text input on mobile devices. *PP* concept is also applicable for other similar syllabic based languages or Brahmic family of scripts such as Khmer, Lao, Bangla, Thai, Tibetan, Hindi and Nepali etc. [3]. We investigated *LRUDC* button text input interface based on the concept of *PP*. Currently there is no consonant cluster or word prediction method for Myanmar language yet, and therefore, we compare *KSPC* (Keystrokes per Character) [4] and *CPM* (Characters per Minute) [10] of LRUDC with famous QWERTY based "Win Myanmar Visual Keyboard Input" [9]. From our initial analysis, *KSPC*

of *LRUDC* button interface is 18.20% lower than "Win Myanmar Visual Keyboard Input". And *CPM* of *LRUDC* button interface is only 18.37% lower than "Win Myanmar Visual Keyboard Input". *CPM* of *LRUDC* button interface is lower than Win Myanmar Visual Keyboard Input because *LRUDC* button interface is not one to one keyboard mapping. According to the result of the initial user study, LRUDC button interface is very user-friendly, and even first time users were able to type at ~38.55 CPM with mouse and ~35.53 CPM with stylus pen. We believe that LRUDC button is one of the possible text input interfaces for PP.

2. Related Works

In this section, we summarize predictive text entry methods of mobile devices already in use and some methods under development. We refer to some of the similar text input interfaces like *LRUDC* button, too.

2.2 Predictive Text Entry Methods

Predictive text entry methods predict most possible characters, words or phrases based on the buttons pressed by users, usage frequency, linguistic models and users' typing history etc. The earliest predictive text entry method for phonetic language was done in Japan in the 1960s (Kurihara & Kurosaki, 1967). Today, all Japanese mobile phones support word-based prediction, and some of them support phrase-based prediction as well. To our knowledge, there are two basic methods to overcome the ambiguity occurred by predictive text input methods; *Dictionary-based Disambiguation* and *Prefix-based Disambiguation* methods [6].

2.2.1 Dictionary-based Disambiguation

Commercial examples of predictive text entry methods based on Dictionary-based Disambiguation are *T9* by Tegic Communications (Grover et al., 1998), *eZiText* by Zi Corporation (Zi Corporation, 2002) and *iTAP* by Motorola (Lexicus Division, 2002). These methods match the key sequence to words in a dictionary and suggest a most possible or frequently used word. If the suggested word does not match the word users intended to write, they can browse through the suggested words list and choose. In some interfaces, users can access the intended word by pressing a next-key. Dictionary-based Disambiguation is not perfect because many words may have the same key sequence. For example, there are four words (i.e. super, strep, purer, surfs) matching the mobile phone key sequence 7-8-7-3-7. The merit of the *Dictionary-based Disambiguation* is the very fast input mechanism for words in the dictionary; however, it is slow for words that are not listed in the dictionary.

2.2.2 Prefix-based Disambiguation

LetterWise and *WordWise* predictive text input methods are based on *Prefix-based Disambiguation* [5], [6].

LetterWise does not consider between dictionary and non-dictionary words, and only considers the letter digram probabilities (e.g. in English, after the letter 't', 'h' often comes and 'g' rarely does in comparison). And thus, any word can be entered though some words may require additional key presses (e.g. next key). The *KSPC* of *LetterWise* is 1.15 [6].

WordWise is a linguistically optimized predictive text input method developed by Eatoni Ergonomics [5]. It uses an auxiliary key (i.e. similar to a shift key on a PC keyboard) for unambiguously entry of some letters on the standard telephone keyboard. The eight letters of English (i.e. 'c', 'e', 'h', 'l', 'n', 's', 't' and 'y') were chosen for unambiguous entry. This specific combination was chosen to minimize the program's lookup error rate and query rates (MacKenzie, Kober, Gutowitz, Jones and Skepner 2001). However, the demerit of the *WordWise* is that two keys must be pressed in parallel.

2.3 Similar Text Input Interfaces

Gesture Keyboard (GKB) for Devanagari (one of the Indic scripts) is based on handwritten gesture recognition technology, which was proposed by R. Balaji, V. Deepu, Sriganesh Madhvanath and Jayasree Prabhakaran [7]. GKB input method is very appropriate with the nature of syllabic scripts writing system. In this input method, users do not need to write down Devanagari consonants, and they are already shown on a tablet keyboard. Users can type a consonant by giving a special gesture command (i.e. strike through over a consonant). Other matras (i.e. vowel signs) can be typed by writing at a specific position relative to the glyph of the base consonant. This input method is smart and can be applied to other similar syllabic scripts. Recognition accuracy and typing speed can increase compared to normal handwritten techniques. However, users need to write down vowel signs or other combination symbols correctly, which may lead to slow down typing speed. In addition, it is still necessary to create recognition engine for vowel signs or other characters.

Multi-directional Input Keypad (MIK) assigns 5 characters on a key of mobile phone keypad for alphabetic languages such as English and German [8].

MIK uses five simple manipulations within the key's surface. They are 1) short-time touch (pressure) or stronger pressure on the key, 2) Northward lateral movement of a finger on the key with the following release, 3) Eastward lateral movement of a finger on the key with the following release, 4) Southward lateral movement of a finger on the key with the following release and 5) Westward lateral movement of a finger on the key with the following release. Logically, it is not even necessary to position a finger on the central region of the key. For example, key "2" assigns "North" as 'A', "East" as 'B', "South" as 'C' and "West" is reserved. The letter 'A' can be typed by moving lateral motion of finger to the North on the button number 2 (see Fig.1).

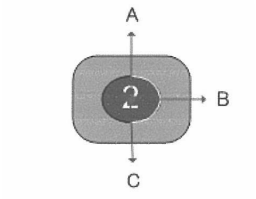

Fig. 1 Directions of the finger movements to type the letter 'A', 'B' and 'C' on MIK mobile phone keypad

3. Myanmar Language Writing System

Myanmar or Burmese language has a phonetic writing system, and words are basically formed by combination of a consonant and vowels (e.g. "ေ-", "ိ", "ီ" and "ော" etc.). But independent vowels (e.g. "အ", "ဣ", "ဩ" and "ဧ" etc.) do not need to be combined with consonant to get a pronunciation. Myanmar language has various types of characters compared to English (i.e. consonants, dependent vowels or medials, independent vowels, finals, tones and subscript characters or conjunction alphabet etc). And Myanmar language contains many Pali words especially in religious vocabulary such as praying. Overall writing direction is from left to right, and the word order is SOV (Subject + Object + Verb). In a Myanmar sentence, spaces are used to mark phrases, not to divide words. From our studies, possible combinations of a consonant and vowels (i.e. a consonant cluster) are formed by four directions or Left, Right, Upper and Lower positions (see Fig.2).

Upper
+
Left + Left + Consonant + Right + Right + Right
+
Lower

Fig.2 Logical structure of Myanmar consonant cluster (here, Left = left vowels, Right = right vowels, Upper = upper vowels and Lower = lower vowels)

A Myanmar word can contain one or more consonant cluster(s). For example, "ကျောင်းသား" (student) contains 3 consonant clusters (i.e. "ကျ", "င်း" and "သား").

4. Concept of Positional Prediction

Here, we briefly explain our proposed "Positional Prediction" or consonant cluster prediction concept for Myanmar language [1], [2]. Myanmar language writing system largely depends on adding left, right, upper and lower characters to consonant. Here, left, right, upper and lower characters mean Myanmar dependent vowels, directives and subscript consonants that are always written with a consonant, and their positions are defined when they are combined. PP uses four directional arrow keys to get positional information of dependent characters. For example, to type "လူ" meaning human in Myanmar language, users only need to type "လ" (La) consonant and down arrow key, and then make selection from the possible combination list of La consonant with lower vowels. The typing steps can be seen in Fig.3.

လ	+	↓	+	Selection
(Consonant "La")		(Positional Information of Vowel)		(Selection from the Possible Combination List of "La")

Fig.3 Typing steps of a Myanmar word "လူ" (human) with PP

The vowel positional information adding order can be "Consonant + Left + Down + Up + Right" or "Consonant + Left + Up + Down + Right". Logically, it can also support hand writing order (i.e. "Left + Consonant + Down + Up + Right" or "Left + Consonant + Up + Down + Right"). Users only need to mention positional vowel information once for one direction even for the words that need to combine more than one positional vowel. For example, users need to type "consonant + right" only for "consonant + right + right + right" consonant clusters.

PP text input method is applicable for many kinds of mobile devices because almost all of current mobile devices contain four directional arrow keys (e.g. Nokia N76 mobile phone, Dell X51 PDA, Sony PSP portable game player and XO laptop). The merit of the proposed predictive text input method is that even first time users can type Myanmar sentences with

appropriate typing speed (i.e. average typing speed is 32.96 *CPM* and ~41.57 *CPM* with mouse, ~41.84 *CPM* with stylus pen) [1], [2].

5. Left, Right, Up, Down and Center (LRUDC) Button Interface

LRUDC button is a new proposal of typing interface for Myanmar language. The main idea is to apply the PP text input concept to each Myanmar consonant button or key. We logically divide a button into 5 areas (i.e. Left, Right, Up, Down and Center). "Left area" is for left characters, "Right area" is for right characters, "Up area" is for upper characters, "Down area" is for lower characters and "Center area" is for a consonant. For example, a Myanmar word "ဒီမိုကရေစီ" (Democracy) whose word formation is "Da" consonant + Upper vowel, "Ma" consonant + lower vowel + Upper vowel, "Ka" consonant, "Ra" consonant + Left vowel and "Ca" consonant + Upper vowel. To type this word, users only need to press following six keystrokes:

1. Upper part of the "Da" consonant button
2. Lower part of the "Ma" consonant button
3. Upper part of the "Ma" consonant button
4. Center part of the "Ka" consonant button
5. Left part of the "Ra" consonant button
6. Upper part of the "Ca" consonant button

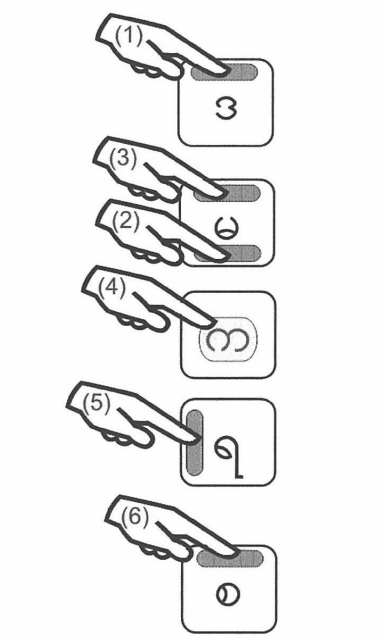

Fig. 4 Typing steps of a Myanmar word "ဒီမိုကရေစီ" (Democracy) with LRUDC button interface

By using *LRUDC* button interface, the movement time between consonant buttons and four direction arrow keys can reduce. This method is very easy to understand for native users, but the size of the *LRUDC* buttons needs to be bigger than normal buttons. *LRUDC* button interface can be applicable not only for software button but also for hardware button [8]. If we consider *LRUDC* button interface for mobile phones, the performance will also depend on keyboard mapping, size of keys, number of suggested consonant clusters on the screen and interactive feedback etc.

6. Prototype Implementation

We implemented a software prototype of *LRUDC* button interface for Myanmar language text input (see Fig.5) with Microsoft Visual Studio 2005. For the implementation, Visual Basic programming language was chosen, which is simple coding and suitable for rapid development.

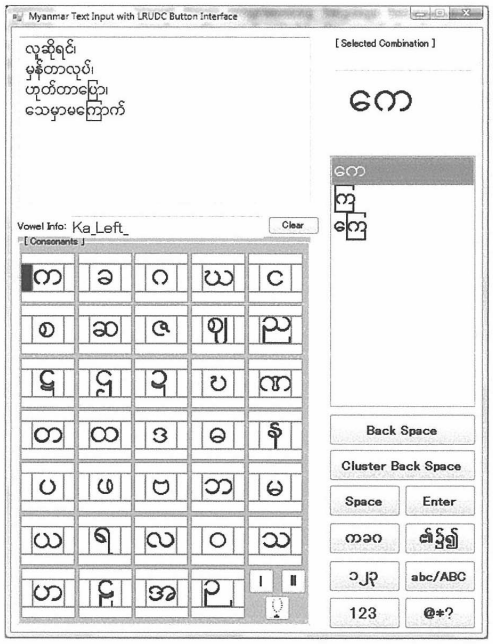

Fig.5 LRUDC Button Interface Prototype

The program was designed to run on a tablet PC and electronic white board. The program computes a list of possible vowel combinations based on the left, right, up and down parameter for the consonant of the pointed button. The program also removes impossible or unmeaning and unpronounceable vowel combinations, and the best suggestion is displayed as a list. Users can easily type the same consonant

cluster repeatedly. This is useful because some Myanmar words and names use the same consonant cluster twice (e.g. "ဖေဖေ" (mother), "ဖေဖေ" (father), "လာလာ" (come) and "ဒေးဒေး" (Aye Aye; common name of Myanmar girls) etc.)

7. Initial User Study

We held user experiments with our *LRUDC* button interface prototype in order to figure out users' typing speed. We used mouse and stylus pen with Tablet for the user study with five Myanmar native participants who are between 21 and 43 years old. Three of the participants were familiar with PC but had no prior experience of using stylus pen. The experiments procedures are as follows:

1. Explaining the concept of Positional Prediction text input
2. Making demonstration of text input with prototype
3. Allowing 5 minutes practice time for each user to learn the concept of *PP* and *LRUDC* button interface
4. Recording users' typing speed of short SMS message (6 Myanmar sentences) [2] for 5 trial times (including error correction time)
5. Getting their feedback for *LRUDC* button interface

8. Evaluation and Discussion

As an evaluation of the efficiency of *LRUDC* button interface, we made an initial comparative test between *LRUDC* button and Win Myanmar Visual Keyboard interfaces [9]. Average typing speed for "Win Myanmar Visual Keyboard" is referred from our previous experiments held with 2 users for a week. The average *CPM* of the Win Myanmar Visual Keyboard is 42.4, and the one of the *LRUDC* button interface is 34.61. It was found that the *CPM* of *LRUDC* button interface is only 18.37% lower than Win Myanmar Visual Keyboard, because its keyboard layout is based on QWERTY (i.e. using more keys than our prototype) and most characters are mapped one to one.

For the performance analysis, we also calculated *KSPC* [4] and *CPM* [10] of Win Myanmar Visual Keyboard and *LRUDC* button interface. We used 10 random Myanmar words, Pali words, names, place names, phrases, proverbs [11] and poems from the database. In the database words of Myanmar-English dictionary (published by Myanmar Language Commission), 500 Myanmar names, 200 Myanmar place names, 500 phrases, 100 Myanmar proverbs and 10 Myanmar famous poems such as "A Phoe Gyi O" were typed by the first author and his brother Mr. Ye Kyaw Thein. Currently, the electronic version of various corpuses for Myanmar language cannot be found. Higher *KSPC* values indicate that users need to type next key or any additional letters to get a desired word. A *KSPC* value of 1.0 shows perfect disambiguation. Our detail analysis shows that Win Myanmar is 1.18 *KSPC* and *LRUDC* is 0.96 *KSPC*. *KSPC* of *LRUDC* button interface is 18.20% lower than Win Myanmar interface (see Fig. 6). The main reason is that independent vowels do not need to be typed in the *LRUDC* Button interface.

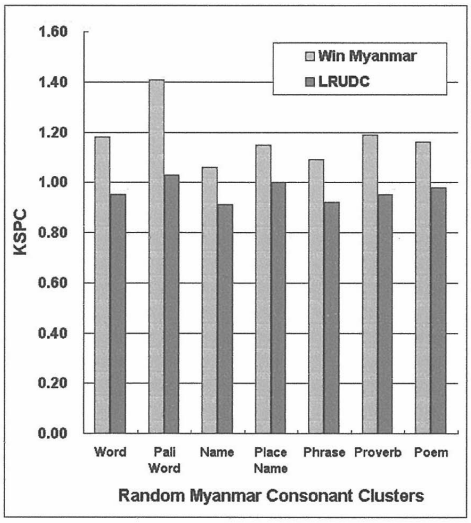

Fig. 6 KSPC of random Myanmar consonant clusters for Win Myanmar Visual Keyboard and LRUDC button interfaces

We also made analysis on *KSPC* values versus number of characters length of a consonant cluster in Win Myanmar and *LRUDC* button interfaces. From our analysis, it was found that the maximum length of a consonant cluster is 5 such as "ကြိုး", "ကျော်" and "မျိုး". We also randomly retrieved 10 consonant clusters for length of 2, 3, 4 and 5 from the database. Fig. 7 shows *KSPC* values comparison between Win Myanmar and *LRUDC* button interfaces based on the length of consonant cluster. From these results, we can clearly see the difference in *KSPC* value between Win Myanmar and *LRUDC* (Average values are 3.98 *KSPC* for Win Myanmar and 3.08 for *LRUDC*).

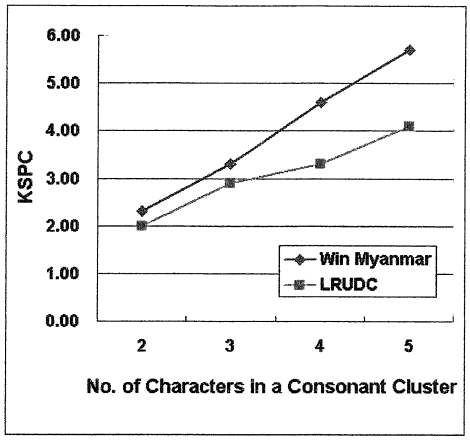

Fig. 7 KSPC versus mean consonant cluster length in LRUDC button

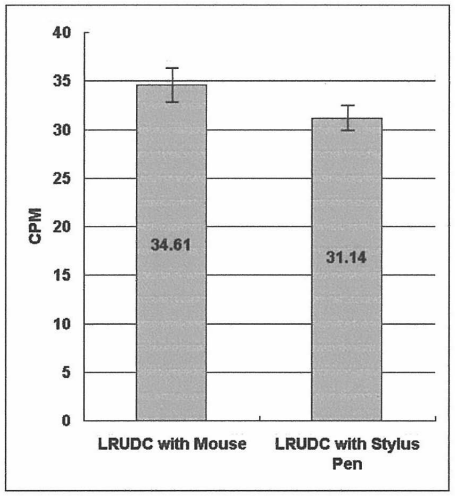

Fig. 8 Average CPM and standard deviation of LRUDC typing with mouse and stylus pen (vertical lines on the bars show standard deviation)

We made typing speed evaluation with Characters per Minute (*CPM*) instead of Word per Minute (*WPM*) [10]. This is because there is no standard definition for a word in Myanmar like in English (i.e. common definition of a word = 5 characters, including spaces) (Yamada, 1980) [10]. Average *CPM* and standard deviation of *LRUDC* button interface typing with mouse and stylus pen can be seen in Fig.8. Participants can type faster with mouse, and possible reason for this is that they are familiar with mouse than stylus pen, and size of the LRUDC buttons may be linked.

9. Conclusion

This paper has reported our investigation into Positional Prediction text input interfaces. We have proposed a new possible text input interface for Myanmar language called *LRUDC* button interface. This text input interface is very simple, easy to understand and applicable for similar syllabic based languages. All of the participants in our user study answered that they prefer *LRUDC* button interface to "Win Myanmar Software Keyboard". We will make further refinements on the current prototype and follow up analysis on such as error rate comparison.

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