POSITIONAL GESTURE FOR ADVANCED SMART TERMINALS: SIMPLE GESTURE TEXT INPUT FOR SYLLABIC SCRIPTS LIKE MYANMAR, KHMER AND BANGLA

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ABSTRACT

In the Next Generation Network (NGN), various kinds of advanced smart mobile terminals will be used for various communication services. We believe that text typing on small mobile devices will become more popular than it is today and also necessary for developing countries such as Myanmar (Burma), Cambodia and Bangladesh etc. In these countries, however, there is no proper or easy text input method for mobile devices yet. Positional Gesture Text Input is a novel concept of text input for syllabic scripts like Myanmar, Khmer and Bangla languages. Text input of syllabic scripts poses a unique challenge because many syllabic characters are formed by combinations of consonants, dependent vowel signs, tones and subscript consonants etc. And thus, text input for syllabic scripts is still difficult even with PC keyboards. In this paper, we propose very simple gesture recognition for syllabic scripts text input based on their writing natures. It is accessible even for first time users and applicable for many mobile computing devices such as tablet PCs, mobile phones, PDAs and portable game players etc.

Keywords— Positional Gesture, pen based text entry, gesture based user interface, soft keyboard, syllabic scripts

1. INTRODUCTION

In the Next Generation Network (NGN) or ubiquitous network, various kinds of services and applications will be run on small and smart mobile devices. Text typing or text communication with smart mobile devices will become more important not only for developed countries but also for developing countries such as Myanmar (Burma), Cambodia and Bangladesh. Official languages of these countries are syllabic based and have different nature from the one of English. But most of the current text input methods or keyboard standards are based on English (e.g. PDA with QWERTY keyboard and Graffiti alphabet) and not considered for syllabic languages. In this paper, we propose a novice text input method "Positional Gesture" (PG) that uses simple gestures and small numbers of command for syllabic (or) phonetic based scripts text input. Gesture interaction has become a popular and important interaction technique for present computing. In earlier days, gesture interaction was used only for Virtual Reality (VR) or 3D user interfaces with special input devices like data glove. Nowadays, we can even find gesture inputs used on consumer electronics such as Nintendo Wii game console, mobile phones integrated with inertial sensors and mouse gesture commands on some web browsers. And some researchers have already proposed gesture based text input methods for wearable computing, but most of them use many gesture commands (e.g. Gesture-to-Character mapping table). Therefore, text input is not accessible for first time users even for English language (only 26 letters). According to the user study results of Myanmar and Khmer language Positional Gesture text input, we believe that this is one of the possible text input interfaces for syllabic scripts.

2. RELATED WORKS

In this section, we discuss some of the current handwritten or gesture based text input methods for touch screen interfaces.

Since traditional handwritten recognition had many limitations like slow typing speed, Goldberg and Richardson introduced Unistroke alphabet in 1993 [1]. In Unistroke, each character is represented by a single stroke and can be used even by blind people. And thus, there is no segmentation problem in the recognition process. However, users have to spend some time for learning Unistroke characters, which are difficult to learn and recall [2]. If we apply this concept to syllabic scripts, it will become more complex and require more learning time of users.

GraffitiTM is another handwriting alphabet developed by Palm Computing for Palm Pilot PDA product series. It requires minimal time for learning Graffiti alphabet because it is very similar to normal English alphabet. For the recognition process, however, Graffiti strokes are more complex compared to Unistroke strokes.

EdgeWrite is also based on unistroke text entry idea for handheld devices like PDAs, and is designed for people with motor impairments [3]. Text can be entered by traversing the edges and diagonals of a square hole imposed over the usual text input area of PDA. In EdgeWrite, recognition algorithm is checking not only

pattern recognition but also the sequence of corners that are hit. The authors of EdgeWrite mentioned that users can type 18% more accurate than Graffiti ($p<.05$), with no significant difference in speed.

All of the input methods mentioned above are based on English alphabet, and though it is possible to create Graffiti like characters or Unistroke based characters for syllabic scripts e.g. in Myanmar language, we may need to define the writing positions for combination characters (e.g. vowel signs, tones, subscript characters etc.) because these characters have to be written according to their defined writing positions. (See example word for Myanmar language in Fig.1). And most of the Myanmar characters are similar in shape or glyph such as (က, ဃ, တ, ထ, ဘ, ယ, လ, သ, ဟ), (ခ, စ, ဓ) and (ဂ, င, ပ, ဝ). In handwriting text input, it will be difficult for these kinds of characters to be distinguished by the recognition engine, and this will affect the accuracy.

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 [4]. GKB input method is very appropriate for 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 have to write down vowel signs or other combination symbols correctly, which may lead to reduce typing speed. And then, it is still necessary to create recognition engine for vowel signs or other characters. Although soft keyboards or visual keyboards are possible solutions for syllabic languages, typing syllabic languages is still difficult for novice users. In addition, they are not suitable for small mobile devices, because it is difficult for most syllabic languages characters (e.g. Myanmar, Bangla and Khmer characters) to be distinguished from other similar characters in small soft keyboards.

Khmer soft keyboard is developed by modeling the standard NiDA (National Information Technology Development Authority) keyboard [8]. It was created just after Khmer Unicode 4.0 was released. The Khmer Unicode keyboard layout differs from the one of old version which is not in Unicode in which the subscript of the consonants is not spread on the keyboard anymore. Instead, a subscript sign is used to indicate that the next consonant is subscript of the cluster, and that the typing order is not from left to right in the same order of hand writing, but in the order of word's spelling.

3. SYLLABIC SCRIPTS

In this section, we briefly discuss common writing characteristics of syllabic (or) phonetic based scripts. Here, the syllabic (or) phonetic based scripts mean segmental scripts (like abugida or alphasyllabary languages). In segmental scripts, vowel sounds are denoted by diacritical marks or other systematic modification of the consonants. The vast majority of syllabic scripts are found from India to South-East Asia. We will use Myanmar and Khmer languages as an example of South-East Asian scripts and Bengali or Bangla language as the one of Indic scripts.

Myanmar script has been a major language of Myanmar for over 1000 years old, and it is also the official language there. It belongs to the Tibeto-Burman language family and derives from Sino-Tibetan. Myanmar alphabet adapted the Mon script in the 8th century. Myanmar language has various types of characters compared with 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 for 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. An example of Myanmar writing system can be seen in Fig.1.

Khmer or Cambodian language is the official language of Cambodia. It is classified as a member of the Eastern branch of the Mon-Khmer language family. Khmer alphabet closely resembles Thai and Lao alphabet, but Khmer is not a tonal language. Some words are borrowed from Sanskrit, Pali, French and Chinese in Khmer. It consists of 33 consonants, 23 dependent vowels, 14 independent vowels and several diacritic symbols [6]. All consonants have modified forms, called sub-consonants, when they occur as the second member of a consonant cluster. Overall writing direction is from left to right. The word order follows SVO (Subject + Verb + Object) pattern as in English. In a Khmer text, there is no space between words, and the space indicates the end of a clause or sentence instead. An example of Khmer writing system can be seen in Fig.2.

Bangla is the official language of Bangladesh. Bangla script being a member of the Indo-Aryan language is derived from Sanskrit. It consists of 11 vowels, 39 consonants and 10 vowel signs, and there are 60 symbols in total. Moreover, many ligatures (conjuncts) and few consonant symbols are also used in Bangla script. It is written from left to right, top to bottom of page as in English. Bangla language follows SOV (Subject+Object+Verb) word order. An example of Bangla writing system can be seen in Fig.3.

4. COMMON CHARACTERISTICS OF SYLLABIC SCRIPTS WRITING SYSTEM

4.1 In Myanmar Language

When we make an analysis of Myanmar sentences, we can basically consider that Myanmar characters are written in three levels (upper, middle, lower). And most characters have their defined positions (e.g. "ေ-" and "ြ" have to be written as front vowel, "ျ", "ြ", "ွ", "ှ", "ၟ", "ၠ", "ၡ", "ၢ" etc. should be written as a lower character and "ိ", "ီ" and "ံ" etc. should be written as an upper vowel and "ာ" , "ါ" and **"ဲ"** etc. should be written right side of the consonants). However, there are several exceptional cases, e.g. although consonant "က" (ka) is usually written in the normal level, when it becomes 'subscript ka' or 'stack character', it becomes smaller than normal ka and is written in the lower level as "ဏ္ဍ" ("ဏ" + "ဍ") in "ဥဏ္ဍ". In Fig. 1, a Myanmar word "Eain Htaung Pyu Gyin" (Marriage) is formed by the combinations of left, right, upper and lower characters and it takes three rows. Here, four vertical lines indicate the pronunciation breaks of "Eain", "Htaung", "Pyu" and "Gyin".

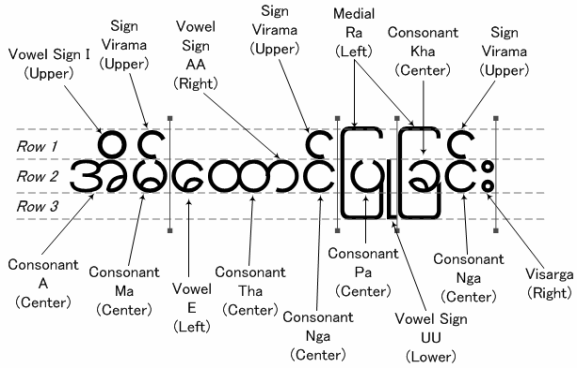

Fig.1 Myanmar Language Writing System

4.2 In Khmer Language

When we make an analysis of Khmer sentences, we can basically consider that Khmer characters are written in three levels (upper, middle, lower) like in Myanmar and Bangla languages. And most characters have their defined positions (e.g. vowel signs "ᦵ", "ᦷ" have to be written in the left side of the consonants, vowel signs "ᦱ", "ᦲ" and "ᦸ" etc. should be written in the right side of the consonants, vowel signs "ᦳ", "ᦴ", and "ᦹ" etc. should be written as a lower characters and vowel signs "ᦶ", "ᦻ", "ᦼ" and "ᦽ" etc. should be written as a upper characters). In Fig. 2, a Khmer sentence "Ti Nih Kampuchia" (This is Cambodia) is formed by the combinations of left, right, upper and lower characters and it takes four rows. Here, three vertical lines indicate the pronunciation breaks of "Ti", "Nih" and "Kampuchia". In the word "Kampuchia", "pu" (Po + U) is written as subscript consonant. In Khmer language, some dependent vowel symbols are written in the place of two rows above or two rows lower than consonant.

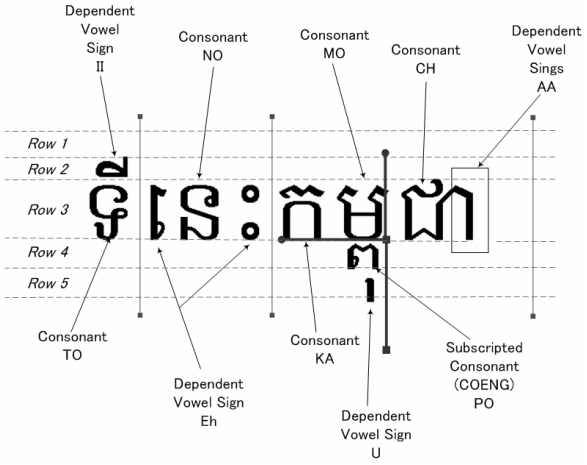

Fig.2 Khmer Language Writing System

4.3 In Bangla Language

When we make an analysis of Bangla sentences, we can basically consider that Bangla characters are written in three levels (upper, middle, lower) like in Myanmar language.

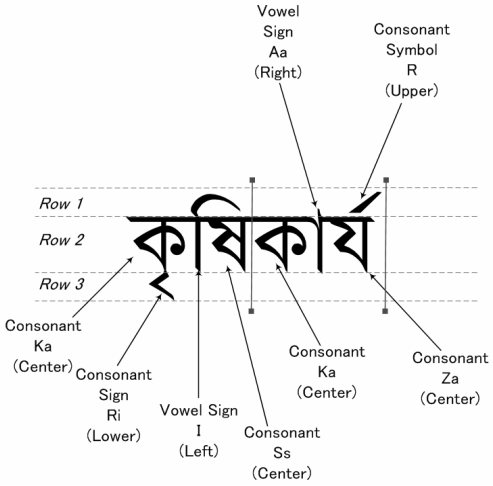

Fig.3 Bangla Language Writing System

And most of them have their defined positions (e.g. vowel signs "ি", "ে", "ৈ" have to be written in the left side of consonants, vowel signs "া", "ী", "ৗ" and consonant symbol "্য" (্য) should be written in the right side of the consonants, vowel signs "ু", "ূ", sign hashant "্" and consonant symbols "্র" (্র), "্ব" should be written as a lower characters and consonant symbol "র্" (র্) and consonant "ং" should be written as an upper characters). And for the ligatures or (combine consonants) such as "ক্ক", "ক্ত", "ক্ম", "ক্ল", "ক্ষ", "চঞ্চ", "প্ট" are written in the middle like consonants. In Fig. 3, a Bangla word "Krissikaarza" (agriculture) is formed by the combinations of left, right, upper and lower characters and it takes three rows. Here, two vertical lines indicate the pronunciation breaks of "Kri"

and "Ssikaarza".

5. CONCEPT OF POSITIONAL GESTURE

When we make an analysis of Myanmar, Khmer and Bangla languages writing systems, there are many common characteristics among them. And we have found that written systems is based on adding of left, right, upper and lower characters to consonant, basically. The logical combination structure found for syllabic scripts writing systems can be seen in Fig.4.

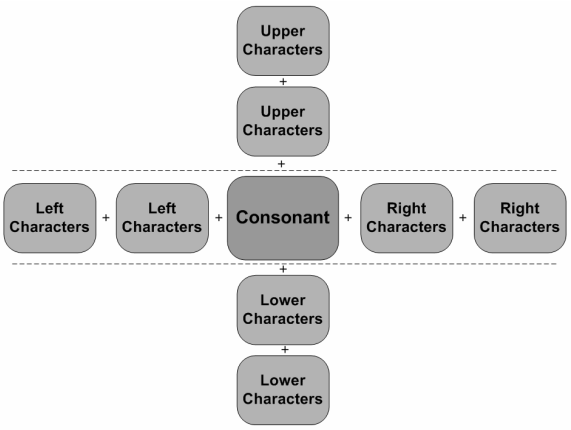

Fig.4 Logical Structure of Syllabic Scripts Writing Systems

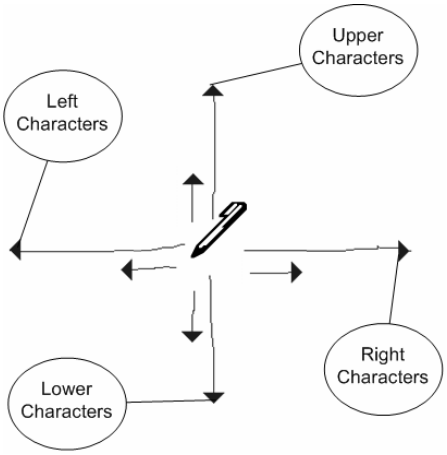

Fig.5 Positional Gesture Text Input Concept

Taking this into consideration, we have developed a new gesture method for syllabic scripts. "Positional Gesture" is a simple gesture text input method for computing devices based on common characteristics of syllabic scripts writing system. The concept is totally based on four simple gesture commands, which are "Left", "Right", "Up" and "Down". "Left gesture command" is for left characters or symbols, "Right gesture command" is for right characters or symbols, "Up gesture command" is for upper characters or symbols and "Down gesture command" is for lower characters or symbols. Here, as a concept, "Left gesture command" can be "dragging mouse pointer to left" or "moving data glove to left" or "pressing left arrow key" or "moving eye ball to left" or anything. For the consonant characters, we can use additional gesture like "drawing dot" or "writing circle" or anything. In our prototypes, we use "Left gesture command with short distance" for Myanmar language and “Double Click” for Khmer language to make it simple. Positional Gesture text input concept can be seen in Fig. 5.

6. PROTOTYPE IMPLEMENTATION

Here, we present Myanmar and Khmer Language Positional Gesture text input interface prototypes (see Fig.6 and Fig.7), which were developed with Microsoft Visual Studio .Net 2003. These prototypes can be used with pen stylus, trackball or mouse.

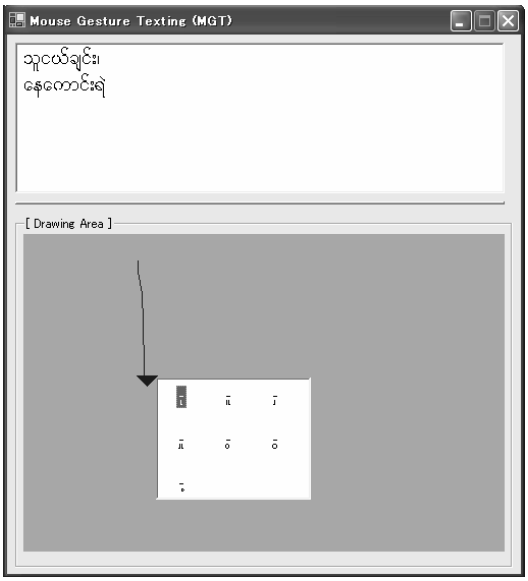

Fig.6 Positional Gesture Prototypes for Myanmar,

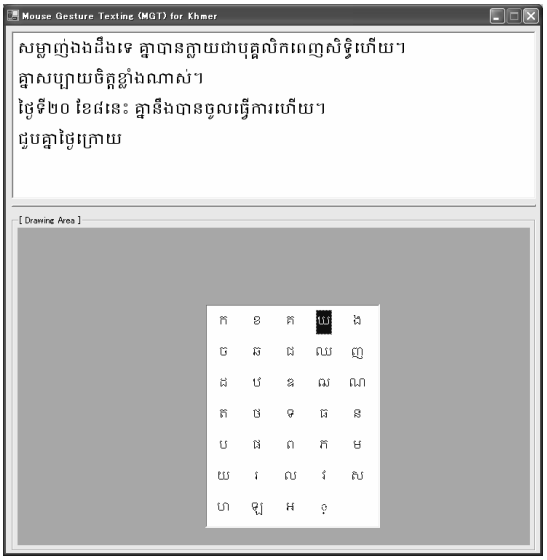

Fig.7 Positional Gesture Prototypes for Khmer,

For the basic text editing, we use "mouse dragging to the left direction by pressing right click button" for "Back Space" function and "mouse dragging to the down direction by right click button" for "Enter" function. Recognition algorithm for our prototype is very simple because it is only necessary to check drawing direction, left click or right

click and length of the path. And there is no need to be straight line, and we allow drawing within angle of 60 degree range for each direction (i.e. Left, Right, Up and Down).

Table 1: Gesture Commands for Myanmar

Gesture Commands	Character Assignments
Left (long)	Left characters (“ေ”, “ြ”)
Right (long)	Numbers (“၁”, “၂”, “၃”, “၄”, “၅” etc.)
Up (long)	Symbols (“@”, “!”, “&”, “$”, “%” etc.)
Down (long)	Subscript consonants (“္တ”, “္ခ”, “္ဂ”, “္ဃ”, “္စ” etc.)
Left (short)	Consonant characters (“က”, “ခ”, “ဂ”, “ဃ”, “င” etc.)
Right (short)	Right characters (“ျ”, “ာ”, “း”, “၊”, “။”)
Up (short)	Upper characters (“ိ”, “ဲ”, “်” etc.)
Down (short)	Lower characters (“ု”, “ူ”, “့”, “ွ”, “ှ” etc.)

Table 2: Gesture Commands for Khmer

Gesture Commands	Character Assignments
Left (long)	Left, Right characters (“ឿ”, “ៀ”, “ោ” etc.)
Right (long)	Numbers (“១”, “២”, “៣”, “៤” etc.)
Up (long)	Symbols (“।”, “,"”, “?”, “!”, “#” etc.)
Down (long)	Independent vowels, Symbols and frequently used characters (“ឱ”, “ឮ”, “។ល។”, “៖” etc.)
Left (short)	Left characters (“េ”, “ែ”, “ៃ”, “ើ”)
Right (short)	Right characters (“ា”, “ះ”, “ាំ”, “ៈ”)
Up (short)	Upper characters (“ិ”, “ី”, “ឹ”, “៊” etc.)
Down (short)	Lower characters (“ុ”, “ូ”, “ួ” etc.)
Double Click	Consonant characters (“ក”, “ខ”, “គ”, “ឃ”, “ង” etc.)

In our prototype, all of the gesture lines are shown with four directions of arrow heads. And the color of the gesture lines will change from blue to red for text editing commands. One limitation of current prototype is that pen stylus should provide left and right click feature

7. USER STUDY WITH PROTOTYPE

We held user experiments for Myanmar and Khmer languages with our developed prototypes in order to know the users' typing speed for Positional Gesture text input. We used PC mouse and stylus pen with Tablet for user study with five Myanmar native participants who are between 21 and 33 years old. And for Khmer language, we used PC mouse and trackball with five Cambodian native participants who are between 24 and 26 years old. All of the participants are familiar with PC but don't have an experience of using pen and trackball. The experiments procedures are as follows:

1. Explaining the concept of Positional Gesture text input
2. Making demonstration of text input with prototype
3. Allowing 10 minutes practice time for each user to learn text input with prototype
4. Recording users' typing speed of short message (6 Myanmar sentences/5 Khmer sentences) for 5 trial times (including error correction time)
5. Getting users' feedback for each prototype with small questionnaires

The Myanmar text (containing 107 characters including spaces) and Khmer text (containing 135 characters including spaces) used for the user study can be seen at Fig. 8 and Fig.9.

သူငယ်ချင်း၊
မတွေ့ရတာ ကြာပြီနော်။
နေကောင်းရဲ့လား။
ငါ့ဖုန်းနံပါတ်အသစ်က ၅၀၀၇၄၅၉၊
အားတဲ့အခါ ဖုန်းပြန်ဆက်ကွာ။
ဒါနော်။

Fig.8 Six Myanmar Sentences for User Study

សួស្តី!
សម្លាញ់ឯងដឹងទេ គ្នាបានក្លាយជាបុគ្គលិកពេញសិទ្ធិហើយ។
គ្នាសប្បាយចិត្តខ្លាំងណាស់។
ថ្ងៃទី២០ ខែ៨នេះគ្នានឹងបានចូលធ្វើការហើយ។
ជួបគ្នាថ្ងៃក្រោយ

Fig.9 Five Khmer Sentences for User Study

8. EVALUATION

We held small questionnaires to participants in order to know their feedback on Positional Gesture.

Table 3: Mean (Standard Deviation) Responses by 5 Myanmar Users for 5-point Likert Scale Questions

Likert Scales (range 1-5)	PG with Pen	PG with Mouse
Difficult-Easy	3.4 (0.89)	4.6 (0.55)
Painful-Enjoyable	3.6 (0.55)	3.4 (1.14)
Slow-Fast	3.0 (0)	4.2 (0.84)
Dislike-Like	4.4 (0.89)	4.6 (0.55)

Table 4: Mean (Standard Deviation) Responses by 5 Khmer Users for 5-point Likert Scale Questions

Likert Scales (range 1-5)	PG with Trackball	PG with Mouse	Software Keyboard
Difficult-Easy	2.0 (1.22)	3.2 (0.84)	4.2 (1.30)
Painful-Enjoyable	2.6 (1.14)	3.6 (0.89)	3.8 (1.10)
Slow-Fast	2.0 (0.71)	3.4 (1.14)	3.8 (1.10)
Dislike-Like	2.8 (1.79)	4.0 (0.71)	4.0 (1.22)

The questionnaires were conducted immediately after typing experiments. We gave participants four Likert Scales (1-5) on which to rate the Positional Gesture text input with 3 different input devices (mouse, pen and trackball). Mean and standard deviation of users for Likert scale questions can be seen in Table 3 and Table 4. Labels for scale endpoints are in the most left columns and higher values are better. From the questionnaire results, we have noticed that most users preferred text entering with mouse than pen stylus or trackball: Myanmar (Mouse>Pen, 4.6>4.4) and Khmer (Mouse>Trackball, 4.0>2.8). One of the reasons might be that the participants used pen with tablet and trackball for the first time in the experiments. The interesting point is that although Likert scales responds by the Cambodian users for trackball are lower than mouse (see Table 4), the average typing speed is nearly the same (7min 38sec for mouse and 7min 37sec for trackball). Overall results of evaluations by users are satisfactory.

8.1 Evaluation by Users' Typing Speed

We recorded the users' actual typing speed and calculated CPM (Characters per Minute) for evaluation process of our Positional Gesture prototype. From the user study results, the average typing speed of Positional Gesture text input to finish six Myanmar sentences (see Fig.8) by pen stylus is 7 minutes 29 seconds (see Fig.10) and 5 minutes 53 seconds by mouse (see Fig.11). And the average typing speed of Positional Gesture text input to finish five Khmer sentences (see Fig.9) by mouse is 7 minutes 38 seconds (see Fig.15) and 7 minutes 37 seconds by trackball (see Fig.16). In general, all of the users' typing speed with our prototypes increased during five trial experiments (see Fig.14 and Fig.19). We used our previous user study result of "Win Myanmar Visual Keyboard" typing speed by 2 users for comparison (see Fig.13) [7]. Average typing speed of 2 users for "Win Myanmar Visual Keyboard" is 2 minutes 30 seconds. We found that Positional Gesture text input method is 199% (with pen) and 135% (with mouse) slower than "Win Myanmar Visual Keyboard". For Khmer, we used Tavultesoft software keyboard that adopted the NiDA keyboard layout, and average typing speed of 5 users is 4 min 38 sec (see Fig.17). For the rest of the paper, we refer to Tavultesoft software keyboard as Khmer Software Keyboard. We found that Positional Gesture text input method for Khmer language is 64% (64.39% for trackball and 64.75% for mouse) slower than "Khmer Software Keyboard".

8.2 Evaluations by Characters per Minute (CPM)

Although Word per Minute (WPM) is the most widely used measure of the text entry performance, we evaluate our Positional Gesture text input rather with Character per Minute (CPM). It is because we cannot find the common definition of "word" in syllabic scripts such as Myanmar and Khmer. Importantly, the WPM/CPM measure does not consider the number of keystrokes or gestures made during entry, but only the length of the resulting transcribed string and how long it takes to produce it [5]. The Myanmar text used for user study contains 107 characters, and the Khmer text contains 135 characters. Based on the user study results, average CPM for Positional Gesture and software keyboards is as follows:

For Myanmar language,
Positional Gesture with mouse: 19.27 CPM
Positional Gesture with pen: 14.29 CPM
Win Myanmar Software Keyboard: 42.8 CPM

For Khmer language,
Positional Gesture with mouse: 17.69 CPM
Positional Gesture with trackball: 17.72 CPM
Khmer Software Keyboard: 29.13 CPM

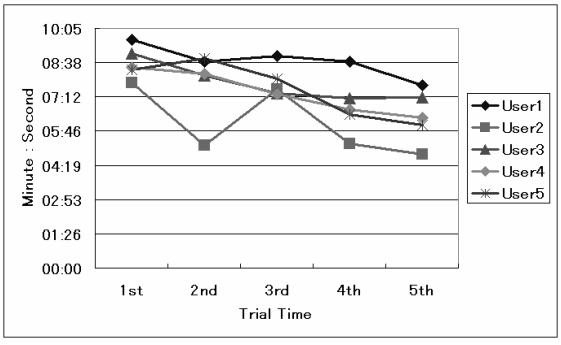

Fig.10 Typing Speed of Five Myanmar Users by Pen

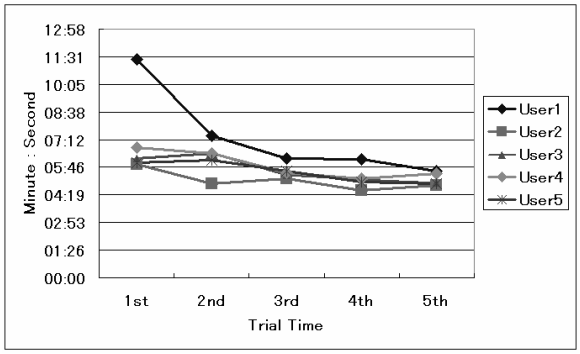

Fig.11 Typing Speed of Five Myanmar Users by Mouse

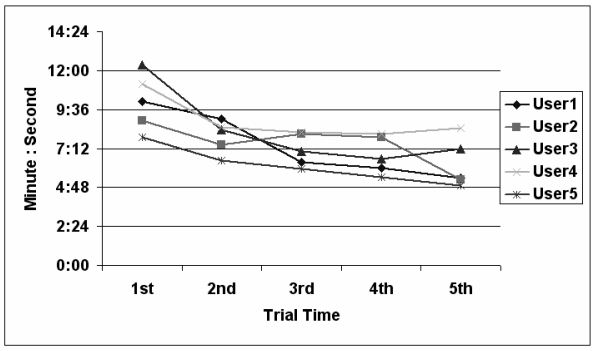

Fig. 15 Typing Speed of Five Cambodian Users by Mouse

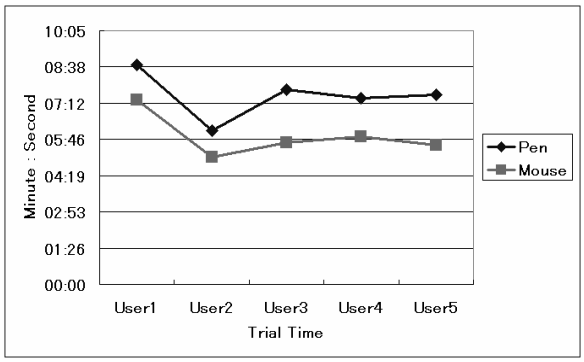

Fig.12 Typing Speed Comparison for Five Myanmar Users for Pen and Mouse

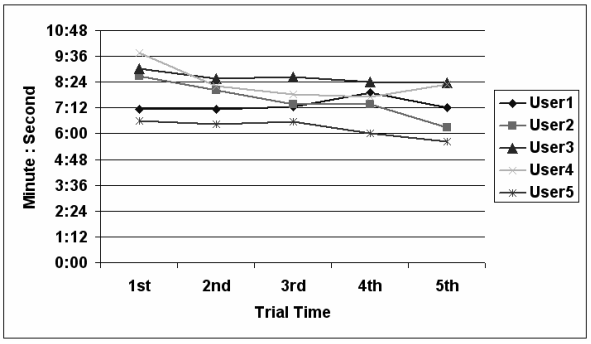

Fig. 16 Typing Speed of Five Cambodian Users by Trackball

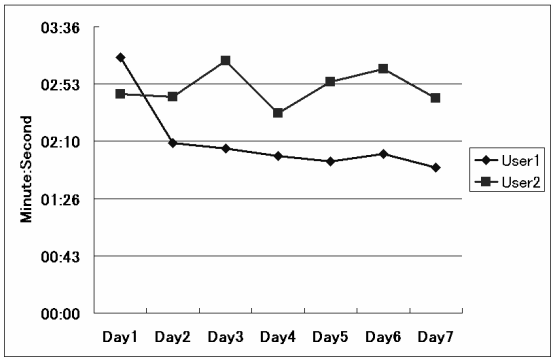

Fig.13 Average Typing Speed of Two Users for "Win Myanmar Visual Keyboard"

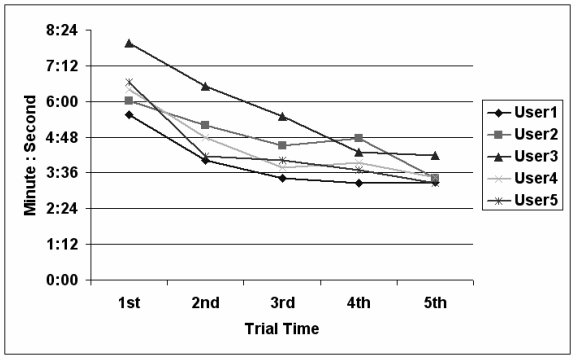

Fig. 17 Typing Speed of Five Cambodian Users by "Khmer Software Keyboard"

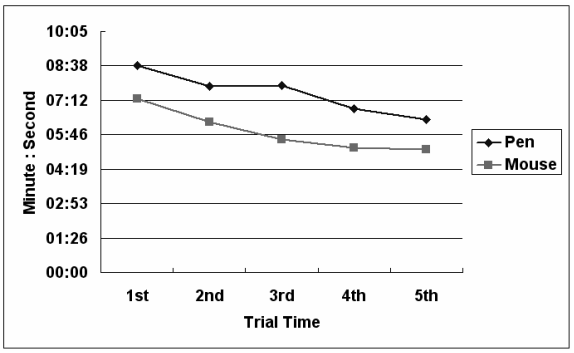

Fig. 14 Typing Speed Improvements of 5 Myanmar Users for Positional Gesture with Mouse and Pen

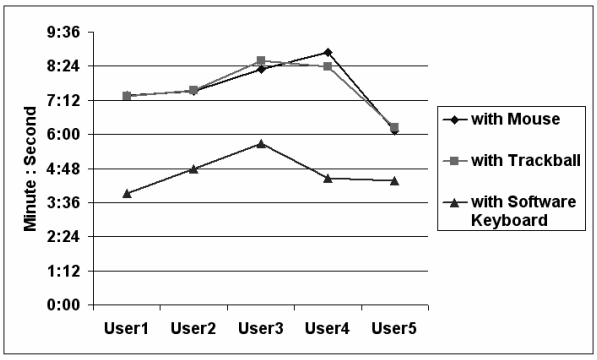

Fig.18 Typing Speed Comparison of Five Cambodian Users for Mouse, Trackball and Software Keyboard

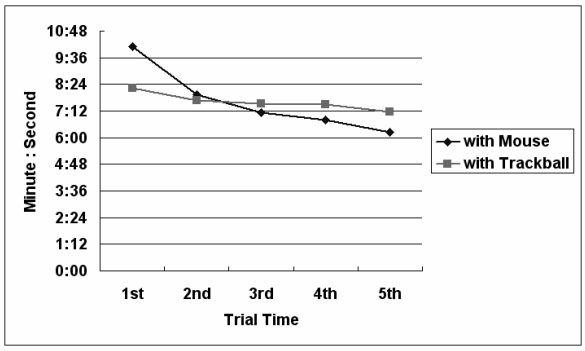

Fig. 19 Typing Speed Improvements of 5 Cambodian Users for Positional Gesture with Mouse and Trackball

9. DISCUSSION

It is desirable to compare user study results of our prototype with handwritten; however, there is no handwritten text input system for Myanmar and Khmer language yet. Although we found some thesis papers regarding off line handwritten recognition for Myanmar characters, we could not find any for online handwritten recognition. And thus, we used "Win Myanmar Visual Keyboard" and "Khmer Software Keyboard" for evaluation process. Average CPM of Myanmar Positional Gesture prototype is 14.29 with pen and 19.27 with mouse respectively. And average CPM for Khmer Positional Gesture prototype is 17.72 with trackball and 17.69 with mouse. If we compare Positional Gesture typing speed with software keyboards, it is slower for both for Myanmar and Khmer language. The reason is that we use very few gesture commands in our prototypes to enable easier typing but software keyboards use one to one key mapping (e.g. 58 keys + shifted mode + right-alt-mode for Khmer software keyboard). Another important reason is that though typing with QWERTY based software keyboard is familiar text input method, Positional Gesture is a new one for all of the participants. The typing speed or CPM can increase or decrease according to the type of input device used. And it also depends on how characters are mapped (i.e. character assignments). From the mean and standard deviation values of Likert Scale questions (see Table 3 for Myanmar language and Table 4 for Khmer language) and the user study results (see Fig. 10 to Fig. 19), we can prove that Positional Gesture is one of the possible text input interfaces for small mobile devices.

10. CONCLUSION

We have proposed the concept of Positional Gesture text input for syllabic languages. The concept is very simple and easy to understand. With our prototypes, even first time users can type Myanmar and Khmer text with appropriate typing speed. We use very few gesture commands for text input (basically 4 gesture commands such as left, right, up and down), and thus, it is a possible typing method not only for children but also for senior people. Positional Gesture text input concept is applicable for many other input methods such as hand gesture, eye gaze and brain input etc. And it is extendable for other similar syllabic languages such as Nepali (language of Nepal), Lao (language of Laos) and Hindi (one of the languages of India) etc. also. We have already developed Bangla language prototype, and are planning to make user study and follow up analysis in the near future. We believe that Instant Messaging (IM) and Messaging Services (SMS, MMS, etc.) are important NGN Services. If our concept works well with advanced smart terminals, this will provide as a possible text input methods for the syllabic languages in the Next Generation Network or Ubiquitous environments.

REFERENCES

[1] Goldberg, D., Richardson, C., "Touch Typing With a Stylus", *Proc. of the ACM Conference INTERCHI '93*, Amsterdam, The Netherlands, 1993, pp. 80-87

[2] MacKenzie, I.S., Soukoreff, R.W., "Text entry for mobile computing: Models and Methods, Theory and Practice", *Human-Computer Interaction 17*, 2002, pp. 147-198

[3] Jacob O. Wobbrock, Brad A. Myers, John A. Kembel, "EdgeWrite: A Stylus-Based Text Entry Method Designed for High Accuracy and Stability of Motion", *Proc. of the ACM Symposium on User Interface Software and Technology (UIST '03)*, Vancouver, British Columbia, 2003, pp. 61-70

[4] R. Balaji, V. Deepu, Sriganesh Madhvanath and Jayasree Prabhakaran, "Handwritten Gesture Recognition for Gesture Keyboard", *Proc. of the Tenth International Workshop on Frontiers in Handwriting Recognition (IWFHR-10)*, La Baule, France, 2006.

[5] MacKenzie, I.S. and Kumiko Tanaka-Ishii, *Text entry systems (Mobility, Accessibility, Universality)* (Morgan Kaufmann Press, 2007).

[6] Documentation of how to type Khmer Unicode by KhmerOS http://www.khmeros.info/drupal/?q=en/download/docs (6 March 2008)

[7] Win Myanmar Visual Keyboard http://winmyanmar.myanmars.net/other_features.htm (1 Feb 2008)

[8] Download link of NiDA Khmer Software Keyboard http://www.tavultesoft.com/keyman/downloads/keyboards/details.php?KeyboardID=401&FromKeyman=0 (5 Feb 2008)