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Hangeul Keypad for Smart Phones Using Gesture

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Abstract— **In accordance with development of smart phone, the importance of keypad was increasing, because the smart phone provides a variety of feature like word processor, chatting program, messenger and etc. In this paper, we propose the new Hangeul keypad for smart phones using gestures. And, also we do experiment for performance evaluation of the proposed keypad in this paper. The experiment shows that the proposed keypad is more efficient than other keypads.**

Index Terms— **keypad, text entry, smart phone, Fitt's law, Hangeul**

I. INTRODUCTION

RECENTLY, the most people are using mobile phones. Mobile phones offer a lot of feature including voice call, SMS(short message services), the Internet, and broadcasting service such as DMB . In particular, the SMS service usage continues to increase

We have to use Hangeul keypad in order to send a Hangeul SMS or write a Hangeul memo using mobile phone. Hangeul keypads of current mobile phone are based on the wired phone keypad, and we can input the Hangeul syllables with a combination of characters that are placed on twelve keys.

Many researches of mobile phone keypad have been done, and these are based on traditional telephone keypad[1][2][3]. The researches of Hangeul mobile phone keypad are also[4][5]. But Hangeul mobile phone keypads are not standardized. Therefore mobile phone users feel so hard to use the other kind of keypad because each of the vendors is providing different forms of keypad, the layout and Input method of keypad is different completely from the keypad of their respective companies.

Especially in accordance with the development of smart phone, the importance of keypad is increasing, because the smart phone provides a variety of feature like word processor, chatting program, etc. Therefore, a lot of researches of smart phone keypad is needed[6][7].

In existing mobile phone keypad, we input some character by pressing the keypad. On the other hand, we can use various gestures in addition to simple pressing or touching the keypad on the smart phone because it has a touch pad commonly. So, in according to using variety of gestures on the smart phone, we can place more characters on each key and increase the speed of typing characters.

In this paper, we propose the new Hangeul keypad for smart phone using gestures. Each key of our proposed keypad has two or three Hangeul characters, and almost characters placed in each key can be entered by only one key press or gesture. So, we can improve the text entry speed.

II. RELATED WORKS

A. Hangeul mobile phone keypads

In this section, we survey existing Hangeul mobile phone keypads[4][5] because they are used in the smart phone also.

First, we look over Chun-ji-in keypad, which is the most commonly used.

In this keypad, 7 keys are used for consonants and three keys are used for vowels. The consonants are disposed two consonants for each of 7 keys, totally, we can enter 14 Hangeul consonants in the mobile phone directly. Fig. 1 shows Chun-ji-in keypad.

1 ㅣ	2 ·	3 ㅡ
4 ㄱ ㅋ	5 ㄴ ㄹ	6 ㄷ ㅌ
7 ㅂ ㅍ	8 ㅅ ㅎ	9 ㅈ ㅊ
*	0 ㅇ ㅁ	#

Fig. 1. Chun-ji-in keypad.

The advantage of this keypad is that input method is simple because we can input all Hangeul vowels using combination of only three keys. So, beginners feel easy to use. On the other hand, we have to press a key many times to enter a complex vowel. And this keypad uses the

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multi press method to entering consonants. In this approach, the user presses each key one or more times to specify the input character. For example, the number 4 is pressed once for the character 'ㄱ', twice for 'ㅋ', and three times for 'ㄲ'. The multi-press approach brings out the problem of segmentation. When a character is placed in the same key as the previously entered character, the system must determine whether the new key press still "belong to" the previous character of represents a new character. There are two solutions for this. One is to use a timeout period typically between 1 and 2 seconds. The other solution is to have a special key(timeout-kill) to skip the timeout[8][9]. Fig. 2 shows the examples of entering characters using Chun-ji-in keypad.

ㄱ : 4(ㄱ)
ㅋ : 4 + 4 (ㅋ)
ㄲ : 4 + 4 +4(ㄲ)
ㅙ : 2(.) + 3(ㅡ)+ 1(ㅣ) + 2(.) +1(ㅣ)
안녕 : 11(ㅇ) + 1(ㅣ) +2(.) +5(ㄴ) +12(timeout-kill)
+5(ㄴ)+2(.) +2(.) +1(ㅣ) + 11(ㅇ)

Fig. 2. examples of input character using Chun-ji-in keypad.

Second, we look over ezHangeul keypad. Fig. 3 shows ezHangeul keypad.

1 ㄱ	2 ㄴ	3 ㅏ ㅓ
4 ㄹ	5 ㅁ	6 ㅗㅜ
7 ㅅ	8 ㅇ	9 ㅡ
*	0 ㅣ	#

Fig. 3. ezHangeul keypad.

In this approach, the basic vowels and consonants are placed in the keypad and we can input the complex vowels and consonants using special keys, that are '*(add a stroke)' and '#(add same character to side)'. For example, we press only once the number key 1 to input 'ㄱ' and the complex consonant 'ㅋ' can be represented 'ㄱ' + '*' and 'ㄲ' also can be represented 'ㄱ' + '#' .

This approach is more difficult than previous method(Chun-ji-in) and needed to move long distance of a finger. But when we input the complex vowels and consonants, a small number of pressing key are needed. So the text entry speed is faster than previous method generally. Fig. 4 shows the examples of entering character using ezHangeul keypad.

ㄱ : 1(ㄱ)
ㅋ : 1(ㄱ) + *(add a stroke)
ㄲ : 1(ㄱ) + #(add same character to side)
ㅙ : 6(ㅗ) + 3(ㅏ) + 9(ㅣ)
안녕 : 8(ㅇ) + 3(ㅏ) +2(ㄴ) +2(ㄴ)+3 + 3(ㅓ)+
*(add a stroke) + (ㅇ)

Fig. 4. examples of input character using ezHangeul keypad.

There are many Hangeul input approaches included the SKY method for mobile keypad in addition to previous approaches[4]. But actually being used methods are three approaches that are Chun-ji-in, ezHangeul and the SKY method.

However, each of three methods has advantages and disadvantages and isn't freely available because of a patent. Therefore, it is needed the research of new Hangeul keypad that can be used freely and is more efficient.

In addition, there are new keypads for smart phones using gesture, these are DingGul, MilGiGeul, and PalBangMiIn and etc.

DingGul keypad has 12 keys, the basic vowels and consonants are place in this keypad and other characters can be entered using gesture as shown in Fig. 5.

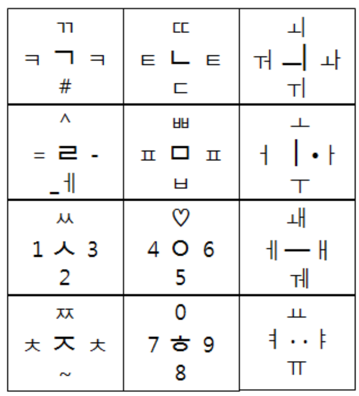

Fig. 5. DingGul keypad.

In this keypad, as shown in Fig. 6, four kinds of gestures are used in each keys, left to right, right to left, down to up and up to down.

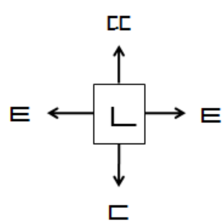

Fig. 6. gestures being used for DingGul keypad.

In case of entering consonants, some consonants are needed two steps can be entered. For example, we have to input two gestures that are down to up and up to down to enter the consonant 'ㅛ'.

This keypad has advantage that can enter five characters for each key, but is difficult to understand and learn and error rate is high because four gestures are used in each key.

MilGiGeul and PalBangMiIn use also gesture to enter a character. But these methods enter a consonant and vowel consecutively using gesture and 15 keys are used in them, so in terms of input method and number of keys are different from other keypads completely.

B. Movement model(Fitts' law)

In this paper, we will use the movement model based on Fitts' law for evaluating performance of the proposed keypad. Fitts' law is a quantitative model for rapid and aimed movements. This method is the most commonly used for evaluating performance of physical interface including keypad[8][9].

Fitts' law defines index of difficulty(ID) that means difficulty of movement on the keypad. ID is expressed as follows,

$$\mathrm{ID} = \log_2 \left(\frac{\mathrm{A}}{\mathrm{W}} + 1\right) \tag{1}$$

Where A is the length(amplitude) of movement and W is the width of target. It is clear that lower values of A will reduce the index of difficulty, leading to better typing speeds. So, Fitts' law is expressed finally as,

$$\mathrm{MT} = \mathrm{a} + \mathrm{b} \times \mathrm{ID} \tag{2}$$

In above equation, ID can be calculated only physical size of key, but two constants, a and b are determined by experiments. We will mention about it in the experiment.

In mobile phone text entry, each character is entered with one or more key called movements. For each movement(M_0, M_1, M_2,...), Fitts' law is used to predict the movement time(MT_0, MT_1, MT_2,...). The total text entry time(TC) is calculated as the sum of all the required movements:

$$\mathrm{TC} = \sum_{i=0}^{i<n} \mathrm{MT_i} \tag{3}$$

In this paper, we measure the each keypad's *TC* and those are compared with each other.

III. DESIGN OF THE HANGEUL KEYPAD FOR SMART PHONE USING GESTURES

A. Considerations of designing keypad

The most important considerations of designing a mobile phone keypad are simplicity and efficiency.

The simplicity is that the keypad layout should be simple and has a consistency. For example, if the arrangement of vowels and consonants are not consistent or the input method of complex vowels and consonants are not consistent, the users are hard to understand the keypad layout, also hard to use the keypad. Therefore, we have to decide simply and consistently whether which characters are placed or not on the keypad and whether which characters are entered using the special input method or not.

The efficiency is also considered. The efficiency means that the text entry speed is minimized. The text entry speed is determined by the number of keystrokes per character and the distances between keys have to be pressed. Therefore, we have to consider how to minimize the number of keystrokes and the distance between keys in a mobile phone keypad

In this paper, we design new keypad that is more efficient and simple in consideration of these points. For this purpose, we will apply a gesture to new keypad design.

B. Define gestures for the proposed keypad

Recently used mobile devices, including smart phones are equipped with high quality touch pad by default. In touch pad environment, we can enter commands through various movements (this is called "gesture") as well as pressing key. Fig. 7 shows various kinds of gestures are used in touch pad.

Fig. 7. gestures are used in touch pad.

In this study, first, we select gestures to be used in our new keypad. The size of key on the smart phone keypad is proportional to the size of the screen, and commonly, the width is 15 - 18(mm) and the height is 10 - 12(mm) approximately. It is difficult to use complex gestures because the size of key is too small. Therefore, we only use simple gestures like key press, ruling from left to right and from above to below for our smart phone keypad. As a result, three characters per each of keys can be entered through these three gestures in the proposed keypad.

C. Layout of the proposed smart phone keypad

Hangeul syllable is composed of 19 syllable-initial characters and 21 syllable-peak characters, and 27 syllable-final characters. As Syllable-initial characters and syllable-final characters are the same shape, we may consider only 27 consonants and 21 vowels for entering Hangeul syllable. Because the proposed smart phone keypad is the basis of traditional mobile keypad that has only 12 keys because of compatibility, we can't assign all characters to keypad. Therefore, we assign only simple consonants and vowels to the proposed keypad as shown in Fig. 8.

Consonants: ㄱ ㄴ ㄷ ㄹ ㅁ ㅂ ㅅ ㅇ ㅈ ㅊ ㅋ ㅌ ㅍ ㅎ
Vowels: ㅏ ㅐ ㅑ ㅒ ㅓ ㅔ ㅕ ㅖ ㅗ ㅛ ㅜ ㅠ ㅡ ㅣ

Fig. 8. consonants and vowels assigned to keypad.

Complex consonants and vowels are represented by combination of simple consonants and vowels in the proposed keypad. For example 'ㄲ' can be represented by combination of 'ㄱ' and 'ㄱ' and complex vowel, 'ㅙ' can be represented by combination of 'ㅗ' and 'ㅐ'.

Now, we assign characters to keypad. As mentioned above, the proposed keypad can enter three characters per key using gesture. So, we make groups that are composed of three or two characters. The basic principle of grouping is that morphologically similar characters belong to the same group. And we select the simplest character as the representative of group and then we determine the gesture for entering the rest of characters as shown in TABLE I.

TABLE I
GROUPS OF CHARACTER

Group no.	press	→	↓
1	ㄱ	ㅋ	ㄹ
2	ㄴ	ㄷ	ㅌ
3	ㅁ	ㅂ	ㅍ
4	ㅅ	ㅈ	ㅊ
5	ㅇ		ㅎ
6	ㅣ	ㅏ	ㅜ
7	ㅡ	ㅓ	ㅗ
8	ㅕ	ㅑ	ㅠ
9	ㅔ	ㅖ	ㅛ
10	ㅐ	ㅒ	

Next, each of character groups is placed on the keypad. First, the consonants are placed on the left side of keypad and the vowels placed on the right side of keypad. It is to maintain compatibility with traditional Hangeul keypad. Each of groups are placed in accordance with frequency of character[10]. Frequent character group are assigned to easy position to press and infrequent character group are assigned to side of keypad[11].

The final layout of proposed keypad was attained as shown in Fig. 9.

ㅅㅈ ㅊ 1	ㅇ ㅎ 2	ㅣㅓ ㅗ 3
ㄴㄷ ㅌ 4	ㄱㅋ ㄹ 5	ㅡㅏ ㅜ 6
ㅁㅂ ㅍ 7	ㅔㅖ ㅛ 8	ㅕㅑ ㅠ 9
*	0 _	ㅐ ㅒ

Fig. 9. layout of proposed keypad.

Fig. 10 shows the examples of entering character using the proposed keypad.

ㄱ : 5 press (ㄱ)
ㅋ : 5 → (ㅋ)
ㄲ : 1 press (ㄱ) +*(add same character to side)
ㅙ : 3↓ (ㅗ) + 12 press(ㅐ)
안녕 : 2 press (ㅇ) + 6 → (ㅏ) +4 press(ㄴ) + 4 press(ㄴ) + 9 press(ㅕ)+ 2 press (ㅇ)

Fig. 10. examples of input character using the proposed keypad

IV. PERFORMANCE STUDY

A. Experiments

In this section, we determine the constants of Fitts' law equation that are used in our experiment.

As mentioned above, we use 3*4 standard keypad for experiment. First, we measure the keypad size to calculate the distance of movement. The keypad size of smart phone is different from each other because it is proportional to touch pad screen size. So, we assume that the keypad has 12 buttons. Button's width is 10.5(mm) and height is 10(mm). Then, the length of movement(A) can be defined as the distance between each centers as shown in Fig. 11.

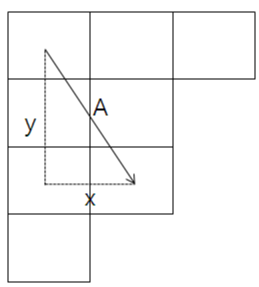

Fig. 11. the length of movement(A).

Therefore, we can get A as follows,

$$A = \sqrt{x^2 + y^2} \quad (4)$$

Fitts' law is inherently one-dimensional as evidenced by a single "width" term. However, Physical keys on a mobile phone keypad are laid out in a two-dimensional array, and each key has both width and height. Therefore, as suggested by MacKenzie and Buxton, we used the height of the keys as W[12]. Finally, ID is expressed as follows,

$$ID = \log_2\left(\frac{\sqrt{x^2 + y^2}}{10} + 1 \right) \quad (5)$$

Now, we have to determine two coefficients, a and b. The experiment was carried out to determine these coefficients. 30 peoples participated in this experiment. They entered characters thirty times for each of ID and we measured the average movement time. Fig. 12 shows the results of experiment. In this experiment, the movement time(MT) grows linearly with index of difficulty(Id), as predicted by Fitts' law. A linear regression of MT on ID was performed. The results is that intercept(a) is 243.4(ms) and slope is 68.26(ms/bit) and correlation is 0.97. The correlation in the linear regression is high, indication that Fitts' law predicts the movement time with high accuracy.

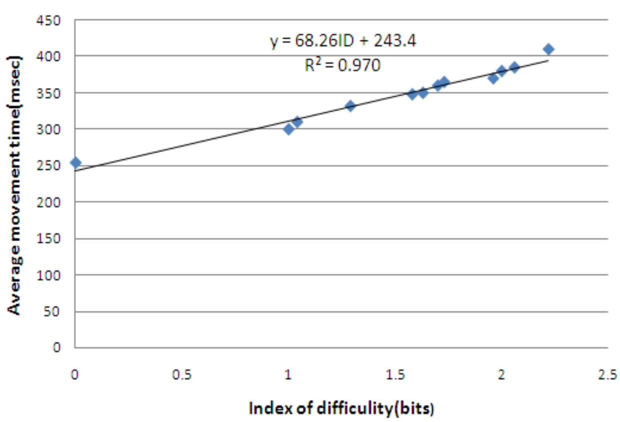

Fig. 12. Results from experiment.

Finally, MT is expressed as follows,

$$MT = 243.40 + 68.26 \times ID \ (R^2 = 0.970) \quad (6)$$

Because the proposed keypad use gestures to enter a character, the key entry time is different from traditional keypads. So we measured the time of entering gesture. When ID = 0, the time takes 243.4(ms) in case of touching keypad, and 358(ms) in case of entering gesture. Therefore, when we predict the total time to enter characters, we will add differences of times in proposed keypad if we have to use a gesture to enter some character.

B. Evaluations

In this section, we evaluate the performance of proposed keypad. We predict the total text entry time(CT) using Fitts' law for three types of keypad that are Chun-ji-in(type a), ezHangeul(type b), DingGul(type c) and the proposed keypad(type d) and compare them for each other. For our evaluation, we used three kinds of simple text(1:안녕하세요, 2:전화해줘, 3:회의중입니다) that are the most commonly used in SMS.

Fig. 13 shows the CT for four types of keypad.

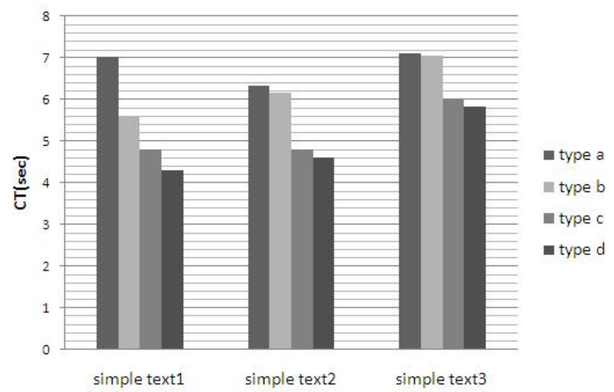

Fig. 13. Total text entry time(simple text).

AS shown in Fig. 13, we can find that the proposed keypad require the least text entry time.

We may have to input a long text on smart phones. So, we experimented with a long text that is composed of 300 words, too. It is extracted from Korean corpus.

Fig. 14 also shows the CT for a long text.

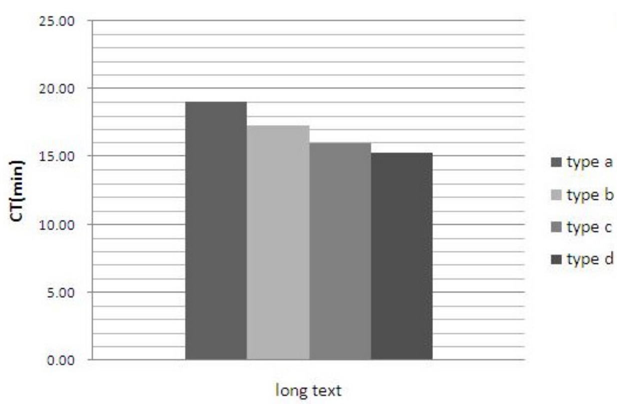

Fig. 14. Total text entry time(long text)

Next, we evaluated the proposed keypad using keystrokes per character(KSPC)[13]. KSPC are represented as follows,

$$\text{KSPC} = \frac{\text{total number of keystrokes}}{\text{total number of characters}} \quad (7)$$

Fig. 15 shows the KSPC of each types of keypad for each text that are used in the previous experiment.

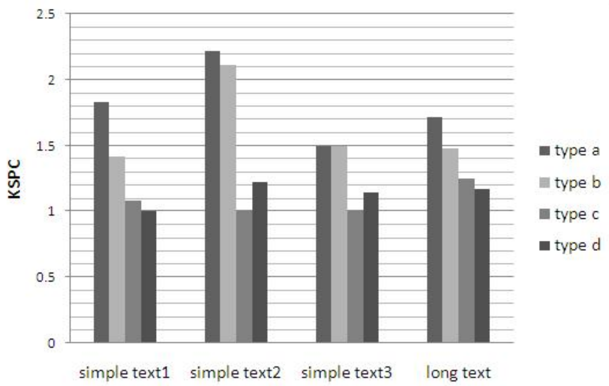

Fig. 15. KSPC of each types of keypad.

As shown in Fig. 15, the proposed method need the fewest keystrokes in case of simple text1 and long text and type c is more efficient in case of simple text2 and simple text3. These results are due to diversity of character being used in the test data. So, we should pay more attention to the fourth case(long text) because the long text contain various consonants and vowels.

Finally, according to the experiment, the proposed keypad is more efficient than other keypads in terms of the number of keystroke and the text entry time. This result is because the proposed keypad requires shorter distance of movement for entering a text than other keypads and the number of keystrokes in the proposed keypad is less than others for entering complex vowels and consonants, especially.

V. CONCLUSION

In this paper, we proposed Hangeul keypad for smart phones. We used a gesture to enter a character in the proposed keypad. We could reduce the text entry time and the number of keystrokes. Also, we did the experiment with the movement model that is based on Fitts' law for evaluating performance of the proposed keypad. Finally, the experiment shows that our keypad is more efficient than other keypads. The proposed keypad can be used in various devices with touch pad like pda, tablet PC, and etc.

In the future, we will distribute the proposed keypad program and refine it.

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