A Thesis for the degree of Master

Korean EdgeWrite: A Korean Text Entry Method for a Joystick

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May 13, 2008.
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Professor Geehyuk Lee
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We certify that this work has passed the scholastic standards requested by the Information and Communications University as a thesis for the degree of Master

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Major Advisor: Professor Geehyuk Lee
Text in English

Abstract

As advanced features were integrated into joystick-use devices such as video game consoles or portable devices, text entry become an important function. There were some researches about English joystick text entry techniques but, because of the late introduction of the latest joystick-based devices for example PlayStation 3, Korean joystick text entry methods had not been researched except ASK-HIM which was our former research. We introduced Korean EdgeWrite, a Korean text entry method for a joystick. To achieve efficiency and easiness, the initial gesture was designed with the analysis of Hangeul; the initial design was modified by a pilot test. The Korean EdgeWrite gesture design was enhanced again after applying participants' gesture design from the guessability test. Keystrokes per character for the Korean EdgeWrite could be comparable with that of multi-tap. Immediate usability test showed the Korean EdgeWrite was similarly easy to remember for novice compared to the EdgeWrite or Graffiti. In a user study, most of the participants could learn the Korean EdgeWrite

gestures within no longer than 10 minutes. They could enter the text faster using the Korean EdgeWrite than using an alphabetic selection keyboard or a multi-tap selection keypad. Also, the performance shown by a group of well trained users could be comparable with that of a mobile phone keypad. In a post-test survey, the participants gave a higher rating to the Korean EdgeWrite than to the selection-based text entry methods in terms of the preference and the speed. The Korean EdgeWrite outperformed ASK-HIM, another non-selection-based joystick text entry method in Korean, too.

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List of Abbreviations

ICU	Information and Communications University
KSPC	Keystrokes per Character
ASK-HIM	Analog Stick Korean Hangeul Input Method
CPM	Characters per Minute

I Introduction

1.1 Motivation

The market of the game console is getting bigger and the latest consoles such as Microsoft Xbox 360, Sony PlayStation 3, and Nintendo Wii are continuously evolving. Former video game console such as PlayStation 2 have been distributed widely, it adopt the newest technology as well.

Not only the consoles but also the portable devices which have the joystick such as Sony PlayStation Portable (Figure 1) or portable media players are used widely.

Figure 1. Sony PlayStation Portable Web browser screenshot with Wikipeia Web page.

Several advanced features are integrated into the device, among advanced features; text entry is one of the most important capabilities to support Web surfing and text messaging. Current joystick text entry methods are date stamp or selection based methods which have slow speed. Therefore, novel method for

joystick text entry is needed.

Research about text entry method for a joystick in English is currently on going, but because of the late introduction of the latest consoles in Korean, research about Korean text entry method for a joystick is not active yet.

1.2 Proposed Method

In this thesis, Korean EdgeWrite is introduced as a new Korean text entry method for a joystick. Korean EdgeWrite is a letter-like gestural text entry method which is derived from EdgeWrite by Wobbrock. Chapter 3 describes details.

1.3 Thesis Organization

Chapter 2 describes prior work related to Korean EdgeWrite. Some of the work relates to general text entry, others relates to the joystick text entry in English or in Korean.

Chapter 3 introduces Korean EdgeWrite including the core concepts, goal and design. Section 3.5 describes Korean EdgeWrite alphabets in terms of the design principle. Section 3.6 describes keystrokes per character of Korean EdgeWrite to verify the efficiency of Korean EdgeWrite design. Section 3.7 describes the guessability of Korean EdgeWrite which can explain how beginner can guess the symbols. Section 3.8 describes the immediate usability of Korean EdgeWrite, so how novice can learn Korean EdgeWrite can be shown.

Chapter 4 presents a user study of Korean EdgeWrite compared to the alphabetic selection keyboard and the multi-tap 3x4 selection keypad. Questionnaire is collected to get the subjective evaluation. Comparison between Korean

EdgeWrite and ASK-HIM is followed. Results show Korean EdgeWrite is faster than any other methods and the participants give better questionnaire scores to Korean EdgeWrite.

Chapter 5 concludes with summary, several discussions, future work, and some closing remarks.

II Related Work

2.1 English Joystick Text Entry Method

TwoStick [5] is a joystick text entry for dual joystick game controller. 9 by 9 table (Figure 2) showed the location of the alphabet and the numbers. Moving left joystick selects the large scale area; moving right joystick selects the small scale area. For example, moving a left joystick to the left-top area and moving a right joystick to the top area enters the letter ‘b’.

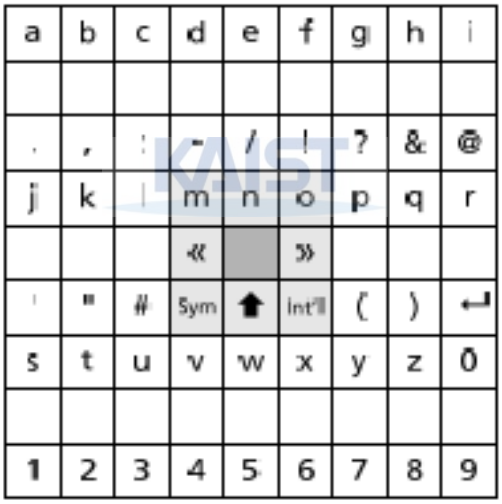


Figure 2. Layout of the TwoStick.

Quikwriting [2] is a stylus text entry method but it is adapted to the joystick text entry. It also uses two joysticks but it has different principles with TwoStick. Each character is located in the eight different areas with nine small areas (Figure 3). Movements of the joystick select the large area and small area.

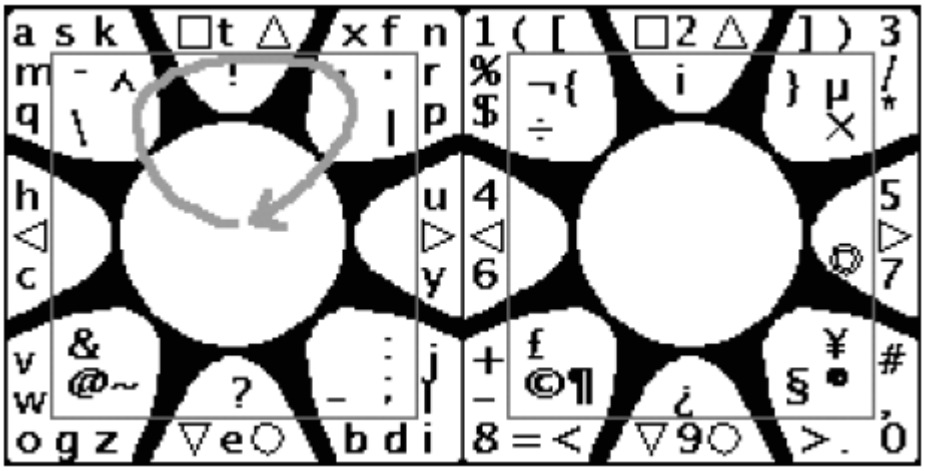


Figure 3. Design of the Quikwriting

MDITIM [3] uses four directions – north, south, east, and west. Combination of the directions made the text; Figure 4 shows the progress of writing the character ‘M’.

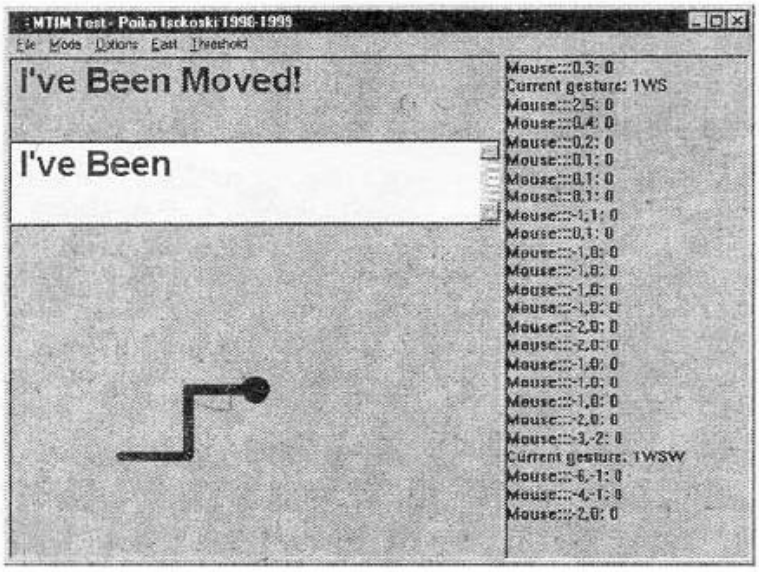


Figure 4. Example of the MDITIM

Dual joystick controller text entry [6] uses the layout of QWERTY keyboard with two separated area (Figure 5). Left joystick controls the left area key, right joystick moves the right area key. Additional buttons are used to select the alphabet.

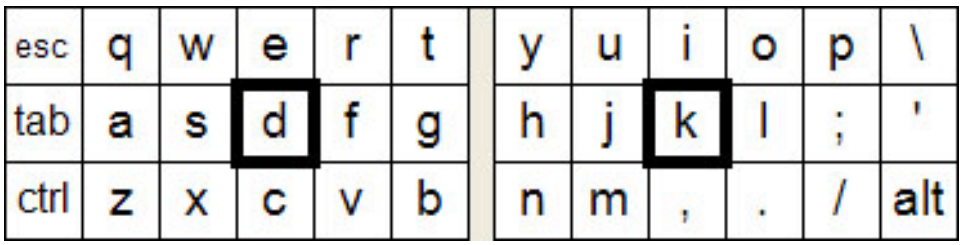


Figure 5. Keyboard layout of dual joystick controller text entry.

EdgeWrite [16] is introduced as a stylus-based unistroke text entry method: a user makes a letter by moving the stylus, and then the moves on the four corner square areas are detected. The gesture (Figure 6) for a letter looks similar to the mapped alphabet, so it is easy to learn. These characteristics make the method easy to be adapted to various devices including joystick [15].

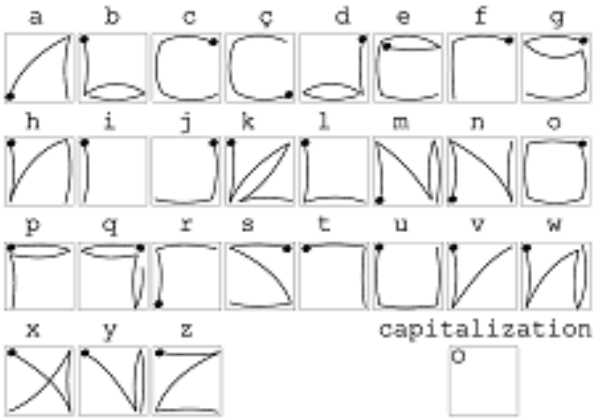


Figure 6. Design of the EdgeWrite

2.2 Korean Joystick Text Entry Method

Kim [4] introduced a new Korean text entry method for a joystick called ASK-HIM. It was direction-based text entry method for a joystick. Four basic consonants (ㄱ, ㄴ, ㅁ, ㅅ) were assigned to four different directions – up, down, left, right. Clockwise or counter-clockwise rotation made fortis or aspiration Hangeul. Four basic vowels (ㅏ, ㅓ, ㅗ, ㅜ) were appointed to the four direction like consonant, clockwise or counter-clockwise rotation added strokes to the basic vowels. Additional key was required to change consonant mode and vowel mode.

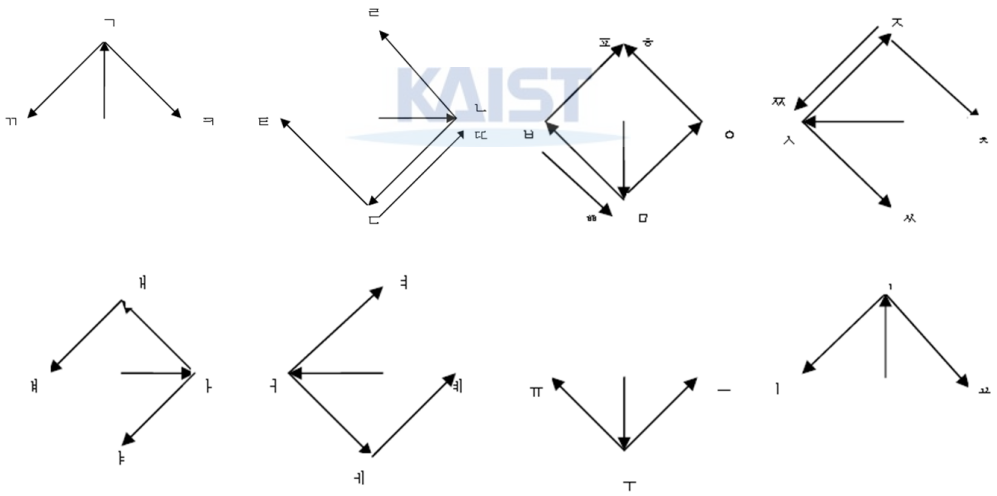


Figure 7. Design of the ASK-HIM

2.3 Text Entry Evaluation

MacKenzie [8] suggested keystrokes per character (KSPC) as a measure of

text entry technique. It is calculated a number of key required to enter a letter considering the letter frequency. KSPC of QWERTY keyboard is 1 because it requires 1 key to enter a text. KSPC of multi-tap used in mobile phone is about 2.

Myung [11] calculated text entry speed of Korean on the mobile phone using keystroke analysis method. The speed was about 55 characters per minute.

III Korean EdgeWrite

3.1 Background

ASK-HIM was suggested as a new Korean joystick text entry method, but it had several problems. At first, ASK-HIM use two different mode – consonant mode and vowel mode which was changed by pressing button. Although it is possible to use dual joystick to increase the speed, it is inconvenience to change input mode when entering every alphabet or considering using left joystick for entering consonant and right joystick for entering vowels. Furthermore, it use additional buttons to input enter key, space bar, and backspace bar. It is not a problem for the game pad which has one or two joystick and a lot of buttons, but portable device can't have such buttons like game pad. Four basic consonants' direction is difficult to learn because there is no relationship between Hangeul and the direction even though there are relationship between vowels and the directions. Two basic consonant are also problem because it should be a basic direction consonant, but it couldn't be because of the limitation of the number of the directions. Rotation directions are another problem, users couldn't learn easily whether adding strokes or doubling consonants is counter-clockwise rotation or clockwise rotation. In summary no relation between gesture and Hangeul showed such problems. As ASK-HIM had several problems to be a good Korean text entry method for a joystick, new text entry method was needed. Among several joystick text entry methods, in terms of efficiency, consistency and so on, EdgeWrite was the best candidate for the Korean joystick text entry method.

3.2 Core Concepts

Korean EdgeWrite is a Korean text entry method for a joystick. It derives concepts EdgeWrite. It is unistroke gestural text entry method, so there is no broken line while writing one alphabet. Four areas located in the corner is the key concept of Korean EdgeWrite, the gestures are sequence of the area, not every path of joystick movement. It is not trivial to implement unistroke text entry method in joystick, because timing of segmentation for the joystick is not trivial. Fundamental characteristic of joystick is used to solve this problem. Joystick returns to the center when the user takes off their finger. Segmentation of alphabet is occurred when joystick returns to the center.

3.3 Goal

While developing Korean EdgeWrite, two different issues were considered: and easiness. To be a good text entry good performance is required. Performance for text entry method can be reported by speed and error rates. Therefore, Korean EdgeWrite should have fast speed and low error rates. Furthermore, new introduced design should be easy to use for a user. Making easy to guess is one way of achieve this goal, high consistency also make easy to remember design. Korean EdgeWrite should be either easy to guess or high consistent design.

3.4 Design Procedure

Designing Korean EdgeWrite was not completed at the first time. To make initial Korean EdgeWrite design, the shape of Hangeul was analyzed manually. We watch every alphabet, and tried to make design of 4 corner sequence gesture.

To check whether proposed gesture design was suitable for a joystick, we implemented a test program which enters text with Korean EdgeWrite using a joystick. A pilot test was performed to test Korean EdgeWrite design and enhance it. Korean EdgeWrite design was upgraded by applying pilot test result and participants' feedback.

3.5 Korean EdgeWrite Design

Design of Korean EdgeWrite was derived from the shape and the characteristics of Hangeul. Consonant symbols were started from the lenis symbols. Nine lenis symbols (ㄱ, ㄴ, ㄷ, ㄹ, ㅁ, ㅂ, ㅅ, ㅇ, ㅈ) matched with nine letters, the aspiration (ㅊ, ㅋ, ㅌ, ㅍ, ㅎ) were made by adding one stroke to the lenis. Similar to the characteristic of Hangeul, doubling the lenis symbol was equal to the fortis (ㄲ, ㄸ, ㅃ, ㅆ, ㅉ). The position of the sky mark from the vowel symbol was the key factor of Korean EdgeWrite vowel gestures, was used to determine the direction of the gesture. (Figure 8)

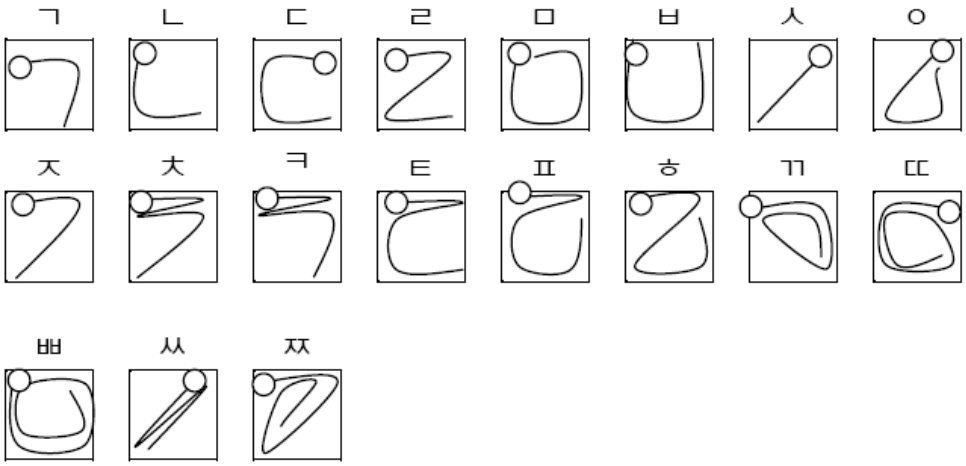


Figure 8. Design of the Korean EdgeWrite consonants

A design of ㄱ, ㄴ, ㄷ, ㄹ, ㅁ, ㅂ, ㅡ, ㅣ was copied from shape of Hangeul. It was trivial to design because shape of above alphabets was combination of straight line. Some modification existed for design of ㄹ, ㅂ because of Korean EdgeWrite concept.

The pilot test affected design of ㅅ, ㅈ, and ㅇ. There should be two straight line for ㅅ but the pilot test showed drawing two straight line using a joystick is difficult, so design become one straight line. ㅈ was similar to ㅅ with one additional stroke at the top. It was hard to separate ㅁ and ㅇ because Korean EdgeWrite detected only 4 corner area, so several way to classify was appeared such as differentiation of staring point or differentiation of rotation direction, but it might be confused for the user. Triangle design was assigned to ㅇ as a solution.

The aspiration (ㅊ, ㅋ, ㅌ, ㅍ, ㅎ) and the fortis (ㄲ, ㄸ, ㅃ, ㅆ, ㅉ) was designed from principles of Hangeul – adding stroke principle. The aspiration was made by adding one stroke to the design of the lenis symbols. Doubling

the lenis gestures made the fortis gesture.

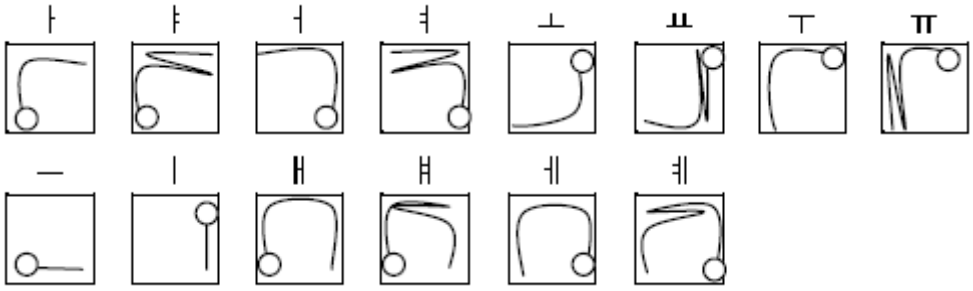


Figure 9. Design of the Korean EdgeWrite vowels

It was hard to assign vowels because it should be different from the design of the consonants. Especially, vowels was confused with ㄱ or ㄴ. To solve this conflict several candidates were considered. Some method was easy to remember but had long strokes; some had short strokes but was hard to remember or had low consistency. As a solution to this, drawing a gesture from the opposite side of the original stroke was selected. Basic vowels ㅏ, ㅓ, ㅗ, ㅜ were designed as above principles, consistency could be high, average strokes were 2 which was low enough.

ㅑ, ㅕ, ㅛ, ㅠ were considered as one more stroke to ㅏ, ㅓ, ㅗ, ㅜ, design was copied same consideration. ㅐ, ㅒ, ㅔ, ㅖ were combination of ㅏ, ㅑ, ㅔ, ㅖ and ㅣ, design of ㅐ, ㅒ, ㅔ, ㅖ were combination of ㅏ, ㅑ, ㅔ, ㅖ and ㅣ.

3.6 Keystrokes per Character Calculation

To see how efficient design Korean EdgeWrite was, Keystrokes per character was calculated. Keystrokes per character was measure for key-based text en-

try method in English, some modification was needed to apply to the Korean joystick text entry method. Keystroke was considered as a number of a joystick movement for this case. Hangeul consist of Choseong, Jungseong, and Jongseong as a syllable, a character meant an alphabet – consonant or vowel not combination of them. Letter frequency data was calculated by NLP/IR Lab at Kookmin University.

KSPC of Choseong for Korean EdgeWrite was 2.78, of Jungseong was 2.03 and Jongseong was 1.21. Sum of KSPC meaning KSPC for 1 syllable was 6.0, so average KSPC for one alphabet was 2.0. It was similar value with that of multi-tap which was very famous text entry method used for mobile phone; so, it was okay to say Korean EdgeWrite was efficient design.

3.7 Guessability

3.7.1 Background

Guessability introduced by Wobbrock measures initial user experience. It is especially important for symbolic input because user should match between symbols and referents to do action. The guessability can be calculated as following equation where G is the guessability, S is the resultant symbol set, and P is the proposed symbols. Higher guessability implies that it is easy to guess the gestures for novice.

$$G = \frac{\sum_{s \in S} |P_s|}{|P|} \cdot 100\%$$

G: guessability
P: proposed symbols
S: resultant symbol set
P_s: set of proposed symbols using symbol s

Figure 10. Guessability equation.

3.7.2 Method

35 participants took part in the guessability test. Participants were recruited from undergraduate lecture; most of them were freshmen students. No one had prior knowledge about EdgeWrite or Korean EdgeWrite.

Participants used their own computers at computer experience room, so test were progressed at once. They used the mouse; guessability test program implemented in C# was used to capture their mouse movement.

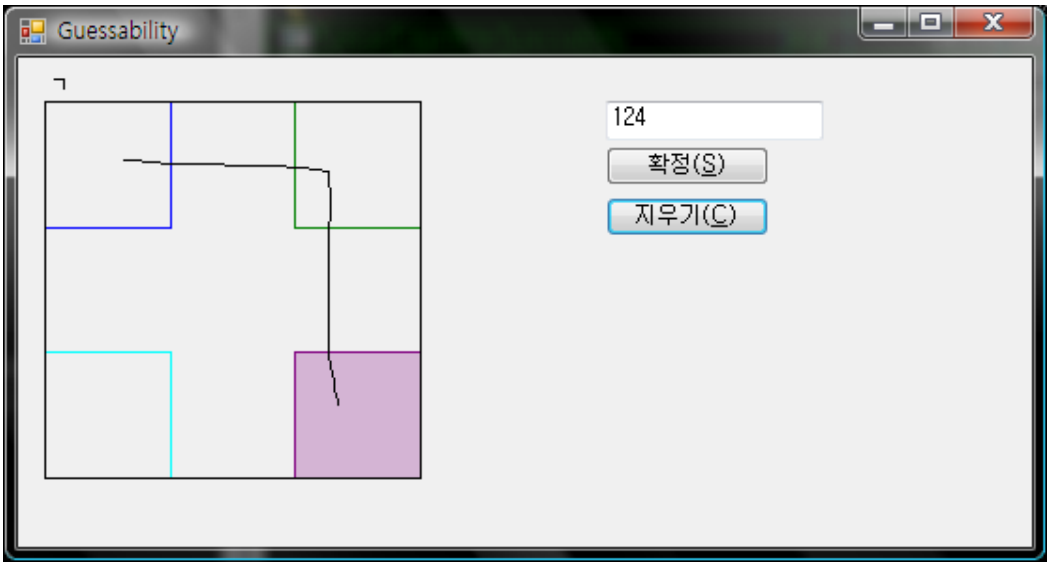


Figure 11. Guessability test software

The author explained fundamental concepts of Korean EdgeWrite to subjects in terms of unistroke and 4 corner areas detection. No further design goal was shown to them, so they can guess creative gestures. The guessability test program (Figure 11) showed 28 Hangeul including 14 consonants and 14 vowels in alphabetical order, the participants made their own gesture for each Hangeul. It is possible to modify the gesture of Hangeul before confirming the gesture. Color feedback was used to show whether mouse was in the 4 corner areas or not. Mouse movement and numerical path – 1 for top-left area, 2 for top-right area, 4 for bottom-right area, and 8 for bottom-left area - were collected via e-mail.

3.7.3 Results

Results of guessability of Korean EdgeWrite were analyzed automatically. A new program was implemented in C# to analyze raw data which contains mouse movement of participants. Text file contains x axis and y axis value of

mouse which saved when mouse move event occurred. Not only mouse movement but also sequence of area was recorded in the text file. Analyzing program showed mouse movement to the screen just like participants entered, sequence of area was also shown, too.

For each participant and each alphabet, Analyzing program compare whether the alphabet is included in the proposed symbol sets. And calculate its rates. It is not counted participant' alphabet is not matched with alphabet in the proposed gestures even though sequence of area is the same.

Because 35 participants entered 28 alphabets, 980 gestures were collected. However there were several invalid gestures for example no touch of any corner areas and so on because of misunderstanding of Korean EdgeWrite concepts by participants. Number of collected gestures was 650 except invalid gestures. Number of matched gestures matched with proposed symbols was 249, so guessability was 38.3%. Because Hangeul have two categories: consonants and vowels, guessability was calculated for each category – guessability of consonants was 44.3% with 200 matched gestures under 451 total valid proposed gestures. (Table 1)

Table 1. Guessability results (%).

Alphabet	Guessability
ㄱ	91.1
ㄴ	97.0
ㄷ	88.2
ㄹ	82.4
ㅁ	74.3
ㅂ	29.4
ㅅ	26.5
ㅇ	35.3
ㅈ	8.8
ㅊ	2.9

ㅋ	14.3
ㅌ	42.3
ㅛ	5.7
ㅎ	5.8
ㅏ	11.7
ㅑ	5.3
ㅓ	11.7
ㅕ	5.2
ㅗ	11.7
ㅚ	5.0
ㅜ	6.3
ㅟ	0.0
ㅡ	82.6
ㅣ	95.9

Wobbrock [14] showed that guessability EdgeWrite (English) was 51.0%, the experimental environment was very similar: twenty university students or staff.

3.7.4 Maximizing Guessability

With author-proposed gestures, guessability may be low although author designed very carefully. Therefore, collected gestures by participants affect the design of original. User-thought design may have conflict among them or original design, removing conflict was needed. After removing conflict the user-proposed design was added to the Korean EdgeWrite design.

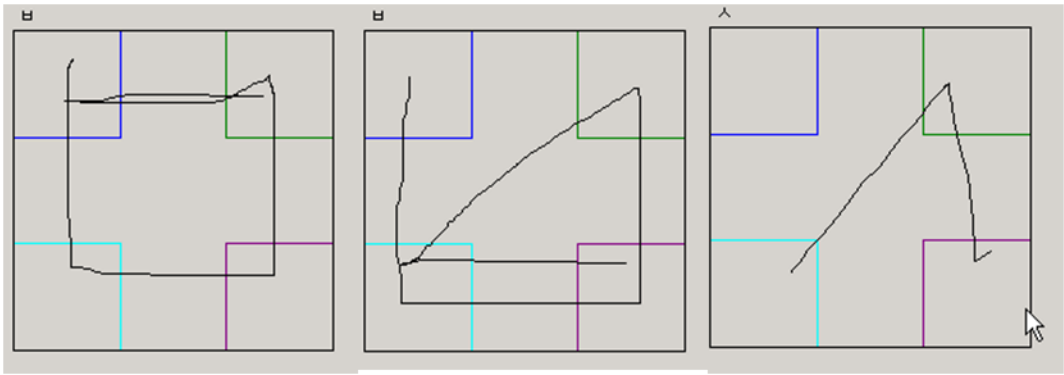


Figure 12. Example of the participants' design of the Korean EdgeWrite which were applied to renew the design.

After redesign of Korean EdgeWrite, guessability was recalculated using previous participants' data, only difference was the proposed symbol sets. The guessability of enhanced Korean EdgeWrite was 66.5% where guessability of EdgeWrite after same procedure was 80.1%.

3.8 Immediate Usability

3.8.1 Background

Guessability of Korean EdgeWrite showed much lower than that of EdgeWrite even though author design the symbols very carefully. By the analyzing the participants' data manually, several facts can be found as a cause of low guessability: low guessability of some consonants and very low guessability of most vowels.

Average guessability of ㄱ, ㄴ, ㄷ, ㄹ, ㅁ, ㅡ, ㅣ was 87.3% which was high enough but average guessability of ㅂ, ㅅ, ㅇ, ㅋ was 30 to 40 %, and guessability of ㅈ, ㅊ, ㅍ, ㅎ was 3 to 10%. Furthermore, gussability of vowels except ㅡ, ㅣ was 5 to 15% which was very low guessability.

Author analyzed that participants had no unified design principles and they set their own design principles. If design principles by participants did not match with that of author, guessability could be lower. It showed high guessability with basic consonant or vowels, it may be important by calculating immediate usability which can show how new users learn easily.

$$Accuracy = \frac{|A_c|}{|A|}$$

A: Number of entered alphabets
A_c: Number of correctly entered alphabets

Figure 13. Equation of calculating accuracy of text entry.

Immediate usability [9] verifies learning aids for new users – accuracy (Figure 13) after immediate study. Participants studied or practiced with referents and test after studying or practice to calculate number of symbols entered correctly. MacKenzie suggested two different type of immediate usability: 1-minute immediate usability which was rates after 1 minute of studying, 5-minute immediate usability which as rates after 6 minutes of practice. In the Korean EdgeWrite case, 1-minute studying means that reading the Korean EdgeWrite chart without any joystick handling, 5-minute practice means that practice the Korean EdgeWrite gesture using the joystick while watching the chart.

3.8.2 Method

14 participants including 2 female undergraduate or graduate students took part in the immediate usability text. They were 22.8 years old. There were no left-handed person; they did not have any prior knowledge about Korean EdgeWrite or EdgeWrite. Some participants use joystick often, but no one have experience with joystick text entry in Korean or English.

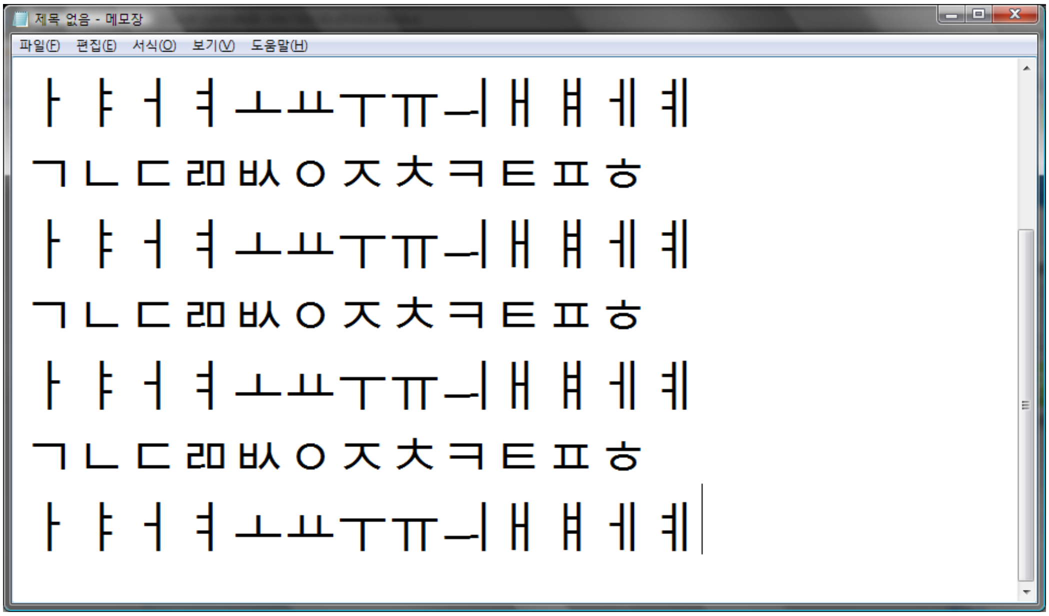


Figure 14. Example of the immediate usability test writing Hangeul

The subjects were told fundamental principles of Korean EdgeWrite including unistroke gesture, importance of four corner areas sequence. Furthermore, design principles of Korean EdgeWrite such as backward direct of writing vowels or adding stroke principles for consonants and so on (Figure 14).

Figure 15. Logitech RumbePad 2

The participants studied Korean EdgeWrite with the chart for 1 minute. They could use computer screen or paper as they want. After 1-minute studying of Korean EdgeWrite, they entered 28 Hangeul alphabets in alphabetic order five times. They entered Hangeul into Notepad – Microsoft Windows default text editor, using joystick; font family was Malgun Gothic, font size was 36 points. 3 Logitech RumblePad 2 (Figure 15) were used for every immediate usability test. If they entered incorrectly, they let jump to next Hangeul alphabet.

After 1-minute immediate usability test, they got a rest if they want. 5-minute immediate usability was continued. The immediate usability participants practiced Korean EdgeWrite by entering Hangeul alphabet into Notepad freely. They used Logitech RumblePad 2, it was possible to watch Korean EdgeWrite chart in computer screen or paper.minute immediate usability showed 88.0% (standard deviation=18.6) where English EdgeWrite showed 78.8%. 97.6% (standard deviation=6.14) of Korean alphabet entered correctly after 5-minute practices, 5-minute immediate usability of English EdgeWrite was 94.2%.

3.8.3 Results

The results save as text file, they was analyzed manually. 13 participants entered 28 alphabets five times for 1-minute immediate usability and 28 alphabets five times more for 5-minute immediate usability. Therefore, 1960 alphabets were collected for each text, but one participant's data was not saved so only 13 participants' data – 1820 alphabets was analyzed.

The participants correctly entered 1599 alphabets; immediate usability was 87.8% which was 1599 over 1820 times 100. One subject entered alphabets perfectly. The subject entered 1925 alphabets correctly, so immediate usability was 98.2%. Nine of fourteen participants showed perfect input.

3 participants were tested immediate usability once more after 1 month. One of the participants made perfect text entry, average accuracy by 3 people was 99.5%.

With similar experimental environment in terms of subjects or procedure, Wobbrock showed 1-minute immediate usability was 81.6%, 5-minute immediate usability was 94.2%. MacKenzie showed 1-minute immediate usability was 81.8%, and 5-minute immediate usability was 95.8%

Compare to other two symbolic text entry methods, Korean EdgeWrite showed better immediate usability, it means Korean EdgeWrite can be learned quickly with fundamental principles of studying of practice.

IV Evaluation

Two existing joystick Korean text entry methods – alphabetic selection keyboard and multi-tap selection keypad - were used to compare with Korean EdgeWrite. The evaluation checked the speed and the error rates of each method; additional questionnaire was given to the participants. Another gestural Korean joystick text entry method ASK-HIM was compared with Korean EdgeWrite, too.

4.1 Competitor Methods

Although Korean text entry methods for a joystick are not researched much, two text entry methods are used commonly: *alphabetic selection keyboard* and *multi-tap 3x4 selection keypad*. These methods were used as competitor methods to Korean EdgeWrite. Following sections describes their detail information and implementation issues.

4.1.1 Alphabetic Selection Keyboard

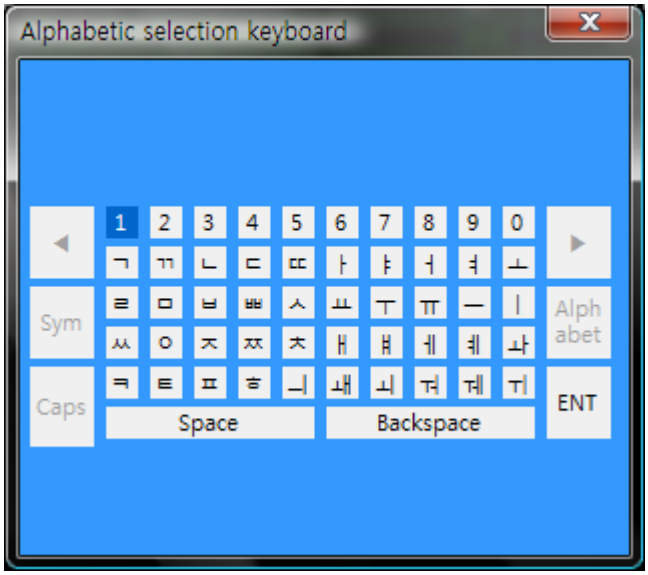


Figure 16. Alphabetic selection keyboard used in the evaluation.

Alphabetic selection keyboard (Figure 16) is a text entry method for Microsoft Xbox 360. Hangeul 19 consonants and 21 vowel including diacritic vowels are located in alphabet order. Alphabetic layout is used in this method, but it is possible to use dubeolsik or sebeolsik layout. Consonants are located in left five keys, vowels are located in right five area except "ㅚ". Space bar and backspace is located bottom side, enter key is at bottom-right. Caps lock key, arrow keys, symbol mode key, alphabet mode key exist at Xbox 360, but are not used in this study. Highlighted key is changed by joystick movement to up, bottom, left, or right; highlighted key is moved to another side after movement of border.

4.1.2 Multi-tap 3x4 Selection Keypad

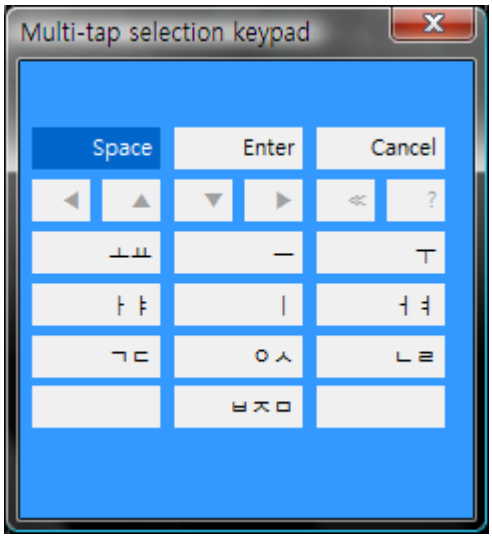


Figure 17. Multi-tap 3x4 selection keypad used in the evaluation.

Multi-tap 3x4 selection keypad (Figure 17) is used for Sony PlayStation Portable and Sony PlayStation 3. Multi-tap method is commonly used for the mobile phone text entry, clicking same key once enters alphabet at the first position of the key, clicking same key twice enters alphabet at the second position of the key, and clicking same key three times or more enters alphabet at the third or more position of the key. Layout of the key was shown on the key, but multi-tap 3x4 selection keypad used in this study and PlayStation showed candidate alphabets at the top of the keypad because each key have more than 3 or 4 alphabets while common mobile phone key contains only 3 or 4 alphabets for one key.

Layout of the keypad is different from device such as Samsung Anycall, LG Cyon or SKY and so on, Sony used unique layout for the their keypad. Consonants and vowels are separated, consonants key showed only basic consonants only.

4.2 Method

4.2.1 Subjects

14 native Korean subjects from undergraduate and graduate school were recruited. The mean age was 22.8 (SD=2.9). Every participant took part in the previous immediate usability test, so no more practice was necessary. All of them were right-handed and two were female. The subjects were paid 20,000 won for a 100-minute test.

4.2.2 Apparatus

Korean EdgeWrite and evaluation program (Figure 18) were developed in C# using Microsoft DirectInput 9.0c. The alphabetic selection keyboard and the multi-tap 3x4 selection keypad were also implemented for comparative study. The program was running on Microsoft Windows XP with 19 inches monitor and the resolution was 1280 by 1024. Logitech RumblePad™ 2 was used for test. The resolution of the test program was that of PlayStation Portable. Competitor methods were alphabetic selection keyboard and multi-tap 3x4 selection keypad described in the section 4.1.

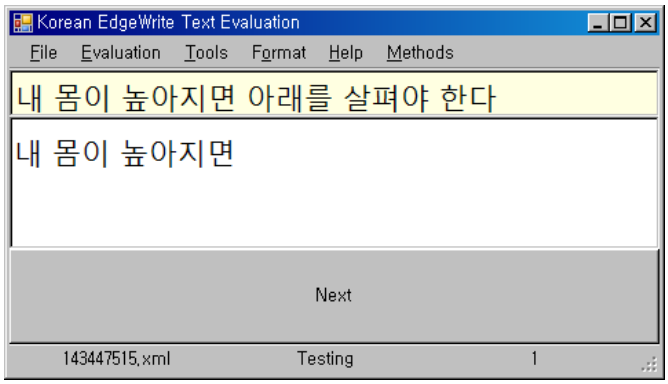


Figure 18. Korean EdgeWrite text evaluation software.

4.2.3 Procedure

Each of the subjects used Korean EdgeWrite, the alphabetic selection keyboard, and the multi-tap 3x4 selection keypad in counterbalanced orders. A single-factor within-subjects design was used, so participants took three methods.

The participants had a practice session before the test. We let them enter several phrases with the selection-based text entry methods until they felt comfortable with the methods. One phrase was enough for the most subjects since the methods were easy to learn. The participants practiced Korean EdgeWrite for 10 minutes with the Korean EdgeWrite chart. (Figure 1)

After the practices of three methods, they entered 10 sentences using each method. The phrases came from Korean proverbs and those phrases contained only Hangeul characters.

4.2.4 Measure

Character per minute (cpm) and corrected error rates were measured. In this paper, character per minute means the number of the consonant or the vowel entered not the letter consist of the consonant and the vowel. Since a combina-

tion of consonants and vowels makes a letter, it was hard to calculate uncorrected error rates in Hangeul. Therefore, no errors were allowed and the total error rate was same with the corrected error rate. We conducted post-test questionnaire to get subjective data.

4.3 Results

4.3.1 Speed

Korean EdgeWrite showed faster speed than other two methods. (Figure 19) Means (and standard deviation) of cpm for Korean EdgeWrite was 30.57 (3.78), for the alphabetic selection keyboard was 25.32 (4.33), and for the multi-tap selection keypad was 27.82 (5.55). ANOVA showed significant differences ($F_{2,36}$=4.21, p<.05) among three methods. (Table 2)

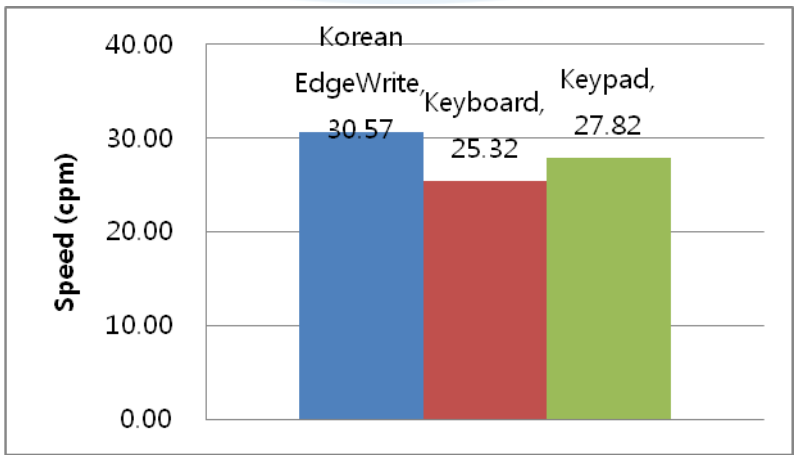


Figure 19. Text entry speed for three methods for a joystick.

4.3.2 Error Rates

Korean EdgeWrite had higher error rate (Figure 20) and there was a signif-

icant difference among the methods ($F_{2,9}$=5.35, p<.05). Korean EdgeWrite is gestural text entry method while alphabetic selection keyboard or multi-tap 3x4 selection keypad is selection based so users check the letter before they entered the key; high error rates may be understood.

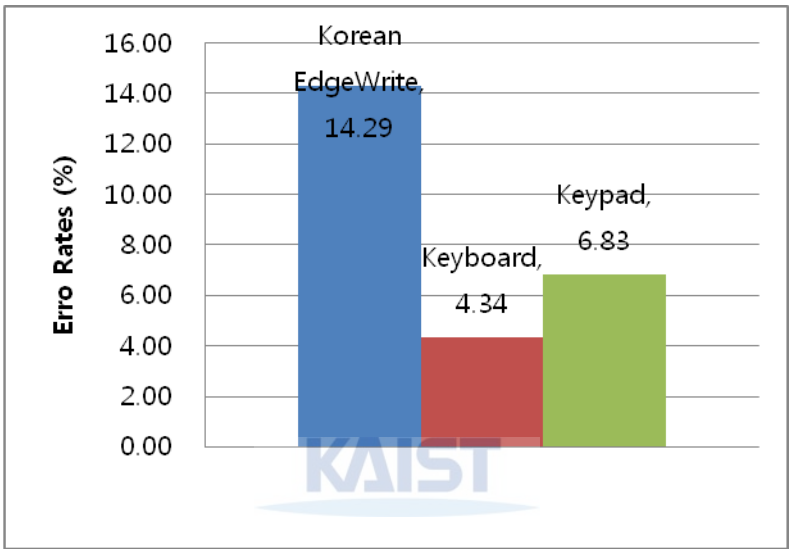


Figure 20. Error rates of three methods for a joystick.

4.3.3 Questionnaire

The subjects filled a questionnaire after the test session. They answered that Korean EdgeWrite was more enjoyable and faster than others. In addition to this, they preferred Korean EdgeWrite than selection-based methods (Figure 21). Analysis of variance showed a significant difference of scores ($F_{2,9}$=5.35, p<.05) among the methods.

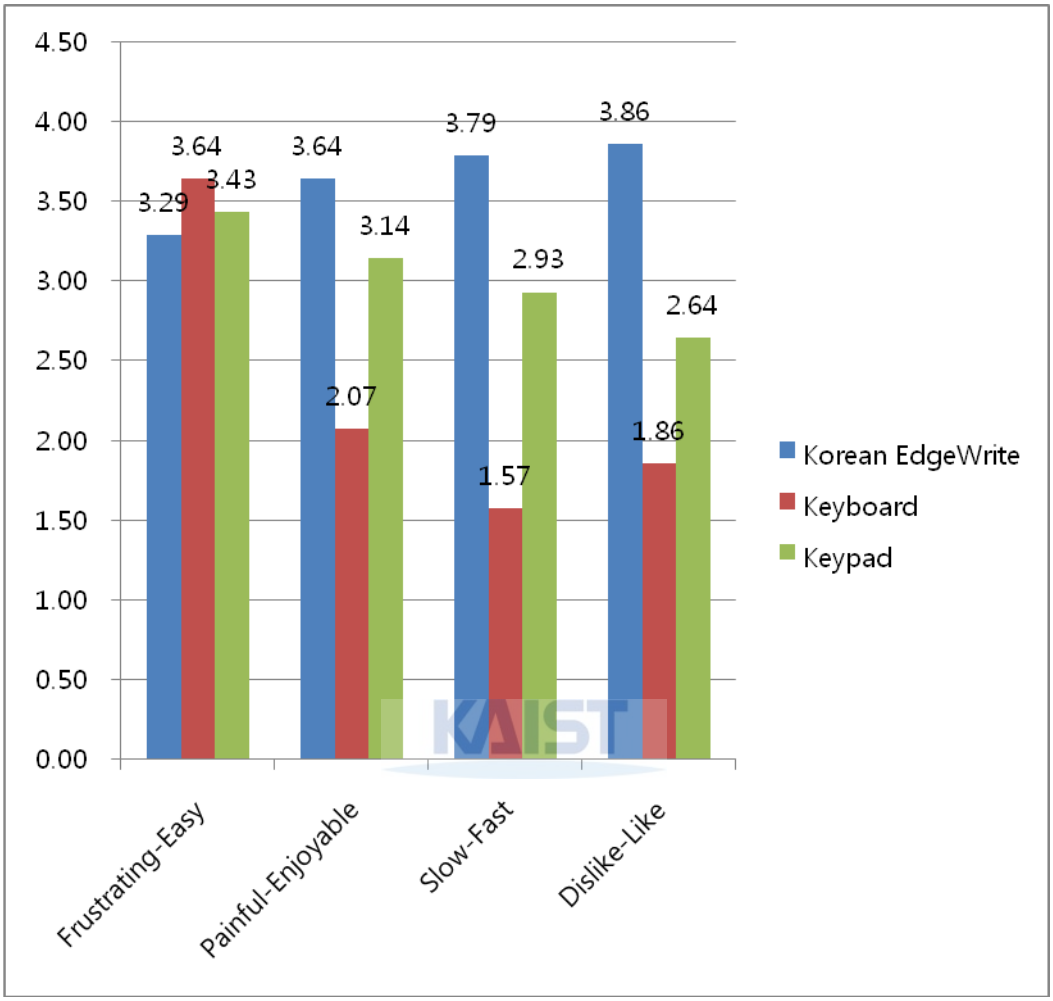


Figure 21. Questionnaire results.

Table 2. Evaluation results.

Participants	Korean EdgeWrite	Keyboard	Keypad
A	33.40	22.09	23.99
B	25.46	28.54	27.46
C	30.67	25.98	34.47
D	30.33	20.95	23.84
E	34.49	27.85	27.03
F	30.88	27.08	27.77

G	28.49	21.77	20.41
H	36.92	31.35	31.81
I	27.23	24.01	25.99
J	27.89	26.80	32.48
K	31.83	33.06	40.02
L	24.60	18.72	21.40
M	35.19	20.93	24.96

4.4 Well-trained User Evaluation

To see result of well-trained user, 3 subjects who were in the previous test took part in the additional test. They practiced three joystick text entry methods over 30 minutes, and they tested speed and error rates.

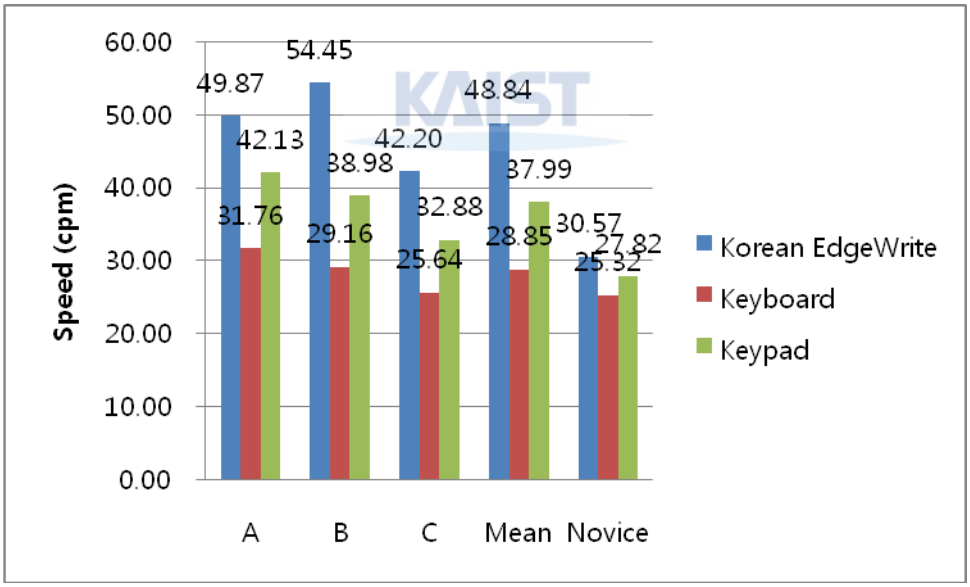


Figure 22. Well-trained user evaluation result in term of speed.

The speed of the Korean EdgeWrite (Figure 22) outperformed selection-based text entry, one of the participants showed comparable speed with the mobile phone use.

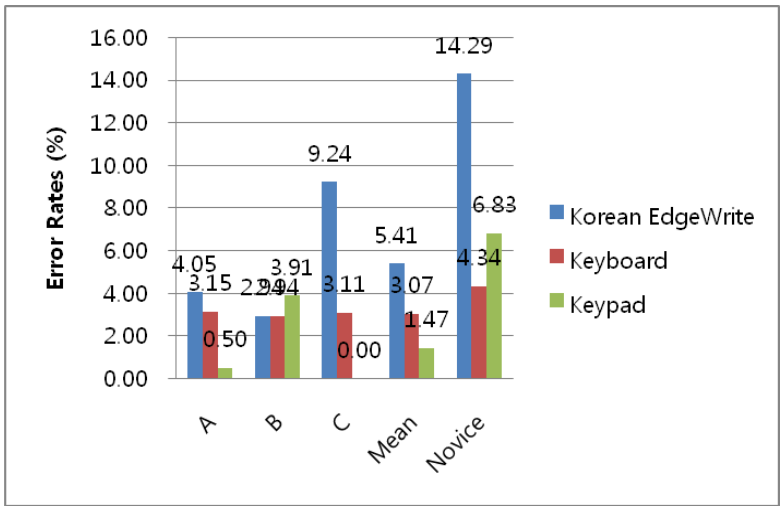


Figure 23. Well-Trained user evaluation result in term of the error rates.

Error rates of the Korean EdgeWrite (Figure 23) become much lower than novice even though one participant still made lots of errors.

4.5 Comparison with ASK-HIM

Two competitor methods – alphabetic selection keyboard and multi-tap selection keypad were selection-based joystick text entry methods. Therefore, effectiveness of the design of the Korean EdgeWrite couldn't be compared. Another gestural Korean joystick text entry method ASK-HIM was compared with the Korean EdgeWrite to show effectiveness of the design of the Korean EdgeWrite.

3 participants who took part in the previous test and 1 new participant were enjoyed the evaluation between the Korean EdgeWrite and ASK-HIM. They were beginner of the ASK-HIM, so we let them to learn ASK-HIM gesture and practice as much as they want. Following procedures were same with the previous test.

The participants showed better performance in terms of the speed and error rates. Their average speed of the Korean EdgeWrite was 31.86 cpm, but the

speed of the ASK-HIM was 17.59 cpm. Error rates of the ASK-HIM was 45.95% which was more than four times of that of the Korean EdgeWrite.

Participants gave higher value to Korean EdgeWrite (Figure 24) for every questions than ASK-HIM. They prefer Korean EdgeWrite rather than ASK-HIM.

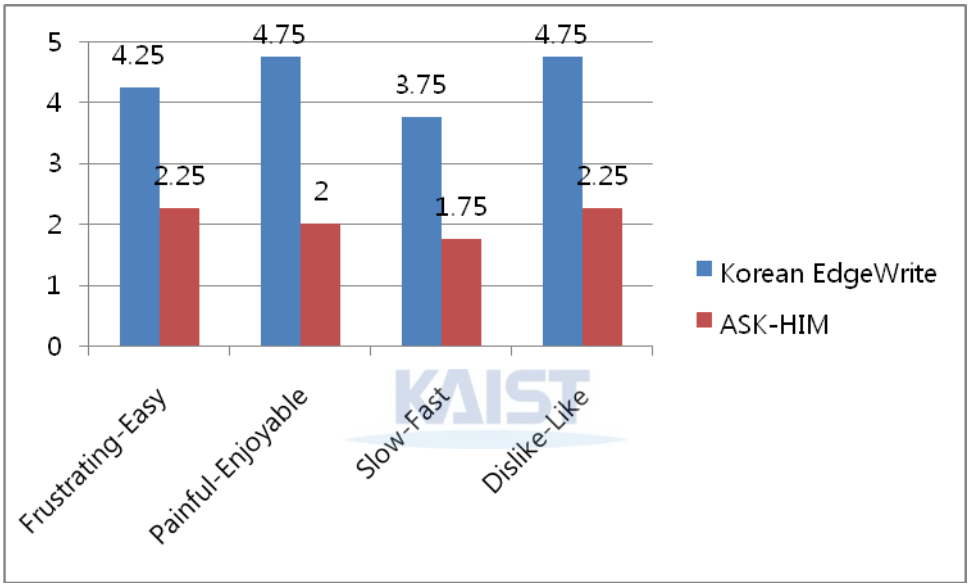


Figure 24. Questionnaire results between Korean EdgeWrite and ASK-HIM.

V Conclusions

5.1 Thesis Summary

We introduced Korean EdgeWrite, a new Korean text entry method for a joystick. At first, initial design was considered as Korean EdgeWrite, The design was modified by the pilot test, guessability test upgraded the design again. Immediate usability test showed Korean EdgeWrite was easy to remember. Novice users entered Korean EdgeWrite faster than the alphabetic selection keyboard or the multi-tap 3x4 selection keypad, but error rates of Korean EdgeWrite was higher than others. However, well-trained user entered Korean EdgeWrite with similar accuracy than others while the speed of it was much faster than the other selection-based text entry methods. The text entry speed by the expert could be close to the speed of the mobile phone text entry [11]. In spite of the fact that the subjects did not feel Korean EdgeWrite was easier than others, they preferred Korean EdgeWrite and felt Korean EdgeWrite was more enjoyable and fast than others. The participants said that Korean EdgeWrite was not easy because they should learn gestures to enter text. However they thought learning Korean EdgeWrite was not a heavy burden. Furthermore Korean EdgeWrite outperformed another gesture-based Korean text entry method ASK-HIM.

5.2 Discussion

Korean EdgeWrite is a gesture-based text entry method, so it does not need secondary focus while entering the text. Transcribed area and keyboard/keypad selection area are separated when users use the selection-based text entry; users should move focus to check inputted letters which can be a burden. Selection area for keyboard becomes a problem with very small device be-

cause of limitation of the screen size while Korean EdgeWrite does not need any other space.

Alphabetic selection keyboard and multi-tap keypad were implemented as competitor methods. However the parameters of the joystick such as polling time, key event time and so on could effect on the speed and user satisfaction. The emulated program was implemented with careful comparison with original Sony PlayStation or Microsoft Xbox, for example alphabetic selection keyboard supported border movement while multi-tap keypad did not as PlayStation and Xbox did, but it may be not perfect.

Korean EdgeWrite segmented the letter when the joystick returns to the center area. It was a trivial and made it easy to implement. Also, by the pilot test it was implemented as very low delay or miss of segmentation. However, combination of the consonant and the vowel make the Hangeul, many Korean user think that segmentation should be at the between one syllable not alphabet. It was another design issue although it was not mentioned in the previous section, but it was very difficult to segment by syllable because equal segmentation was needed to design unified gesture and implement easily.

Korean EdgeWrite is gestural text entry method, even though the gestures are easy to learn, sometime it may be forgotten. Currently, there is no way to input the text when the user forgot the gestures unless the user read the Korean EdgeWrite chart again. Martin [10] suggested visual feedback on the Korean EdgeWrite, the way to represent visual assist used in the Martin was one of the options to the Korean EdgeWrite but was not implemented because of time limit. It is not good idea to apply visual feedback to portable device but large screen device such as video game console can support visual feedback, so user can enter the text without reading the chart again.

In this study, Korean was only consideration but alphabet, number, or sev-

eral signs including comma, semi-colon, question mark, and so on are possible text to input. EdgeWrite supports several modes such as alphabet mode, number mode, special character mode, European character mode and so on. Korean EdgeWrite can be a mode of EdgeWrite then it will be possible to input every character.

5.3 Goal Achievement

We have shown the efficiency and easiness of Korean EdgeWrite. KSPC calculation showed KSPC of Korean EdgeWrite was comparable to that of multi-tap. In the evaluation, the participants could enter the text faster than the selection keyboard or the multi-tap keypad. Although beginner made more errors in the evaluation, well-trained user could achieve the speed of the mobile phone text entry by novice and made similar errors compared to the other methods.

High immediate usability compare to EdgeWrite or Graffiti showed the easiness of Korean EdgeWrite, meaning it was easy to remember Korean EdgeWrite design for beginners.

5.4 Future Work

In this thesis, a short preliminary evaluation and a well-trained user evaluation were analyzed. These tests were enough to find out the brief comparison between Korean EdgeWrite and other text entry methods in terms of speed, error rates, and preferences after short practice at the lab test. However, the time when users use the Korean EdgeWrite would be more complex and long. Users may use the Korean EdgeWrite not only while sitting down the chair but also while standing up. There may be no enough time to practice about 10 minutes or users may not want to practice. The learning curve on speed and error rates or user

feedback from long-term user test must be considered in the future.

Physical or mental fatigue to the user is another issue which should be considered in the future. Learning the Korean EdgeWrite gestures may be a mental fatigue for some users even though it was not a harden burden for the participants – the participants took part in this test were young people who are very familiar with the computer and they do very well with the new device in many cases - old people may think it is difficult to learn the gestures. Measure the physical fatigue is challenge work, but it is good feature to increase the user satisfaction.

Considering a left-handed person may be performed to provide equal right. Every participant was a right-handed person, so there was no consideration for a left-handed person. A left-handed person may use left joystick when dual joystick device using same gestures with a right-handed person or using mirrored gestures which are horizontal reverse.

We did not analyze detail of the evaluation data to know which gestures made the most error. With the analyzing of these things, it is possible to redesign Korean EdgeWrite and it may decrease the error rates.

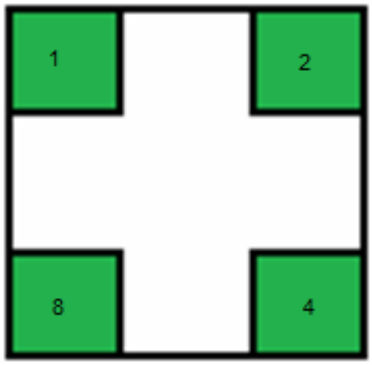
Some devices such as PlayStayion game pad or Xbox game pad support dual joystick. It is possible to use two joysticks sequentially or use left joystick to write consonants and use right joystick to write vowels. It may increase the speed of text entry but it was not applied because of extensibility of the Korean EdgeWrite - there are many single joystick devices. However optional dual joystick support can give the benefit, so further research on comparison of dual joystick use and single joystick Korean EdgeWrite may be helpful.

5.5 Final Remarks

The Korean EdgeWrite showed better performance in terms of the speed, comparable results on the error rates. Quantitative results are important for the text entry technique evaluation, but the qualitative study such as user preferences must be considered as much as possible.

Appendix A Korean EdgeWrite Character Set

Following table show the whole character set of the Korean EdgeWrite. Gestures consist of the sequence of the numbers which represent the area. One alphabet can contain more than one gesture, gestures are separated by whitespace. Following figure represents the relation between the numbers and the areas.



Hangeul	Sequence
ㄱ	124 14
ㄲ	124124
ㄴ	184 8242
ㄷ	1214 2184
ㄸ	1218412184 21842184
ㄹ	1284 12484
ㅁ	12481 181248 1812484 184124 18421
ㅂ	1421 18181212 1818484 18248 1842 184212 184248 18428 184284 184842 82
ㅃ	1818121218181212 18184841818484 18421842
ㅅ	1814 28 2824 284 428 814 8184 824
ㅆ	18141814 2828 28242824 428428 814814 824824

ㅇ	1841 184218421 21842 218421 2481 2842 4284 48124 8148 8248 8421
ㅈ	12148 12424 128 12824 4128
ㅉ	1242412424 128128 1282412824
ㅊ	184 1212424 12128 1212824 121284 124821 21284 412128
ㅋ	12124 12412 12421 12482 2124
ㅌ	1212184 1218284 12184 121848 1218484 18482 212184 21841 21848 2184812 218484
ㅍ	1212484 12181248 1218184 12182484 121842 12218284 1242184 12481 12818 1282484 128284 12841
ㅎ	12121842 1212481 1212842 121484 121841 1218421 124812 12481212 12842 12848
ㅏ	142 1812 182 812
ㅑ	181 181212 181284 18224 1824 18284 184812 1848121 18484 4812 8121 81212
ㅓ	1242 241 2484 4124 421
ㅕ	121242 1248 128424 242 24218 248421 4212 42121 484124
ㅗ	1484 1848 184848 248 481 4848 842
ㅛ	181848 1821 182484 18481 24248 481424 8424 84242
ㅜ	1218 21241 218
ㅠ	121818 121824 1241 124218 1242181 1281241 2181 21818
ㅡ	84
ㅣ	18 24 42 81
ㅐ	18124 8124
ㅒ	1812124 812124
ㅔ	124242 42124 4218

ㅖ	12124242 4212124 421218
Space	12
Backspace	21 48
Enter	2482

석사학위논문

Korean EdgeWrite: 조이스틱을 이용한 한국어 입력 방식

공학부 김호진

비디오 게임기나 휴대용 기기 등 조이스틱을 장착한 여러 기기들의 기능이 늘어남에 따라 문자 입력의 필요성은 점점 커지고 있다. 조이스틱을 이용한 영문자 입력에 대해서는 연구가 진행이 되고 있지만 최신 기기의 도입이 늦었던 한국의 경우 저자의 연구였던 ASK-HIM 을 제외하면 조이스틱 문자 입력에 대한 연구를 찾기 힘들다. 이 논문에서는 조이스틱을 이용한 새로운 한국어 입력 방식인 Korean EdgeWrite 를 소개한다. 높은 효율과 쉬운 난이도를 이루기 위해 한글의 모양 분석을 통해 최초의 디자인이 이루어졌고, 초기 평가를 통해 수정을 하였다. 또한 예측 가능도 평가에서 얻어진 피실험자의 의견을 바탕으로 추가적인 디자인 수정 과정을 거쳤다. 문자 당 키 입력 횟수 측정을 통해 Korean EdgeWrite 가 휴대폰에서 쓰이는 멀티탭 방식과 비슷한 효율을 보여준다는 것을 확인하였고, 즉각 사용성 테스트를 통해 EdgeWrite 나 Graffiti 보다 처음 사용자들이 기억하기 쉽다는 것을 알 수 있었다. 사용자 테스트에서 대부분의 사용자는 10 분 미만의 연습을 통해서 Korean EdgeWrite 의 디자인을 외울 수 있었으며, 가나다순 화상 키보드나 멀티탭 키패드 방식 문자 입력보다 더 빠른 속도로 문자를 입력하였다. 강화된 훈련을 거친 사용자의 경우 휴대폰 사용자 정도의 속도로 입력이 가능했으며 오류의 발생 빈도도 다른 방식과 비슷한 정도로 줄어들었다. 사용자들은 설문 조사에서 Korean EdgeWrite 가 다른 두 가지 문자 입력 방식에 비해 선호도, 속도 측면에서 좋은 점수를 주었다. 덧붙여 Korean EdgeWrite 는 저자의 다른 조이스틱 한국어 입력 방식인 ASK-HIM 보다 좋은 성능을

보여주었다.

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