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A Three-Set Type Korean Keyboard Model, 38K, with High Compatibility to the KS Computer Keyboard

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Objective: The purpose of this study is to design a three-set type (Sebulsik) keyboard that is to input Korean text with no shifted keys and also compatible with the standard Korean computer keyboard or ANSI keyboard.

Background: The KS computer keyboard is two-set type (Dubulsik). Existing and proposed designs of three-set type of past studies are not compatible with KS or ANSI keyboard and are complex with many redundant letters.

Method: The number of Korean letters for 3-set type is analyzed. Then Korean letters are arranged with normality and with spatial compatibility to the KS Korean keyboard, and symbols were arranged to same positions with ANSI keyboard.

Results: Initial consonants of 14 numbers and 6 vowels are arranged as exactly same positions of KS keyboard, and other vowels are arranged with spatial compatibility. Symbols are arranged to the same positions with ANSI keyboard, and 10 digits are confirmed and has compatibility to International standard.

Conclusion: A 38-key model, 38K, is designed to require minimal keys to input Korean text with no shifted keys, increased the compatibility to the KS Korean computer keyboard.

Application: Using the proposed 38-key model, 38K, it can be taken into account for keyboards in industrial production. It is applicable to user group of 3-set type Korean keyboard with more easy than past keyboards.

Keywords: Korean computer keyboard, KS, Three-set type, Two-set type, Normality, 38-key model, 38K, Compatibility

1. Introduction

An important device of the computer input is a keyboard. The Korea Industrial Standard of keyboard layout where Korean letters are arranged is "Keyboard layout for information processing" (KS X 5002, 2007), which was defined as Dubulsik layout (2-set type). There is another important Korea Industrial Standard where the physical criterion is specified, "Keyboard for personal computer" (KS X 5003, 2011). However, the arrangement of symbols is slightly different from these keyboards. The products in the market are, strictly speaking, slightly different from these KS, but more compatible with American keyboard standards.

In English, for an example, the "A" and "a" are the same alphabet of "A", however,

as a capital and a small letter which are different fonts. In contrast, though the initial consonant "ㄱ" and the final consonant "ㄱ", for an example, are the same Korean alphabet "ㄱ", however, they are different phases, ie, different positions in Korean scripts (Hangul) of compound syllable. Therefore, Sebulsik (3-set type) is valid. There must be normality of one letter per one key position, and one letter per one stroke by default, and must be available for analog device. The special keyboards, for examples, allow one letter per two strokes, or two letters alternating of one stroke.

NIKL (2007), and Kim & Yoo (2008) studied for 2-set type Korean keyboards. Kim (2009) analyzed advantages and disadvantages of 2-set type Korean keyboards and suggested the necessity of 3-set type, modes classification, design principles, and some models. The important point is not to use "Shifted keys" (the upper of two symbols labeled on a key, or a capital letter) and use minimum keys, so 38 keys were arranged for 38 letters.

In this paper, we designed a 3-set type keyboard model to increase the compatibility to the current Korean standard as a unique model which provide improvement from the past studies. It is very difficult to design a 3-set type keyboard which has compatibility to 2-set type, because the arrangement of letters for the existing 3-set type and 2-set type are very different. Hence, a 3-set type design should be developed, having a normality and high compatibility to the 2-set type standard.

The row identification numbers are defined in the International Standards, however, the 1st row (Digits row), the 2nd row (Q row), the 3rd row (A row), and the 4th row (Z row) from the top are defined in this paper.

2. Preliminary

2.1 Representative 3-set type keyboards

Representative 3-set type keyboards are Sebulsik 390 and Sebulsik 391 as shown in Figure 1. Their advantages and disadvantages, and comparative study with 2-set type have been previously studied in past works of Kim (2009), etc. However, there was no normality of the one letter per one stroke, due to historical custom of use of typewriters. For example, Sebulsik 391 (also known as "Final" which can be mis-interpreted, because it is the inventor Kong's final design) which accepts 58 letters among all 67 Korean letters or letter clusters (ligatures) of initial consonants, medial vowels, and final consonants, too complex with many redundant letters. Also, any 3-set type keyboard has no compatibility to 2-set type standard. Examples of the user reviews for 3-set type are as follows. (http://pat.im/1010)

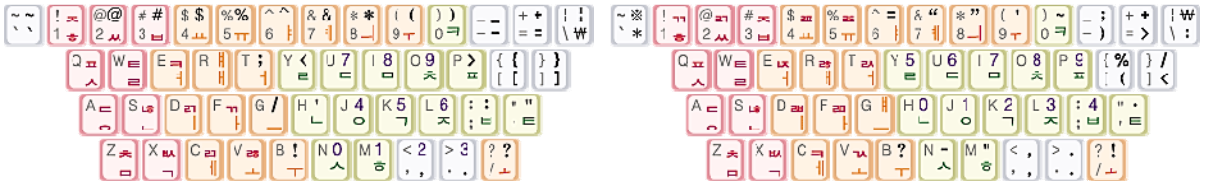

Figure 1. Sebulsik 390, and Sebulsik 391 (Kong-final) keyboards

"I really don't have need for ㅗ and ㅜ (duplicated allocation for ligatures including ㅗ and ㅜ, such as ㅘ, and ㅝ, by author comment) at all, and I believe it is inefficient to have too much unnecessary final consonants ligatures. Furthermore, I'm sure it is not only difficult to remember the final consonant ligatures of very low frequencies, but also it is more quicker and easier to stroke two keys than to stroke a key by stretching a finger to the uncomfortable positions and even more so by pushing a shifted

position. I think if people really want to use the 3-set type, people should discard (or retrofit) keyboards for the typewriter and should be to fit the current situation, which is keyboard layout must be studied again fully excluding typewriter layout."

"Sebulsik 391 is considered as a difficult one to learn for the symbols positions among keyboards for text."

Above reviews show the current status even though there is a necessity of 3-set type.

There is no evidence the final consonant "ㅆ" at the 1st row is better than the double tapping of "ㅅ" in normal fingering range, therefore it is depends on the users preference. Furthermore, symbols @, #, $, [,], and so forth, of the standard keyboard layout are missing. Duplicated allocation of ㅗ and ㅜ does not match the rule of one letter per one position, and ㄺ, etc, do not fit the rule of one letter per one stroke. Then An Jong-Hyeok proposed Sebulsik Sunarae with no-shifted letters, which take 44 keys, therefore, the little finger must be stretched extremely which is problematic.

An, M. (2000) proposed a 3-set type keyboard with the special input as one letter per two strokes, such as ㄱ+ㅎ → ㅋ, having initial consonants at left area, medial vowels at right area, and final consonants at bottom area. However, whether English or Korean, steno keyboards have initial consonants at left area, final consonants at right area, and vowels at bottom area, and An, M. (2000) has the problem that causes musculoskeletal diseases of the thumb and wrist because 10 final consonants are arranged at the bottom row broadly.

The Shin Sebulsik was proposed by Shin Kwang-Jo and developed by Park Kyeong-Nam, etc., which is a special 3-set type design where output letters are different depending on each input of the key, such as two letters alternating per one stroke, ie, the first stroke makes a vowel, and the second stroke makes a final consonant. Further, Bokbulsik (Dual type) was proposed, where if the first stroke is at left then 2-set type is assumed, and if the first stroke is at right then 3-set type is assumed. They have inconsistency between recognition and behavior, and it is impossible for analog design.

2.2 Model 38 keyboard

Kim & Jeong (2002) classified Korean characters as 'set of 2 parts (2-set type)' and 'set of 3 parts (3-set type)' and each is classified as the full set, the common set and the minimum set. There are the full set of 67 characters, the common set of 42 characters (including ㅐ, ㅒ, ㅖ, and ㅖ), and the minimum set of 38 characters (24 basic alphabets plus 12 basic final consonants) for 3-set type.

Focusing on this point, Kim (2009) developed "Model 38 (Sebulsik 38, or Kong-Kim 38 Model)" by 38 characters of the minimum set of 'set of 3 parts', that has no shifted letters, normality of one letter per one stroke, minimum number of keys, and symbols are compatible to KS. Kim (2009) emphasized the large number of keys of past 3-set type designs are caused by hereditary custom to make good feature of output of mechanical typewriters. Now it is sufficient to input 3-set type by 24 Korean alphabets of "Hangul orthography" plus 14 final consonants, so Kim (2009) designed that 38 letters allocated with no shifted positions and symbols and digits are compatible to standards. Digits layout must be consistent to International standard. digits array must be Figure 2 (1), 2×5, 5×2 arrays must be Figure 2 (2) and (3), if necessary, in a special devices, and (4) in keyboard, according to ITU standard (ITU-T E.161, 2001). Therefore Kim 38 model is consistent to International standard among existing 3-set type keyboards. The 38 model is shown as Figure 3.

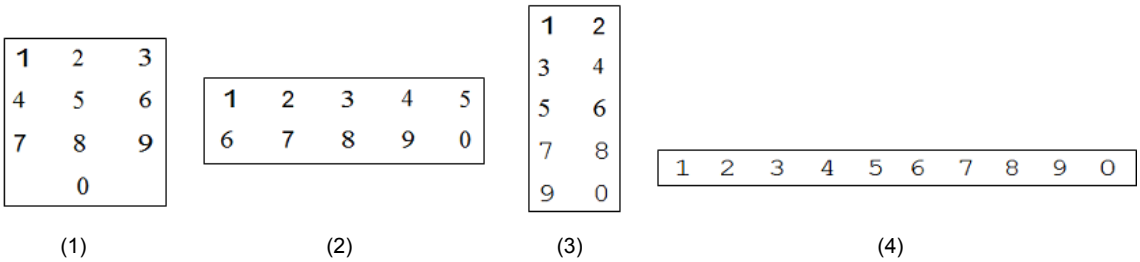

Figure 2. Arrangements of digits of ITU standard

Figure 3. Model 38 keyboard

3. Improvement of 38 Keyboard - Increasing the Compatibility to the KS Computer Keyboard

3.1 Conceptual approaches

Though the 38 model is an innovative concept than in the past, we seek to improve as follows in this paper.

1) Because the apostrophe (') position at the 3rd row is out of normal range of the little finger, a slash (/) position is used instead.

2) We tried to be compatible to KS, and we considered frequencies. Further, Korean script is writing from left to right, therefore the arrangement of initial consonants in left side and vowels in right side is better than their opposite sides.

3) Consonants replacing such as the position ㄱ is replaced to ㄴ, or vowels replacing such as the position ㅠ is replaced to ㅕ, is not compatible and is not good because of reverse learning.

4) The design is approached as the order of ① initial consonants, ② medial vowels, and ③ final consonants, relationally with feedback.

First, according to human factors engineering, sense of the normal work area and the maximum work area (Jeong & Lee, 2009), "normal finger range" and "maximum finger range" from home keys are defined. The normal finger range is defined as the 2md row, the 3rd row (home row) and the 4th row, and the maximum finger range includes the 1st row to the normal finger range. If all 24 alphabets of KS keyboard are arranges as initial consonants and medial vowels, then there are only 4 positions are remained in the normal finger range. Hence the practical design is impossible in fact.

Frequencies of initial, medial, and final sounds of 38 letters, organized from Kim & Jeong (2002), are shown as Figure 4. Let former 28 letters are "high frequency group" and remaining letters are "low frequency group". The high frequency group is consist of 13 initial consonants, 7 medial vowels and 8 final consonants, and the key point is how these letters are arranged to the normal finger range with high compatibility to KS.

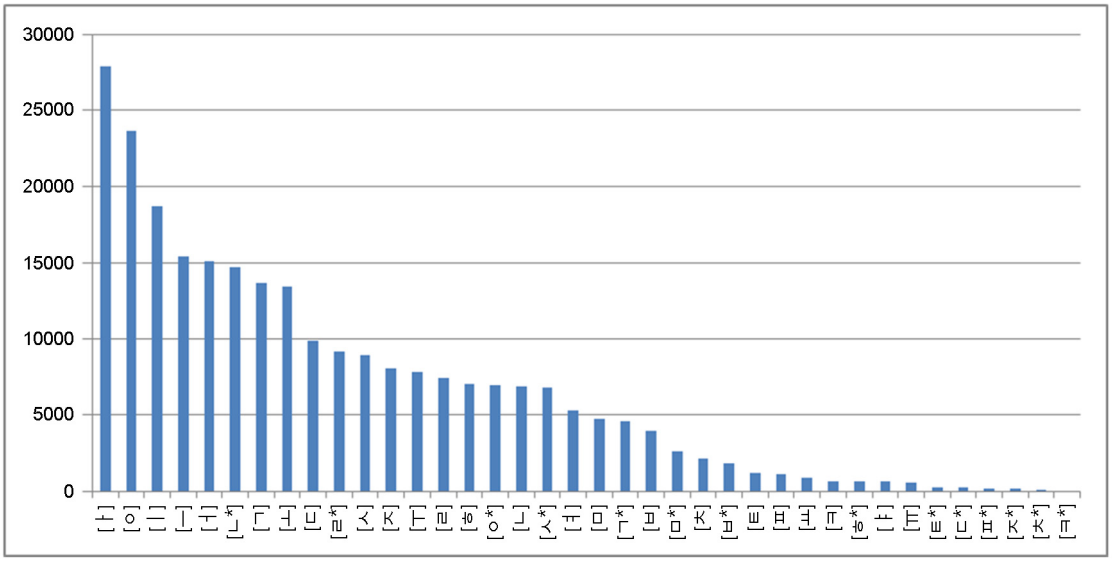

Figure 4. Frequencies of initial, medial and final sounds of 38 letters

3.2 Arrangement of initial sounds (consonants), medial sounds (vowels), and final sounds (consonants) for model 38K

1) Initial consonants: 14 consonants (13 of the high frequency group plus ㅋ) is sustained to same position to KS for high compatibility and usage of initial consonants. By this reason, the last of high frequency group, "ㅛ", may be out of the normal fingering range.

2) Medial vowels: positions of 6 simple vowels (ㅏ, ㅓ, ㅗ, ㅜ, ㅡ, and ㅣ) of the high frequency group is sustained to the same to KS. For the allocation of the vowel of the next frequency, ㅕ, if the original position is sustained, a problem occurs that final consonants are scatters as 4 areas. On the other hand, though "ㅠ" is one of the low frequency group, it is not appropriate by the approaching concept and separation of final consonants area that allocating another vowel to original ㅠ position, hence the position of ㅠ is sustained. Remaining ㅕ, ㅛ, and ㅑ are allocated to the direct above positions with high spatial compatibility, then inconvenience of reverse learning is minimized.

3) Final consonants: 7 final consonants of the high frequency group are allocated in the normal fingered range considering their frequencies, after analyzing of the finger load score of "TheScience (2011)" and positions of final consonants of Model 390, Model 391, and Model 38. "ㅎ, ㅌ, ㄷ, ㅍ, ㅈ, ㅊ, and ㅋ" of the low frequency group are allocated in the maximum fingered range, where 5 consonants are located to the left of the area unavoidably. The difference of frequencies between ㅌ and ㄷ is 0.01%, the arrangement may be redesigned as a research in the future. Because ㅅ is higher frequency than ㅂ, and it is used as ㅆ, it is allocated to middle finger's position than the little finger's position.

3.3 Arrangement of shifted characters

First, 12 digits and symbols on basic position that are replaced by letters must be compensated. Ten digits are allocated to the shifted position of the second row as with previous studies that are compatible to ISO. Two symbols (/ and ;) are not simple. Future allocation in shifted positions must be considered for 2-set type and 3-set type. In this paper, shifted positions of the third row are avoid for consistent design to 2-set type, "/" and ";" are allocated from number 1 key of the 4th row which is at symmetric position of "/". Symbols other than in ANSI keyboard are not allocated.

By above approaches, Sebulsik 38K model is designed as shown in Figure 5.

Figure 5. A model 38K - KS compatible

3.4 Comparative analysis

Rating measures are quantitative index of load scores, etc., and qualitative ratings theoretically, and speed (letters per a minute) and error rate as index of efficiency empirically. Error rate is integrated to speed rate, subtracting a determined number of letters per one error from the speed rate. In this paper, quantitative index and qualitative ratings are approached first, and an experiment will be studied later. Using preliminary experiment, intuition and memory is superior to existing 3-set type by previous learning effect because 38K is designed compatibly to the standard. However, exact result will be studied later as well.

Representative 3-set type keyboards of normality of 1 letter per 1 stroke (not special keyboard as two letters alternating per one stroke) and the keyboard 38K of this paper, are analyzed comparatively as shown in Table 1. Qualitative analysis and quantitative load scores are compared. 390 is chosen between 390 and 391, because 390 is more compatible to ANSI. Strictly speaking, 390 and 391 includes two letters per 1 stroke such as ㄹㄱ, however, these are well known and included. Qualitative analysis also has quantitative factors. Quantitative analysis use position load scores of Kim & Yoo (2008) and high load of the shift key, and high loads of out of little finger as shown in Figure 6, considering frequencies of allocated letters for keys. Rates of decreasing about the largest value are evaluated after getting load scores. The model of this paper is superior for every terms. The position load is lessen over 40%. 390 is better only for historical custom of typewriters, however, now typewriters are not used. All are possible even to analog.

3.5 Conversion methods between 2-set type and 3-set type, and labeling of letters on key-caps

2-set type and 3-set type have trade-offs of advantages and disadvantages. Due to characteristic of Korean script, 3-set type

Table 1. Comparative analysis of 3-set type keyboards of normality (H) High, (M) Medium, (L) Low

Terms	Criteria	Sebulsik 390	Sunarae	Model 38	This paper (38K)
Number of keys	Less as possible	39 (M)	44 (L)	38 (H)	38 (H)
Number of shifted letters	Less as possible	13 (L)	0 (H)	0 (H)	0 (H)
Compatibility of ANSI	Higher as possible	Digits 0%, Signs 81% (L)	Digits 0%, Signs 66% (L)	Digits 50%*, Signs 100% (H)	Digits 50%*, Signs 100% (H)
Compatibility of letters in KS keyboard	Higher as possible	0% (L)	0% (L)	0% (L)	81% (H)
Scores of position load	Less as possible	2,527 (L)	1,919 (M)	1,906 (M)	1,805 (H)

*The arrangements of digits follows ITU Standard but digits are on shifted positions.

8	6	5	4	4	5	5	4	4	5	6	10	15	20
	4	3	2	2	3	3	2	2	3	4	8	10	
	3	2	1	1	2	2	1	1	2	3	6		
shift 50	4	3	2	2	3	3	2	2	3	4	shift 50		

Figure 6. Load scores by key positions

will be a standard in the near future. Not having standard of 3-set type at the present time can be a blessing in disguise. As Roman letters have capital and small letters, it is valid Korean have initial and final consonants. When the current standard of 2-set type accept 3-set type, there are problems of labeling letters and switching method of two types. Switching in a keyboard must be easy and compatible to human psychology. Representative methods are such as "CapsLk", or a function key (Shift, Alt, or Ctrl) + "한/영", the author think "CapsLk" is desirable.

Labeling of letters on key-caps is an important problem. It can be as shown in Figure 7. If it is same position or relatively compatible position to the standard, it may not be labeled on the key-cap. The label can be placed on the front face or in the middle column of the key, considering International standard (ISO/IEC 9995-1).

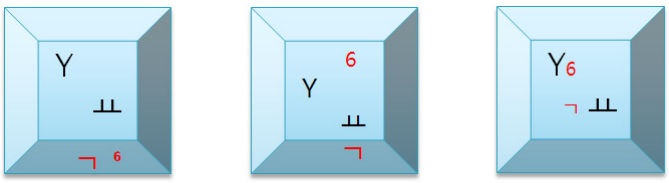

Figure 7. Examples of labeling of letters of 3-set type

4. Conclusions

Characteristics and advantages of 3-set type keyboard have been well-discussed. A 3-set type can maintain compatibility to

analog. Model 390 and Model 391 are well known, however, allocated letters are too many and are not suitable for the modern computer environment.

Therefore, allocation of 38 letters for only basic positions of 38 keys has been studied already in the past, but in this paper, breaking away from conventional thinking, the design "38K" of initial consonants in left area and high compatibility to the KS standard is designed.

The key concept of 38K model is 14 initial consonants and 6 medial vowels are positioned at same of existing KS. Another key concept is ㅛ, ㅕ, and ㅑ are moved to the top row for spatial compatibility. ㅠ is maintained at the original position. 14 final consonants are arranged newly considering frequencies, and it is enough of additional labeling. A unique model 38K keyboard minimizes the reverse learning for high compatibility. The quantitative load score is reduced as 40% than 390 model, further, all qualitative factors are superior. It has a significant impact. But users who sticks to the custom cannot be compelled.

Ten digits are allocated to the shifted position of the second row that is compatible to ISO. As 3-set type, the 38K model can input all Korean text with no shifted letters of minimum keys, and has high intuition and memory by high compatibility to KS. This model is superior for overall aspects to existing 3-set type which has partial advantages and stubborn customs of typewriters. In the future, when a joint keyboard of South and North Korea is developed, same logic will be applied. An experiment for speed, ie, letters per a minute, and some possible improvement in arrangement considering adjacent strokes will be studied future.

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