Menu-Selection-Based Japanese Input Method with Consonants for Pen-Based Computers

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Abstract. We have developed a menu-selection-based Japanese input method for a pen device. To obtain user-input kanji-form text rapidly, the system requires sequence of consonant. Following this, the user selects kanji-form candidates inferred by the system. In some situations, consonant sequences can trigger an explosion of kanji-form candidates. Therefore, we have implemented a method for reducing candidates through vowel fixing. The user can input consonants, and select kanji-form candidates fluidly, using FlowMenu.

1 Introduction

Computers that are operated with a pen, such as PDAs and TabletPCs, have recently become popular. Large displays with a touch-sensitive panel are available as electronic whiteboards for seminars and meetings.

Presently, these computers use, primarily, a software keyboard for character input. However, there are two problems in using a software keyboard with a pen:

1. The user must move the pen between scattered interfaces, such as a menu bar and the software keyboard. The larger the display is, the more severe the problem becomes.
2. Tap operations with a pen put a heavy strain on the user, since the user must manipulate the pen.

Another popular character input method is that of an on-line character recognition system. Unfortunately, the recognition accuracy is low with respect to Japanese, due to the large number of Japanese characters to be recognized. Furthermore, current character recognition systems are implemented in a window like a software keyboard. Therefore, this system inherits the problems of a software keyboard.

If the problem of Japanese input using a pen can be solved, pen-based computers will become more efficient. We describe a new and efficient Japanese input method called "Popie", which solves these problems. The Popie system is based on FlowMenu[1], which has a doughnut-shaped interface and has been developed for pen devices. FlowMenu inputs characters using Quikwriting[2], selects menus with a single interface, and integrates all operations fluidly. Unfortunately, FlowMenu does not support inputting non-alphabet characters, such as Japanese or Chinese characters.

This problem occurs when working in languages such as Chinese or Korean, with a large number of characters. We can apply the Popie method to languages in order to solve this problem.

2 Japanese Input Using FlowMenu

2.1 Japanese Input Method

In this section, we briefly explain the method used to input Japanese text on desktop computers. Japanese text consists of *kanji* and *kana*. *Kanji* are Chinese characters, and *kana* are character in a phonetic alphabet. We input words using a sequence of phonemes by means of *kana*. Then, the input system shows possible candidates for the Japanese text that correspond to the input. The Japanese text input finishes when a candidate is selected.

Most *kana* characters are composed of a consonant and a vowel. In total, *kana* consists of 15 consonants, five vowels and the symbol ‘X’ (Table. 1). An additional five consonants (G, Z, D, B, and P) can be represented using another consonant (K, S, T, and H) and a second symbol ‘*’. In general, a *kana* word is typed as a sequence of consonants, vowels, and symbols.

For example, to input “日本語”, which means “Japanese”), the corresponding *kana* sequence “にほんご”, is typed in, which reads as “Ni Ho N Go”.

Table 1. *Kana*: corresponding to consonants, vowels, and the symbol X

Vowels	Consonants															Symbol (X)		
	ϕ(A)	K	S	T	N	H	M	Y	R	W	G (K*)	Z (S*)	D (T*)	B (H*)	P (H**)	X	XY	-
a	あ	か	さ	た	な	は	ま	や	ら	わ	が	ざ	だ	ば	ぱ	ぁ	ゃ	
i	い	き	し	ち	に	ひ	み		り		ぎ	じ	ぢ	び	ぴ	ぃ		
u	う	く	す	つ	ぬ	ふ	む	ゆ	る		ぐ	ず	づ	ぶ	ぷ	ぅ	ゅ	
e	え	け	せ	て	ね	へ	め		れ		げ	ぜ	で	べ	ぺ	ぇ		
o	お	こ	そ	と	の	ほ	も	よ	ろ	を	ご	ぞ	ど	ぼ	ぽ	ぉ	ょ	
ϕ					ん													ー

2.2 FlowMenu

FlowMenu has a doughnut-shaped interface, creating a radial menu, which consists of eight octants and a central area called rest area.

Fig. 1 presents an example of operation that duplicates an object and moves the object using FlowMenu.

First, the user taps and holds the pen on the target object (a). Then, the FlowMenu is shown (b). Next the user moves the pen from the rest area into the “edit” octant (c). The “edit” sub menu appears, and the user moves the pen into the “duplicate” octant (in this case, the user does not need to move the pen) (d). When the pen returns to the rest

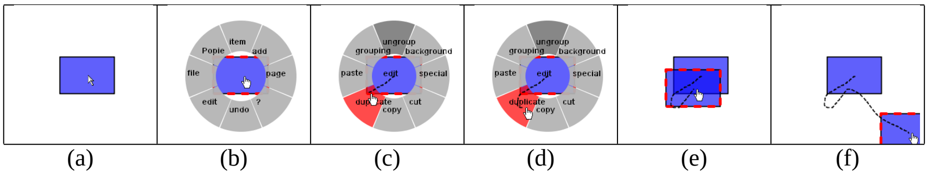

Fig. 1. Example of a FlowMenu operation: duplicate an object, then move the object

area, the object is duplicated (e). Finally, the user can move the duplicated object (f). In this way, FlowMenu provides a series of operations with a single stroke.

One of the advantages of FlowMenu is that it is “eyes-free.” If the user memorizes locations of the FlowMenu items, the user can select a menu item quickly, by means of a gesture. In the example shown in Fig. 1, if the user memorizes the object she/he wants to duplicate by moving the pen into the lower left octant and returning it to the rest area, the user can perform a duplication without looking at the menu item.

2.3 Input Japanese Using Consonants Only

As previously noted, we generally use both consonants and vowels to input Japanese. Some methods that require only ten consonants and a symbol have been developed[3][4]. To input “にほんご” (“Ni Ho N Go”) using such a method, one inputs “NHWK*”. In this method, ‘ん’ and ‘ー’ are input using ‘W’. ‘G’ is replaced with ‘K’ and the symbol ‘*’.

Our Popie system uses a consonants method to input Japanese. We think that reducing operations the number of operations required to input characters is important, because an operation using a pen takes longer than one using a keyboard.

Consonant methods for inputting Japanese have a problem: the number of candidates can explode. This problem can be partially solved by sorting candidates using frequency statistics, based on newspaper articles. Such methods are effective in reducing the number of operations required to input Japanese, including candidate selection. Nevertheless, two problems remain:

1. If the result of candidate sorting is irrelevant, the rank of the target word of the user is lower, so the cost of the select operation is higher.
2. The user can only input known words that are contained in the learning corpus.

We solved these problems by allowing the user to select a vowel with a simple operation when necessary.

Moreover, we adopted completion and inference to reduce the number of operations. With completion, the system estimates the best candidate before the input is complete. For example, the system shows “日本語” (“NHWK”) when “NH” is input. With inference, the system guesses the next word from the last word input. For example, the system shows “入力”, which means “input”, when “日本語”, which means “Japanese”, is input.

These methods have been implemented in systems such as POBox[5], and have successfully reduced the number of operations. In POBox, the user inputs Japanese using consonants and vowels, however, it is possible to apply such a method, using consonants to input Japanese.

3 Popie

We have developed a Japanese input system called Popie, which uses consonants to input Japanese. We have also solved the two above-mentioned problems when using computers with a pen.

Popie requires a sequence of consonant keys "AKSTNHMYRW". "あいうえお" has no consonant, we use 'A' as an expedient consonant. In addition, 'ん' and 'ー' are input using 'W'. Moreover, our method can input "Ni Ho N Go" as "NHWK" without using the symbol '*'. Since the Popie interface is on FlowMenu, the operation consists of a continuous stroke.

3.1 Popie Interface

Fig. 2 shows the Popie interface. The interface consists of three parts: the input & selection, user input and candidate display parts. The user conducts all the operations of Popie in the input & selection part. Popie shows candidates that correspond to the user input in the candidates display part. The input of consonants is shown in the user input part.

When the user inputs "NHWK", the system shows "日本語", which means "Japanese" and reads "Ni Ho N Go", "日本が", which means "Japan is" and reads "Ni Ho N Ga", "日本画", which means "Japanese-style painting" and reads "Ni Ho N Ga", and so on (see Fig. 2).

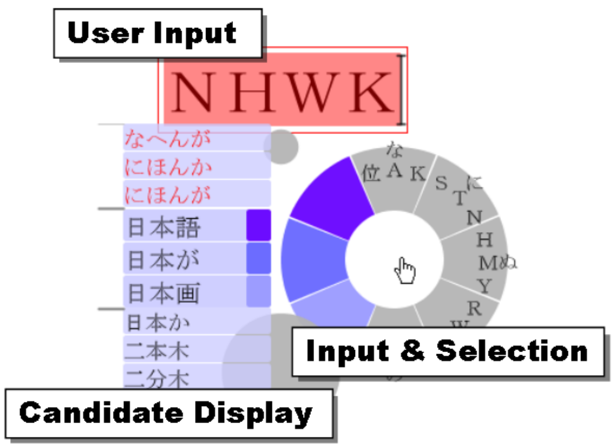

Fig. 2. Popie Interface: The user wants to input "日本語".

3.2 Narrowing Down Candidates Using Vowels

As we have already noted, the problem of the explosion in the number of candidates using a consonants method to input Japanese has been improved. Nevertheless, two problems remain: selecting lower-rank candidates and inputting unknown words.

Our solution is to select a vowel using a simple operation when necessary. Table 2 indicates the number of candidates when the user inputs N consonants and selects M vowels from the beginning of the consonants sequence. This table was made from Popie's dictionary, which consists of the dictionary of the Japanese input method system SKK[6] and word frequency data from newspaper articles (see Section 3.6). If the sorted candidates do not help the user, the user must select the target word from among many candidates, as seen in the case of M=0 in Table 2.

Our method solves this problem by selecting vowels that correspond to the sequence of consonants, from the beginning. Vowel selecting can reduce the number of candidates. For example, if the rank of "日本語" is lower when the user inputs the sequence of consonants "NHWK" to input "日本語" ("にほんご", "Ni Ho N Go"), then the user selects vowel 'i' corresponding to 'に' ('Ni'), and the input becomes "に HWK". Selecting the vowel that correspond to the beginning of the consonant sequence reduces the number of candidates, as seen from the case of M=1 in the table.

Selecting all the vowels corresponding to the consonants also solves the problem of inputting unknown words.

Table 2. The number of candidates in Popie's dictionary when the user inputs N consonants and selects M vowels from the beginning of the consonant sequence

Consonants N		Fixed Vowels M 0	1	2	3	4
1	Average	194.10	23.40			
	SD	162.07	28.17			
2	Average	129.42	20.05	4.99		
	SD	122.68	24.74	10.54		
3	Average	34.63	7.26	3.04	1.95	
	SD	40.78	11.46	5.21	3.23	
4	Average	8.06	3.10	2.19	1.60	1.46
	SD	12.67	4.21	3.06	1.66	1.39

3.3 Input Consonants and Candidate Selection

This section presents the example of inputting "日本語" in Popie in Fig. 3. When the target word is "日本語" ("Ni Ho N Go"), the user inputs "NHWK" and selects "日本語" from the candidates shown by Popie.

First, the user moves the pen from the rest area (a) to the octant labeled "STN", (b). Then, she/he moves to the octant labeled 'N' (c), returns to the rest area (d), and 'N' is

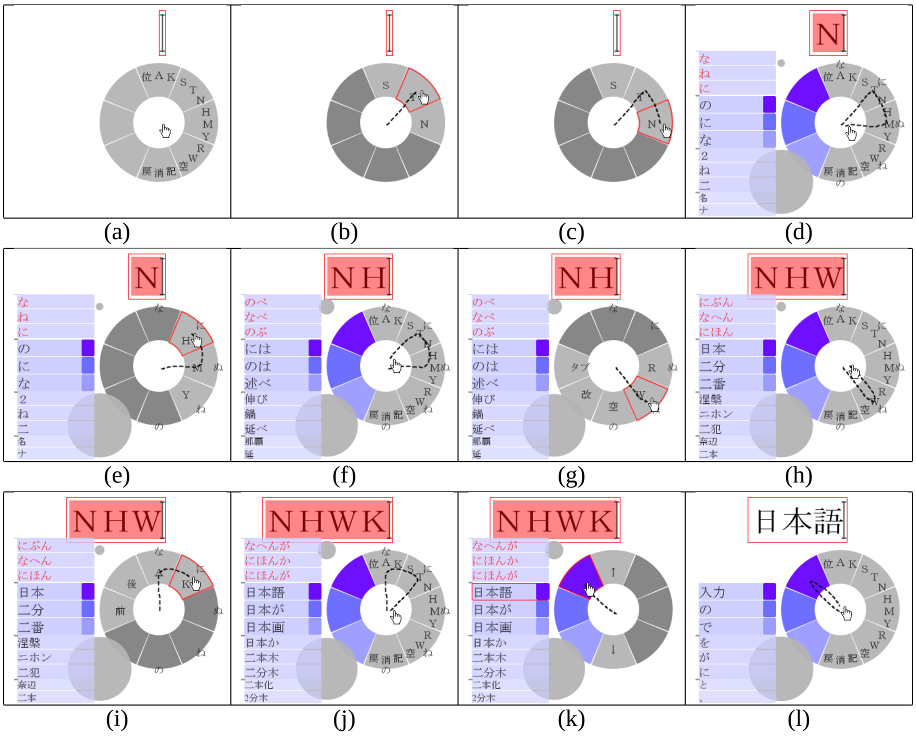

Fig. 3. The operation of inputting “NHWK” and selecting “日本語”

input. Next, she/he moves the pen to the octant labeled “HMY”, then to octant ‘H’ (e), then back to the rest area, and ‘H’ is input (f).

‘W’ and ‘K’ are input in a similar manner (g, h, i, and j). Finally, the user moves the pen from the rest area to the octant corresponding to “日本語”, then back to the rest area, and “日本語” is selected. This series of operations involves a continuous stroke.

If the target word does not appear in the top three, candidates, the user can select any candidate by selecting the up or down arrow (k) to scroll the list.

3.4 Vowel Selection

This section presents an example that involves selecting a vowel using Popie in Fig. 4. The user has already input “NHWK” (a), and the user wants to select the vowel ‘i’ corresponding to ‘に’ (‘Ni’). First, the user moves the pen from the rest area to the octant labeled “STN” (b), then crosses over this octant with across ‘に’ (c) and vowel ‘i’ is selected. The user returns the pen to the rest area and continues operation (d). The vowels “aiueo” are placed at the outer edge of the octant, from north to south in a clockwise manner.

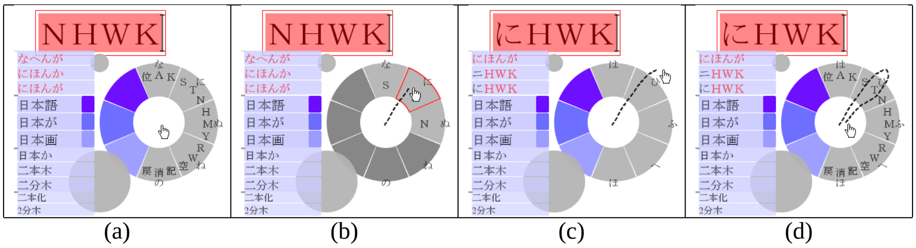

Fig. 4. The operation involved in selecting vowel ‘i’, which corresponds to ‘に’(“Ni”)

3.5 Consonants Key Configuration

In Popie, the main menu has eight items, and each sub menus has eight items. Therefore, the user can input 64 keys. Table 3 shows the key configuration in Popie. The main menu is oriented in a longitudinal direction, and sub menus are placed in a transversal direction. In the sub menu, frequently used keys are placed closest to the parent main menu item. In fact, frequently used keys appear in the diagonal element or the adjacent element in Table 3.

Table 3. Key configuration for Popie

<table>
<tr><td colspan="2" rowspan="2"></td><td colspan="8">Sub</td></tr>
<tr><td>N</td><td>NE</td><td>E</td><td>SE</td><td>S</td><td>SW</td><td>W</td><td>NW</td></tr>
<tr><td rowspan="8">Main</td><td>N</td><td>A</td><td>K</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>NE</td><td>S</td><td>T</td><td>N</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>E</td><td></td><td>H</td><td>M</td><td>Y</td><td></td><td></td><td></td><td></td></tr>
<tr><td>SE</td><td></td><td></td><td>R</td><td>W</td><td>Space</td><td>Return</td><td>Tab</td><td></td></tr>
<tr><td>S</td><td></td><td></td><td></td><td>Symbol</td><td>Delete</td><td>Undo</td><td>Redo</td><td></td></tr>
<tr><td>SW</td><td rowspan="3">Scroll Upper</td><td></td><td></td><td></td><td rowspan="3">Scroll Lower</td><td colspan="3" rowspan="3">Candidate Select</td></tr>
<tr><td>W</td><td></td><td></td><td></td></tr>
<tr><td>NW</td><td></td><td></td><td></td></tr>
</table>

3.6 Dictionary

The dictionary in Popie consists of three dictionaries: word frequency, co-occurrence, and user dictionaries. The co-occurrence dictionary is used to infer the word following the last word selected.

We used text data from the CD Mainichi Newspapers 2001[7] published by Mainichi-Newspaper Co., as the corpus of the dictionary. The text data was analyzed by Chasen[8]. In addition, the word frequency dictionary was augmented using SKK’s dictionary[6].

4 Evaluation

We conducted an experiment with six users to evaluate the input speed of Popie. None of the participants had previously used a computer operated with a pen device. They ranged in age from 18 to 21. The experiment was run using TabletPC (Fig. 5).

Each session lasted 15 minutes. Each subject continued to input text during a session; eight sessions were performed (one practice and seven real sessions). The subject completed one or two sessions per day, with sufficient time between sessions. Text examples were made from a corpus different from the corpus used for the system's dictionary. Each text consisted of 15 to 45 characters. Although the learning function was on, no two texts were exactly alike.

4.1 Results of the Experiment

Fig. 6 shows the results of the experiment and indicates the speed of input using Popie. The horizontal axis shows the sessions, and the vertical axis shows the number of characters input per minute(cpm).

The first session was a practice session, so it is not plotted on the graph. In the second session, the input speed ranged 9 to 14 cpm, and averaged 11.9 cpm. By the last session, input speed ranged from 19 to 29 cpm, and averaged 24.7 cpm.

In a pilot study, the speed of character input using the character recognition tool supplied with WindowsXP TabletPC Edition averaged 18 cpm. The subject was one of the authors, and the procedure used was the same as in the experiment. This result is thought to reveal a general trend, because each individual's writing ability is alike.

Therefore, we believe that Popie is a practicable method for inputting Japanese.

Fig. 5. TabletPC

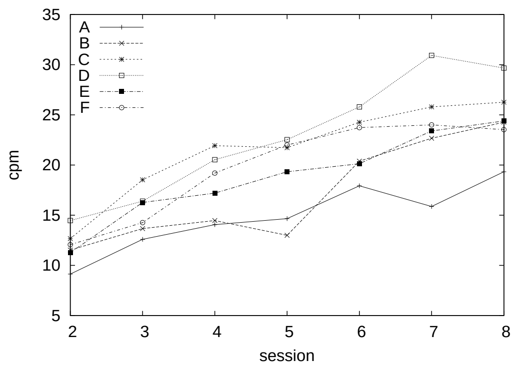

Fig. 6. Input speed of Popie

5 Discussion

Currently, the Popie interface uses the simple kana order ("AKSTNHMYRW") for the consonants key layout. Since layout optimization is often discussed, we examined the key layout in Popie. Nevertheless, we hypothesized that key layout has little influence on the input speed, because the pen is located in the rest area after inputting each consonant.

We examined the layout optimization of ten keys placed on the numbered circle in Fig. 7. In order to discuss key layout optimization, data on the frequency of key use and the input cost of each key are required. In addition, it is also necessary to consider the input of N consecutive keys, because the frequency in the use of consecutive keys changes with each value of N. We calculated the cost for the cases N=1 and N=2.

In this optimization, the input cost was thought of as the input time. Moreover, if the movement speed of the pen is constant, the input time is proportional to the distance, the pen moves, so we use the distance data as the input cost. The frequency of key use was computed from CD Mainichi Newspapers 2001[7], and we considered the following three costs.

1. The distance cost, consisting of r, the distance from the rest area to one octant, and a, the distance between two adjacent octants. (see Fig. 7)
2. The distance cost was computed from the strokes in the experiment, shown as stroke s in Fig. 7.
3. The time cost was computed from the experimental data. Since this cost includes the factor wontedness, we used the average relative time, which is based on the average time per stroke in each session for each user.

The result of the key layout optimization is shown in Table 4. With an optimized key layout, the user can input, at most, 5.5% faster, confirming our hypothesis. We believe that using the familiar *kana* order for the key layout is more important than a 5.5% improvement in input speed.

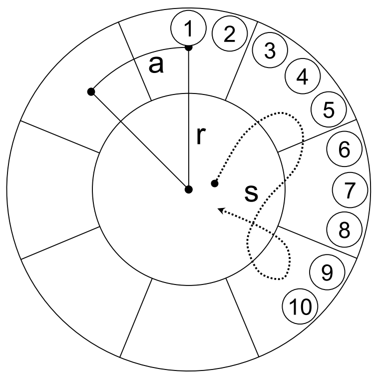

Fig. 7. The numbered circles for the layout, distance (r, a), and stroke s

Table 4. The solution for the optimized key layout and the rate to the current layout for N consecutive keys, and the cost of each

N	Kind of cost	Solution										Rate (%)
		1	2	3	4	5	6	7	8	9	10	
1	Using r and a	T	W	R	A	N	H	S	Y	M	K	96.98
	Distance for a stroke	T	R	W	S	Y	N	K	H	M	A	97.58
	Time for a stroke	T	K	W	S	H	Y	N	M	R	A	99.17
2	Using r and a	T	W	R	S	Y	M	K	H	N	A	94.58
	Distance for a stroke	A	W	H	T	Y	N	S	M	R	K	95.12
	Time for a stroke	T	W	A	S	R	Y	N	M	H	K	98.86

6 Conclusion

We discussed Popie, a method of inputting Japanese for pen-based computers. The user inputs Japanese on the FlowMenu by inputting consonants and selecting candidates shown by the system. Thanks to FlowMenu, the user can input consonants rapidly. Thus, the problems of pen movement between scattered interfaces and numerous tap operation have been solved.

In addition, we implemented a way to select a vowel corresponding to a consonant, in order to solve the problems of selecting lower-rank candidates and inputting unknown words. We showed that the input speed of Popie is higher than that of character recognition. Moreover, we verified that optimization of the consonant key layout was inefficient.

We are planning to evaluate Popie's performance on a large display, and to apply Popie to other languages.

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