A Text Input Interface using a Portable Clavier for Pianists

Yoshinari TAKEGAWA, Tsutomu TERADA, and Shojiro NISHIO
Graduate School of Information Science and Technology, Osaka University
{takegawa, tsutomu, nishio}@ist.osaka-u.ac.jp

Abstract

Due to the miniaturization of computers, wearable computing has attracted great attention. Several text input interfaces for wearable computing devices have already been proposed. However, those devices are not customized for specific users, so the devices do not facilitate sufficiently easy and quick text input. Therefore, the goal of our study is to construct a text input method specialized to pianists by exploiting characteristics of pianists and claviers. The proposed method achieves simple and quick text input by restricting users to pianists. The results of the evaluation suggest that the input speed achieved using proposed interface is twice as fast as that of the Twiddler.

1 Introduction

In wearable computing environments users can operate a computer anytime and anywhere, so providing effective text input interfaces for wearable computing devices is important. The requirements for text input interfaces used with such wearable computing devices are as follows:

· **Portability** The device must be compact and lightweight.
· **Situation Independency** The device must be usable anytime and anywhere independent of the situation.
· **Operationality** Operations must be easy and the input speed must be fast.

Several text input interfaces for wearable computing devices have already been proposed. There are two prominent types of text input interfaces for wearable computing: one is the non-keyboard type that uses voice[7] and gestures[6], and the other is a keyboard type[3, 4, 5]. An advantage of the former is hands-free operation, but there is a disadvantage in the accuracy of input. The latter requires operation by hand, but faster input is enabled. Moreover, the type of keyboard can be subdivided into three types of input methods: Multi-tap, Two-key, and Chording. The Multi-tap is currently the most common text input method for mobile phones. In this method, a user presses a key one or more times to specify a character. In the Two-key, the user presses a combination of two keys to specify a character. In the Chording, multiple keys are pressed simultaneously to specify a character, instead of pressing keys in sequence. In general, the Multi-tap is the easiest and fastest text input method for beginners. However, the Chording is the fastest text input method for experts[4]. Conventional interfaces require users to select between difficulty in learning or slow input speed. In this sense, previous systems do not facilitate sufficient ease of use and input speed. On the other hand, if we restrict the target user and apply his/her favorite interface to text input, we can achieve both simplicity and speed of input. In this research, we focus attention on pianists' ability to construct a text input interface for pianists.

Therefore, the goal of our study is to construct a text input method customized for pianists by exploiting the characteristics of pianists and claviers. The proposed method achieves simplicity and speed of input by restricting users to pianists.

2 Design

In this study, we construct a text input interface customized for pianists by exploiting the characteristics of pianists and claviers. We use a portable clavier whose diapason is just one octave, and whose keys are of the regular size because many pianists are familiarize with regular-sized keys. We suggest a text input method for Japanese (kana) characters using a mobile clavier. Here, kana are syllabic Japanese characters used for writing words. Kana characters and English syllables in brackets that express the English pronunciation of the kana are shown in Table 1. In this paper, we use the English syllables ("[**]") instead of kana characters. By way of exception, "[a], [i], [u], [e], and [o]" consist of only one vowel, and "[n]" consists of only one consonant. There are ten/five consonants/vowels.

Direction To input many characters using few keys, conventional interfaces have achieved many input patterns by increasing the number of strokes or the number of keys pressed simultaneously. We consider the following characteristics for constructing a text input method:

· Japanese people are familiar with the relationship between consonants and vowels.
· The shape of each key of a clavier is long in the vertical direction and short in the horizontal direction, so users can press multiple keys simultaneously and smoothly.

1-4244-1453-9/07/$25.00

Table 1. Kana characters

Consonant \ Vowel	a	i	u	e	o
Null	あ [a]	い [i]	う [u]	え [e]	お [o]
k	か [ka]	き [ki]	く [ku]	け [ke]	こ [ko]
s	さ [sa]	し[si]	す [su]	せ [se]	そ [so]
t	た [ta]	ち [ti]	つ [tu]	て [te]	と [to]
n	な [na]	に [ni]	ぬ [nu]	ね [ne]	の [no]
h	は [ha]	ひ [hi]	ふ [hu]	へ [he]	ほ [ho]
m	ま [ma]	み [mi]	む [mu]	め [me]	も [mo]
y	や [ya]		ゆ [yu]		よ [yo]
r	ら [ra]	り [ri]	る [ru]	れ [re]	ろ [ro]
w	わ [wa]				を [wo]
n	ん [n]				

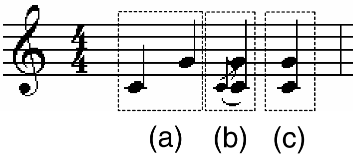

Figure 1. Playing methods

- In piano performance, there are various playing methods, as shown in Figure 1, and pianists are familiar with them.
- Pianists press white keys more accurately and stably than black keys.
- The five white keys (from C to G) are basic keys for piano playing. Pianists feel comfortable with that finger position by allocating one finger for each key because that is the home position for piano playing[1].

Input Method The character-code chart of our text input method is shown in Table 2. Five white keys from C to G are played by methods (a) and (b). To generate "[ku]", the user presses the D key followed by the E key as playing method (a). Note that users cannot input "[ha]", "[mi]", "[yu]", and "[re]" as playing method (b) because the first and second notes are the same. The user plays black keys as the second note in those cases. When users want to input "[ha]," the user plays the C key and the Cis key, Dis key, or Fis key as playing method (b).

The reason the proposed method uses five keys (from C to G) is that users do not need to change the fingering position when allocating one finger for each key, and they can input characters more stably and accurately.

The text input method requires combinations of two notes on white keys and two playing methods. Usually, Multi-tap require many keys or long key combinations, but our approach achieves character input using a small number of keys and just a two-key combination by two playing methods. This leads to both simplicity and speed of the input. Playing method (c) is not used because distinguishing between playing methods (b) and (c) is difficult, although method (c) has only half the number of combinations compared with that in method (b).

3 Evaluation

We implemented a prototype of the suggested text interface. A prototype clavier shown in Figure 2 was used in the pilot study.

Table 2. Chart of character input

(a) First note \ Second note	C	D	E	F	G
C	あ [a]	い [i]	う [u]	え [e]	お [o]
D	か [ka]	き [ki]	く [ku]	け [ke]	こ [ko]
E	さ [sa]	し[si]	す [su]	せ [se]	そ [so]
F	た [ta]	ち [ti]	つ [tu]	て [te]	と [to]
G	な [na]	に [ni]	ぬ [nu]	ね [ne]	の [no]

(b) First note \ Second note	C	D	E	F	G
C	は [ha]	ひ [hi]	ふ [hu]	へ [he]	ほ [ho]
D	ま [ma]	み [mi]	む [mu]	め [me]	も [mo]
E	や [ya]	,	ゆ [yu]	.	よ [yo]
F	ら [ra]	り [ri]	る [ru]	れ [re]	ろ [ro]
G	わ [wa]	を [wo]	ん [n]	ー	IC

IC : Input Conversion

We conducted an evaluative experiment with eight examinees to investigate the effectiveness of the suggested interface. In this evaluation, we compared our method with the Twiddler[4], which is the most commonly used text input interface in wearable computing environments, from the viewpoints of ease of use and learn-ability on the basis of text input speed and error ratio.

3.1 Method

Examinees Four examinees attend a music college and their major is Piano Playing. Another four examinees belong to a graduate school of Information Science and have never played the clavier. All examinees are Japanese and have never used the suggested interface nor Twiddler. The ages of examinees are distributed from 20 to 25 years old. All the pianists and one of the nonpianists are female, three of the nonpianists are male. They are familiar with the Multi-tap input method used on mobile phones.

Experiment Environment In this experiment, we use the IBM ThinkPad X30 with a Windows XP operating system and a built-in MIDI software synthesizer. Examinees listened to the output sounds with headphones only in using the prototype. In using Twiddler, examinees input kana characters by inputting an letters for consonants and vowels according to the key map for chording[4], which is a popular method for Japanese input.

Flow In this evaluation, we had the examinees input texts with the prototype and Twiddler. All phrases were composed of kana characters in Japanese.

We implemented typing software to support this evalu-

Figure 2. Snapshot of person using our interface

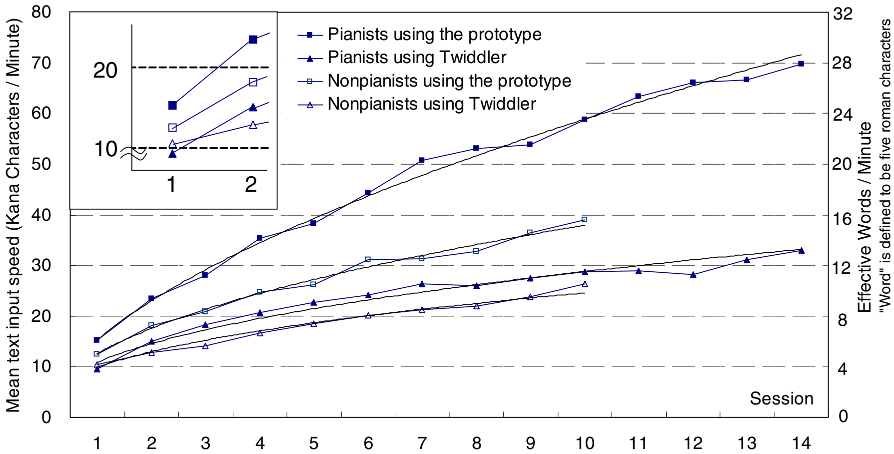

Figure 3. Text input speed

ation. The software consists of two edit boxes. The upper edit box shows a trial phrase, and the bottom edit box shows the examinee's input. The software checks an input letter, and if the examinee inputs an incorrect letter, the letter is deleted. Moreover, the software shows the final phrase when the examinee finished inputting the correct phrase. The length of one phrase is 30 – 50 characters.

The test phrases are randomly selected from Yahoo! news[1]. One session of the experiment is as follows:

(1) Inputting text with the prototype for 20 minutes.
(2) Inputting text with Twiddler for 20 minutes.
(3) Answering a questionnaire: "Were you able to input texts in touch typing? (1: not at all, 5: perfect)".

Note that the participants input text with their dominant hand in a standing position, and we instructed all examinees to input text as quickly and accurately as possible. Examinees can decide the position of their hand and the location of the display freely. We conducted one session per day. The evaluation period for pianists is 14 days, and that for nonpianists is 10 days. Moreover, the execution order of interfaces is changed for every session. Half the participants of each group start from the prototype, and the other half starts from the Twiddler in session 1. Before session 1 starts, we indicate how to use both interfaces. To be concrete, we showed the examinees how to strap the Twiddler and the prototype onto their hand/waist and how to press multiple keys simultaneously to input a character. Moreover, we explained the typical style of using Twiddler, but we did not enforce using the way. We allowed the examinees to input 65 characters with both interfaces for practice.

3.2 Results and Discussion

We collected 80,531 characters from pianists for 14 days, and 36,741 characters from nonpianists for 10 days. The collected data was split into two groups: pianists and nonpianists.

[1] http://headlines.yahoo.co.jp/hl

Table 3. The approximate expression

	Prototype	Twidder
Pianists	$y = 15.354x^{0.5836}$ $R^2 = 0.996$	$y = 12.594x^{0.4788}$ $R^2 = 0.9929$
Nonpianists	$y = 10.86x^{0.4232}$ $R^2 = 0.9687$	$y = 9.8495x^{0.3972}$ $R^2 = 0.9779$

For each interface and group, we show the mean text input speed and its approximated curve[2] in Figure 3. The X-axis indicates the sessions and the Y-axis indicates the text input speed. This value does not include the incorrect input.

Two-way repeated measures ANOVA of text input speed shows a main effect for keyboard method ($F_{1,12} = 22.6, p < 0.01$) and for user type ($F_{1,12} = 6.09, p < 0.03$). The interaction between keyboard method and user type is shown a little effect ($F_{1,12} = 3.70, p < 0.08$). Moreover, Table 3 shows the approximate expression and R^2 value. R^2 value indicates the degree of fitness between row data and values of the approximate expression. Because all R^2 values are over 96%, the approximate expression is extremely credible. We show the error rate for each interface and group in Figure 4. Next, we investigate the results of this evaluation.

Ease of entry The text input speed of pianists/nonpianists in session 1 using the prototype is 1.56/1.16 times faster than Twiddler. Particularly note worthy is that in the prototype the text input speed of pianists is obviously faster than that of nonpianists. On the other hand, in using the Twiddler, the text input speed of pianists is a little less than that of nonpianists. One reason for these results is the examinees' familiarity with the interfaces. Although neither pianists nor nonpianists have used the prototype and Twiddler, pianists are familiar with a clavier due to piano playing. Therefore, pianists can input text by touch typing and using optimum fingering. If they make an input error, they can know this from the output sounds. Nonpianists input text with halting and non-optimum fingering. On the other

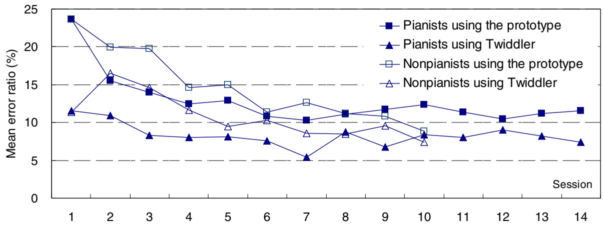

Figure 4. Error ratio

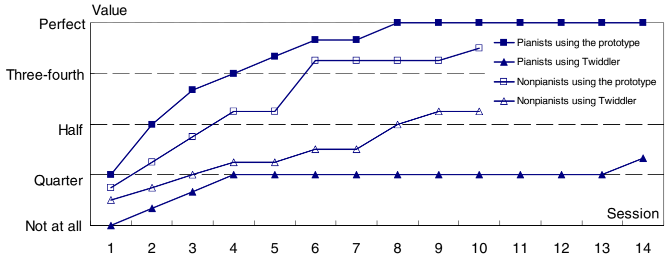

Figure 5. Results of questionnaire

hand, the Twiddler is an unknown interface for both pianists and nonpianists, so the text input speed does not differ between them.

Considering these results, the ease of entry using the prototype is lower than that of Twiddler, but if a user has the skill of piano playing, he/she can input text intuitively with the prototype.

Learning advancement Though the number of keys of the prototype is far less than that of Twiddler, the mapping between characters and keys of the prototype is also simpler than that of Twiddler. Moreover, from the result about touch typing of the questionnaire, as shown in Figure 5, the prototype enables touch typing constantly as the evaluation progresses, but inputting text using touch typing with the Twiddler is difficult, especially for pianists. Therefore, the learning advancement in using the prototype is better than that of the Twiddler, and the interface is suitable for pianists.

On the other hand, when we focus attention on error rates (Figure 4), the error ratio of the prototype is for worse than that of the Twiddler. However, the error ratio gradually declines as this evaluation progresses. The error ratios become almost the same after several sessions.

Usability We consider the usability of the prototype based on examinees' opinions collected in this study. We asked about the usability of the prototype and Twiddler in session 1. Pianists said that the usability of the prototype is better than that of the Twiddler. On the other hand, nonpianists said their usabilities are the same. We think that this difference comes from the difference between the knowledge and learning level in using the clavier. In the case where a user tries to use a new interface, the user needs to learn about the hardware such as key layout, relationships between keys and fingering. The prototype, which utilizes the characteristics of clavier and pianist, reduces pianists' confusion.

4 Conclusion

In this study, we have constructed a text input interface using a new concept that focuses attention on users' ability. In the first stage, we constructed a text input interface for pianists. As a result of the evaluation, the proposed interface facilitated easier and faster text input than when using the Twiddler, and the suggested interface is suited for pianists. We demonstrated the efficiency of the suggested interface for pianists.

Future work includes evaluative experiments based on various skill levels of piano playing, various IT literacy levels and more longitudinal experiments. Moreover, we will investigate how similar the proposed input device has to be to a piano keyboard and how much the sound feedback helps examinees' typing speeds and accuracies.

Acknowledgment

This research was supported in part by a Grant-in-Aid for Scientific Research (A) (17200006) from the Japanese Ministry of Education, Culture, Sports, Science and Technology, by a Grant-in-Aid for Scientific Research from JSPS Research Fellowship, and by Hayao Nakayama Foundation for Science and Technology and Culture.

References

[1] Beyer, F.: Ferdinand Beyer: Elementary Instruction Book For Piano, *G. Schirmer*.

[2] Card, S., Moran, T. P., Newell, A.: The Psychology of Human-Computer Interaction; *Lowrence Erlbaum* (1983).

[3] Engelbart, D. C.: Study for the development of human intellect augmentation techniques. *Technical report, Stanford Research Institute,* (1968).

[4] Lyons, K., Plaisted, D., Starner, T.: Expert Chording Text Entry on the Twiddler One-Handed Keyboard; *Proceedings of IEEE International Symposium on Wearable Computers,* pp. 94–101 (2004).

[5] Matias, E., MacKenzie, S. I., and Buxton, W.: Half-QWERTY: a one-handed keyboard facilitating skill transfer from QWERTY, *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems,* pp. 88–94 (1993).

[6] Nakamura, S., Tsukamoto, M., and Nishio, S.: A Method of Key Input with Two Mice, *Proceedings of IEEE International Symposium on Wearable Computers,* pp. 13–20 (2001).

[7] IBM: ViaVoice, http://www-306.ibm.com/software/voice/viavoice/