Prosody Rule for Time Structure of Finger Braille

Manabi Miyagi
Chiba University
1-33 Yayoi-cho, Inage-ku,
Chiba city 263-8522, Japan
+81-43-251-1111 (ext. 3307)
miyagi@graduate.chiba-u.jp

Yasuo Horiuchi
Chiba University
1-33 Yayoi-cho, Inage-ku
Chiba city 263-8522, Japan
+81-43-290-3300
hory@faculty.chiba-u.jp

Akira Ichikawa
Chiba University
1-33 Yayoi-cho, Inage-ku
Chiba city 263-8522, Japan
+81-43-290-3256
ichikawa@faculty.chiba-u.jp

ABSTRACT
Finger braille is one of the communication methods for the deaf blind. The fingers of the deaf blind are regarded as keys of a brailler. Finger braille seems to be the most suited medium for real-time communication and for expressing the feelings of a speaker. We are trying to develop a finger braille receiver for teletext broadcasting system which will help the deaf blind to use current mass media. We assume that prosodic information is strongly needed to transform letters to finger braille. In this study, we analyzed the time structure of finger braille and found that it is influenced by the structure and meaning of the sentences. Based on the results, we construct a prosody rule for time structure. The validity of the rule was confirmed in an output experiment.

Categories and Subject Descriptors
H.5.2 [**Information Interfaces and Presentation**]: User Interfaces – *Haptic I/O.*

General Terms
Language

Keywords
Finger braille, deaf-blind, prosody, haptic input/output device.

1. INTRODUCTION
People who are both deaf and blind are called “deaf-blind”. They suffer much inconvenience in their everyday lives due to the social handicap. In particular, the deaf-blind with serious impairments are not able to obtain sufficient information necessary for living, something which a hearing and sighted person can do easily. To obtain information for living, they use tactile sensation instead of auditory and visual sensation.

Finger braille is a communication means using tactile sensation. Some deaf-blind people are able to communicate with sighted-hearing people through finger braille interpreters. However, many issues remained to be solved before deaf-blind people can come autonomous and enjoy conversations with others without interpreters.

Typical communication methods for the deaf-blind are (1) print-on-palm (tracing letters on the palm of the deaf-blind), (2) tactile sign language and finger alphabet, (3) “Bulista”, which prints out braille on tape, and (4) finger braille using a Braille code. In finger braille, the fingers of the deaf-blind are regarded as the keys of a brailler. A person types the Braille code on the fingers of the deaf-blind (Figure 1). Of these methods, finger braille using a Braille code seems appropriate for real-time communication.

Figure 1: Typing finger braille

About 350 codes can be transmitted between a skilled deaf blind and a finger braille translator. As compared to oral transmission of 350-400 letters, finger braille is adequate for real-time communication.

Spoken languages employ all types of prosody, which enhance the real-time comprehension of the utterances [2][3]. We believe that a real-time communication method such as speech should convey not only linguistic information but also paralinguistic and nonlinguistic information . Here, we assume that finger braille as a real-time communication method also contains not only braille codes as linguistic information but also paralinguistic and nonlinguistic information. We call it the prosody of finger braille. By examining the prosodic information of spoken languages, we are able to determine such factors as the sentence structure, sentence type (e.g., question, declaration, etc.), and prominence. We suggested that there is similar prosodic information in finger braille.

Equipment for finger braille has been proposed [1][5]. However, no consideration has been given to the prosody. We undertake to develop a finger braille output unit, which can transmit not only braille codes but also the timing structure, so that the deaf blind is able to understand finger braille well.

To accomplish this, we first analyze the timing structure of finger braille. An input and output system for finger braille is developed for communication of the deaf blind, and a prosody rule for finger braille is proposed. Finally, subjective experiments are performed to evaluate the rule.

Table 1: Example of vocalization code

	Mora with voiced consonant	=	Vocalization code	+	Mora with voiceless consonant
	ji	=	V*	+	*si*
Braille**			—— —● ——	+	●— ●● —●

***We use V for vocalization code for instance**

****A black circle indicates raised dot and a bar indicates flat dot of Braille.**

Table 2: Example of numberization code

	Number	=	Numberization code	+	Kana code
	3	=	N*	+	*u*
Braille**			—● —● ●●	+	●● —— ——

***We use N for vocalization code for instance**

****A black circle indicates raised dot and a bar indicates flat dot of Braille.**

2. JAPANESE BRAILLE CODE SYSTEM

A braille code consists of combination of six dots. Japanese braille code system consists of 46 codes which express kana characters (mora with voiceless consonant), and some special codes. There are two types of special codes: Codes to change consonant and codes to change character set. These codes have to be put before the modificated codes. Table 1 shows the example of a function of a vocalization code which changes a mora with voiceless consonant to a mora with voiced consonant.

Codes to change character set have the function to change code set of kana character to the other code set such as number or alphabet. Table 2 shows the function of the code which changes kana character to number.

3. ANALISYS OF THE TIMING STRUCTURE OF FINGER BRAILLE

3.1 Data Recording 1: Prominence Word

3.1.1 Data Recording

To examine the time structure of finger braille, we have developed a new instrument for measuring the prosody of finger braille (Figure 2). Force-sensitive resistors were adopted to detect finger pressure. The output from the six sensors (three for each hand such as in the case of a brailler) was input to a PC every 10 milliseconds.

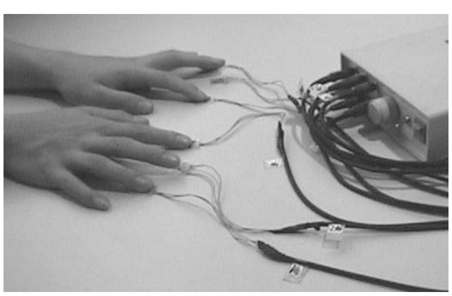

Figure 2: Measuring instrument

A finger braille translator participated as a subject in the recording. The subject was asked to answer questions using the same sentence as followed.

Answer: *3 jini chibaekino higashiguchidesu.*
(At the east exit of Chiba station at 3 o'clock)
Question 1: *nanjini chibaekino higashiguchidesuka* ?
(At what time will we meet ?)
Question 2: *3 jini donoekino higashiguchidesuka* ?
(At which station will we meet ?)
Question 3: *3 jini chibaekino dokodesuka* ?
(At which exit will we meet ?)

The answers by the subjects to all the questions put forth comprise the same words; however, the positions of prominent words changed according to the particular question.

3.1.2 Data Analysis

Figure 3 shows the recorded pressure over time. The duration between the onset of pressure of one typed finger code and the onset of the next one was defined as the duration of the typed code. The duration of all typed codes of the sentence is shown in Figure 4. The sentence was the answer for question 1 described in the previous section. The graph shows that the duration of the last code of each phrase was longer than that of other codes (shown in 91 % of all recording). It also shows that the duration of the last code of the prominent word and the code just before the prominent word were appreciably longer than the others (shown in 73 % of all recording). These results indicate that the long duration clarifies the boundary of each phrase or prominent word.

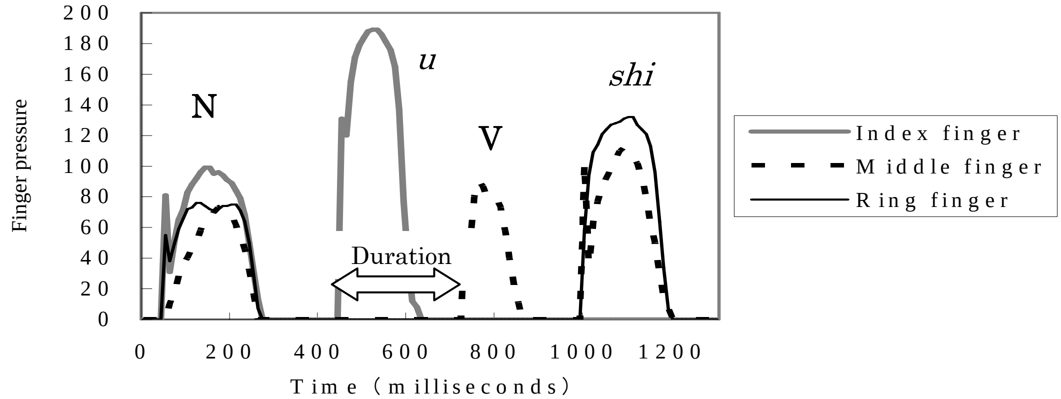

Figure 3: Examples of finger pressure over time

(N : Numberization code, V : Vocalization code)

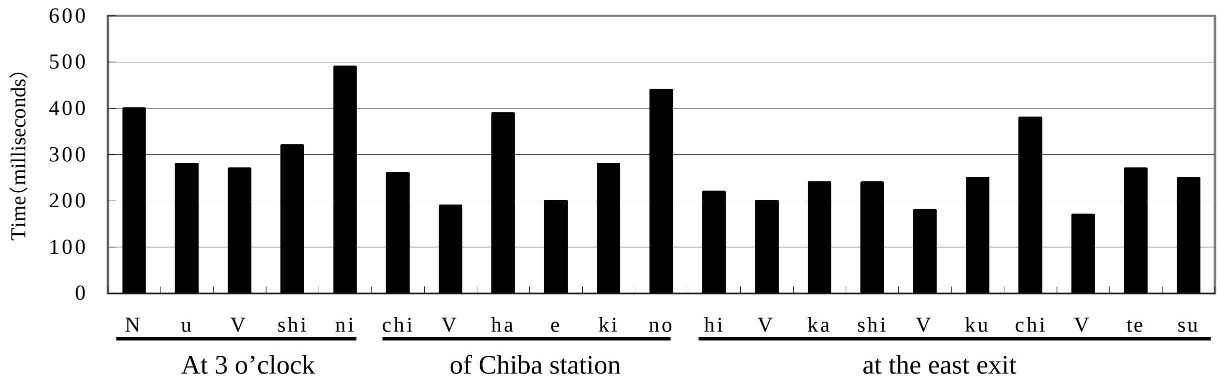

Figure 4: Examples of duration of each code

3.2 Data Recording 2: Ambiguous Sentence

3.2.1 Data Recording

A finger braille translator participated as a subject in the second recording. The subject was asked to type the ambiguous sentences, (sentences which have two meanings) so as to discriminate their meanings (same code sequences but different meaning). The example of the recorded sentences is as followed.

Sentence: *Wakai otokoto onnaga aruiteiru.*
(young man and woman are walking)
Recording A: If only the man is young

Recording B: If both the man and the woman are young

The sentence does not give sufficient information to distinguish whether the word *wakai* (young) applies to only the man or both the man and the woman. However, in oral transmission, the meaning can be distinguished from the change of pitch, power and timing structure of the sound (prosody of spoken language). We assumed that the timing structure of finger braille had the same function. Seven different sentences that each has two meanings, like the example, were recorded. During the recording, the subject consciously typed the sentences to transmit two different meanings to the deaf blind person. For each meaning, the recording was performed twice.

3.2.2 Data Analysis

The result of the first recording suggests that a short duration indicated a strong combination between two codes. Hence we prepared a "prosodic tree" by combining the codes according to the duration as followed.

Step 1 Line up the letters of typed sentences from the left to right.

Step 2 Consider the letters at the end of the sentence to be the trunk.

Step 3 Consider the length of each duration to be the length of the branch, and connect it to the longer branch on its right side.

Step 4 Repeat Step 3 until the process is completed for all letters.

The resulting trees (Figure 5; Figure 6) represent the semantic structure of the recorded sentences. It was suggested that the timing structure of finger braille was affected by not only the structure of sentences but also the meaning of the sentences. These findings support our assumption.

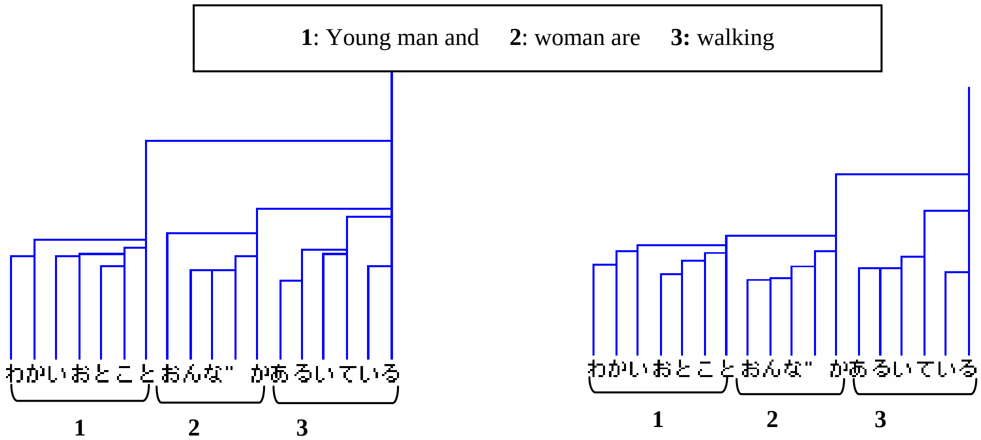

Figure 5: The tree based on recording A

Figure 6: The tree based on recording B

3.3 Data Recording 3: Paragraph

3.3.1 Data Recording

Three finger braille translators participated as a subject in the third recording. The subjects were asked to type short paragraphs from a news program in order to determine the parameter of the prosody rule. The subjects listened to the news and type the paragraph simultaneously.

3.3.2 Data Analysis

Table 3 shows the average duration of the last code of phrases and sentences, and some special codes. For example, the code which acted to change an unvoiced consonant into a voiced consonant had a short duration, while the code which changed the coding system had a long duration. The result indicates that the length of duration has much to do with the function of the special codes. If the deaf blind person fails to read the vocalization code, he/she will misread a following code only. However, if he/she skips the numberization code, it is possible that more than two codes will not be transformed to number and likely misread. It causes a serious effect on understanding of the sentence. Therefore, duration of transform codes became longer, so the codes would no be skipped.

3.3.3 Prosody Rule for Timing Structure

From the results, we derived a rule to model the prosody information of finger braille. The structure of the sentence and the type of the code determined a length of duration of a braille code. The code was previously analyzed whether it was the end of a phrase or a sentence, and whether it was a special code. Each code was given the average values as its duration.

Table 3: Average values of duration by codes

Types of the code	Duration (milliseconds)
Last code of phrase	790
Last code of sentence	697
Vocalization code	343
Palatalized code	357
Code to change character set	587
Others	377

4. OUTPUT EXPERIMENTS

4.1 Conditions

An experiment has been performed to evaluate the effect of the prosody rule. We examined whether the deaf blind have a better understanding when prosody information is added to finger braille output. We have developed a new instrument for output of finger braille (Figure 7). It is available to control the time structure of output by PC.

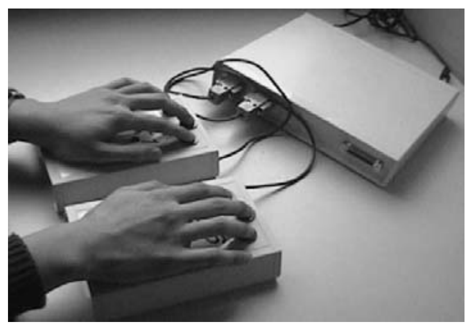

Figure 7: Output instrument

The subject was a deaf blind who uses the finger braille as her major communication means. Before the experiment, there was a rehearsal. The subject could read all the sentences both with and without prosody. In the experiment, to compare two outputs effectively, the parameter was set as half the recorded time, so the output speed became twice the recorded time.

Without prosody, each code was output for 210 ms. With prosody, each code was output for the half of the duration described in Table 3. Each output includes a pause with half of its duration. Four essays about animal lives were output. One essay had 450-500 Braille codes and consisted of three paragraphs. Two essays had prosodic information and two had no prosodic information. There were 10 questions concerning each essay, so 20 questions were prepared for each output. A finger braille translator typed the questions, and the subject answered orally. The questions were repeated until the subject understood completely.

4.2 Results

Table 4 shows the results of the experiment. The subject exhibited a better understanding of the output with the prosody rule. The subject felt that the output by prosody was more natural and understandable as to the timing structure of sentences. The similar results were shown in a study of prosody of spoken languages [4]. The result confirms the validity of the prosody rule.

Table 4: Results of the experiment

Output	Percentage of correct answers
With prosody	85 % (17 correct answers)
Without prosody	50 % (10 correct answers)

5. FINGER BRAILLE RECEIVER FOR TELETEXT BROADCASTING SYSTEM

With inclusion of the prosody rule, our output system can be a real-time communication method that can help the deaf blind to obtain information. We developed a prototype of finger braille receiver for teletext broadcasting system which could help the deaf blind to use current mass media. Similar system has recently been proposed [5]. However, no consideration has been given to the prosody.

In our system, a PC receives the teletext and Braille codes are output according to the durational rules. The outline of the process is (1) receiving teletext, (2) converting kanji text into kana characters, (3) converting kana characters into braille codes, (4) carrying out morphological analysis and syntactic analysis of the teletext sentence, and (5) applying the durational rules.

6. CONCLUSIONS

In this paper, we analyzed the time structure of finger braille. Based on the recording, the prosody rule for finger braille was proposed. Finally subjective experiments were performed and the results show that the prosody rule for finger braille is effective. We are currently analyzing strength of movement in each finger to detect other prosody in finger braille.

7. ACKNOWLEDGMENTS

The authors are grateful to Mr. Uchiyama, and Mr. Wada of Double R&D Co., Ltd. for making the finger braille instruments. We also thank the volunteer subjects for their assistance.

8. REFERENCES

[1] Hoshino, Denda, Otake, & Yonezawa, "Basic Study of Optimum Stimulus Mode for Finger Braille Display", The Transactions of the Institute of Electronics, Information and Communication Engineers. A 81(9), 1273-1279, 1998.

[2] Ichikawa, "Dialogue Languages and Persons with Disabilities", IEICE transactions, Vol.E87-D, No.6, pp.1312-319, 2004.

[3] J. Hirschberg, "Communication and Prosody: functional aspects of prosody," *Speech Communication*, vol.36, pp.31-43, 2002.

[4] Kitahara, Takeda, & Ichikawa, "Study of Prosodic Effect on Acceptance of Spoken Language", In National Convention Record, 1987, pp. 6-17, Yokohama, The Institute of Electronics, Information and Communication Engineers, 1987.

[5] Sakai et al., "Study of New Passive Tactile Braille-Transmission Methods", ITE, Vol. 52, No. 4, pp. 512-519, 1998.