RELATIONSHIP BETWEEN THERMAL PERCEPTION AND MECHANICAL CHARACTERISTICS ON A PALM

Aiming at Developing a Communication Support Device for the Deaf-Blind

Chikamune Wada, Kuranosuke Sako and Hiroshi Horio
Graduate School of Life Science and Systems Engineering, Kyushu Institute of Technology, Hibikino 2-4
Wakamatsu, Kitakyushu, Japan

Keywords: Deaf-blind, tactile display, mechanical characteristics, thermal perception.

Abstract: Our final goal is to develop a portable display which will enable the deaf-blind to character on the palm through the use of tactile sensations. We propose the use of thermal stimulation as the tactile sensation, because in this way small-sized and lightweight devices can be developed. However, it might still be impossible to capture continuous movement, which is necessary to recreate characters on the palm. In past research, we found that thermal perception is dependent on the palm position. Therefore, in this study, we investigated the cause of this position dependence by comparing the skin's thermal perception and its mechanical characteristics.

1 INTRODUCTION

Since the deaf-blind suffer from both visual and auditory impairment, it is easy to understand the communication difficulties that arise due to this affliction.

In this research, we tried to create a device that can facilitate effective communication among the deaf-blind and the non-disabled.

Since schools throughout Japan teach both the deaf and the blind to write phonetic symbols known as "*kana*," most Japanese deaf-blind are familiar with this standard Japanese writing system. Then, some deaf-blind use a communication method which is writing characters on the palm of their hand using a finger. Therefore, we thought this could provide the basis for a communication device that can be used among deaf-blind.

Generally speaking, a person's finger moves continuously when a *kana* is written on the palm. Needless to say, it will be easy to transmit a shape of *kana* by using a kind of pin tactile display for the blind (Itoh, Sakai and Sakajiri, 2003). However, we think the stroke order of writing *kana* is important to let the deaf-blind know *kana*. Then, our goal is to develop a portable display which enables a person to write *kana* on the palm through the use of tactile sensations (Wada and Wada, 2003.). Although this finger movement can be reproduced by using a XY-stage, it is not possible to carry such a stage because of its size and weight. To resolve this drawback, we surmised that a portable display can be realized by making use of a Peltier element, which is both small and light. However, even if the elements were arranged, it might still be impossible to recreate continuous movement of tactile stimulation on the palm. Instead, we supposed that continuous movement can be realized using the apparent motion phenomenon.

In previous research (Horio and Wada, 2005), we investigated the optimal condition under which thermal stimulation of a Peltier element causes apparent motion. However, some subjects could not perceive the apparent motion. We hypothesized that this was due to the individual differences in the characteristics of thermal stimulation reception. Incidentally, it was difficult to measure the thermal stimulation reception while it was easy to measure mechanical characteristics of skin. Therefore, we would like to make a model by which thermal stimulation perception will be able to be estimated by mechanical characteristics.

In this study, we chose response time to cold sensation and mechanical impedance as a parameter of thermal stimulation perception and mechanical characteristics, respectively. Then, we investigated a relationship between the response time and mechanical impedance.

Wada C., Sako K. and Horio H. (2008).
RELATIONSHIP BETWEEN THERMAL PERCEPTION AND MECHANICAL CHARACTERISTICS ON A PALM - Aiming at Developing a Communication Support Device for the Deaf-Blind.
In *Proceedings of the First International Conference on Bio-inspired Systems and Signal Processing*, pages 307-310
DOI: 10.5220/0001070103070310

2 MEASUREMENT OF RESPONSE TIME

2.1 Experimental Setup

Figure 1 illustrates the outline of our experimental setup. Peltier elements (8.3 mm*8.3 mm*2.4 mm) were used to induce thermal stimulation. These elements were connected to a computer through a D/A converter and an amplifier. The thermal stimulation was controlled by the computer. Two thermocouples were used to measure the temperature: one was attached to the Peltier element to measure its temperature, while the other was attached to the palm to measure the skin surface temperature. The thermal data from the thermocouples was directly inputted into the computer through an A/D converter.

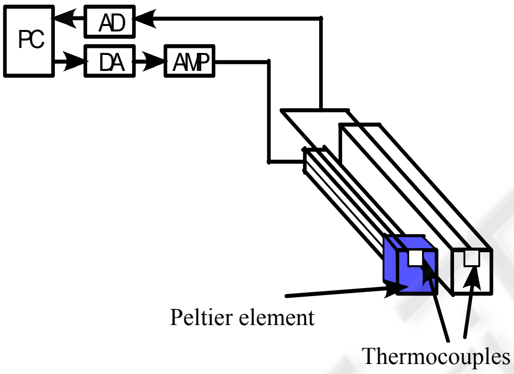

Figure 1: Experimental setup.

2.2 Experimental Procedure

The right palm was thermally stimulated. The palm length and hand breadth were measured, and the palm was divided into 16 parts (Fig. 2). The assigned number and alphabet indicates the place where thermal stimulation was induced. Figure 3 shows the thermal stimulation pattern. The vertical axis indicates the temperature of the Peltier element, while the horizontal axis indicates the elapsed time. Before the start of the experiment, the temperature of the Peltier element was adjusted to the same temperature as the subject's skin surface. The environment temperature was between 25 and 28 degrees Celsius. The subjects were six males, 22 to 25 years of age. The trial was repeated 10 times for each subject. The subjects wore earplugs and eyeshades in order not to hear environmental noise and see.

When the Peltier element surface reached the same temperature as the palmar skin surface, the element was placed on the palm. After a while, the temperature of the Peltier element decreased. The ratio of temperature decrease of the Peltier element was -5.5 degrees Celsius per second.

The subjects were asked to push a switch when they felt that the Peltier element had become cold ("Stop" in Fig. 3), after the temperature of the Peltier element started to decrease ("Start" in Fig. 3). The time interval between "Start" and "Stop" was measured. This time interval was named the "Response time."

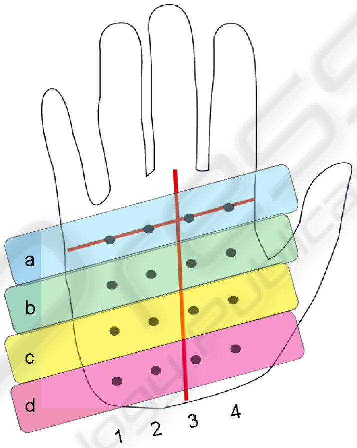

Figure 2: Stimulation points.

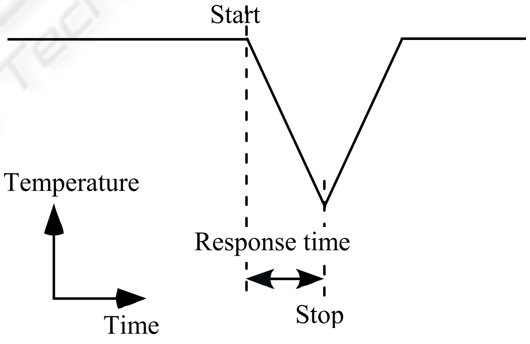

Figure 3: Stimulation pattern.

2.3 Results and Discussion

Figure 4 shows the average results for all subjects. The vertical axis shows the response time in seconds while the horizontal axis shows the stimulation points.

As Figure 4 shows, the response time was different for each stimulation point and about 1 second. Next, we calculated the deviation value for all response time in order to standardize the data. Table 1 shows the results for the deviation value of response time. When the response time was mean, the standardized value was 50. If the value was larger than 50, it meant the response time was longer than the mean and vice versa.

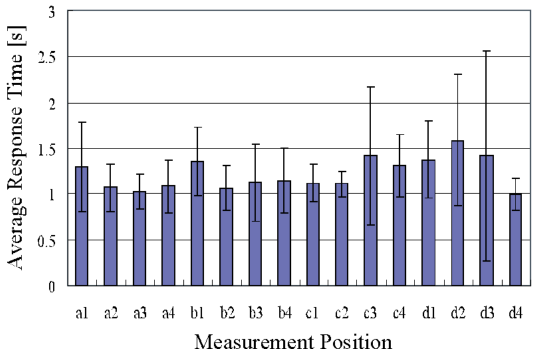

Figure 4: The response time.

Table 1: Standardized response time.

	1	2	3	4
a	47.9	38.2	34.7	40.7
b	53.7	38.6	41.1	40.3
c	44.4	45.6	45.2	53.3
d	53.5	54.0	42.9	34.8

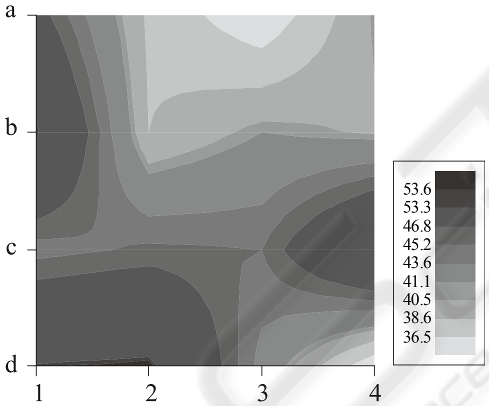

Figure 5: The standardized response time in contour graph.

Figure 5 shows the contour graph of standardized response time. From figure 5, it was found that the response time was short on position "a" and central area of palm. And it was also found that the response time was long on peripheral area of palm.

3 MEASUREMENT OF MECHANICAL IMPEDANCE

3.1 Experimental Procedure

The palmar mechanical impedance can be found from the power and the acceleration caused when the palm is vibrated at various frequencies. Therefore, we devised an experimental setup capable of inducing the vibration of the skin. We used a small vibrator, and measured the power and acceleration by means of an impedance head. The mechanical impedance of the skin was measured with the measurement setup shown in Figure 6. The vibrator outputted a sine wave vibration, and the vibration was relayed to the palm through the impedance head and the contactor pin. We used 15 measurement frequencies: 80, 100, 150, 200, 250, 300, 350, 400, 450, 500, 600, 700, 800, 900 and 1000 Hz. A touch sensor was used to confirm that the palm touched the contactor pin. The same subjects in chapter 2 participated in this experiment. The subjects touched the pin with the palm of the right hand. When the pin touched the palm, the vibrator made the skin vibrate. The subjects were asked to control the pressure of their palm on the contactor pin by watching the output of the load cell. The power with which the skin pushed the pin was set to 50 gf. During the experiment, the subjects were asked to simply place their palm onto the contactor pin. The impedance of the palm was measured by the impedance head, and the data were inputted into a computer. The measurement was made as described in chapter 2 (Fig. 2).

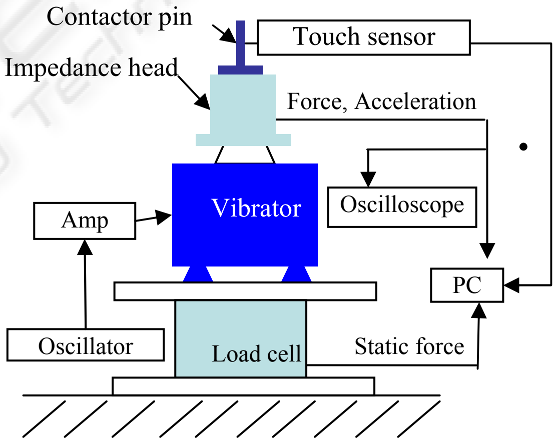

Figure 6: Mechanical impedance measurement device.

3.2 Results and Discussion

From the analyses of mechanical impedance, we divided them into two categories. The typical patterns of each category were shown in Figures 7 and 8. Figures 7 and 8 show the average results for all subjects at stimulation point a2 and d2, respectively. The vertical axis shows the impedance. The horizontal axis shows the frequency in Hz. The lower part of those graphs shows the imaginary part of the impedance. The upper part shows the real part of the impedance.

Figure 7 shows that the value of imaginary part increased as the frequency increased. We called this pattern #1. On the other hand, the value of imaginary part increased and decreased as the frequency increased in figure 8. We called this pattern #2.

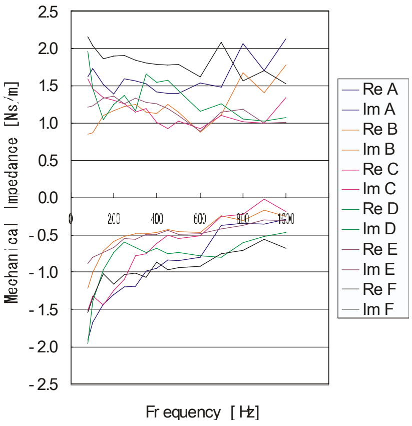

Figure 7: The impedance change (pattern #1).

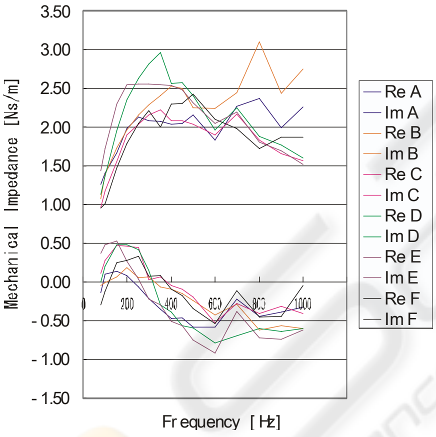

Figure 8: The impedance change (pattern #2).

Table 2 shows the categorized results for all stimulation points. One-asterisk shows that pattern #1 change was obtained in the stimulation point, while two-asterisks shows pattern #2. From table 2, it was found that the pattern #2 was obtained on peripheral palm where the hand was relatively thick and the pattern #1 was obtained on relatively thin part.

Table 2: Position dependence of impedance change.

	1	2	3	4
a	*	*	*	*
b	**	*	*	*
c	**	**	*	**
d	**	**	**	**

3.3 Comparison between Response Time and Mechanical Impedance

Figure 9 shows the combination between figure 5 and table 2. From figure 9, it was found the response time was relatively short at the area of pattern #1, while the response time was relatively long at the area of pattern #2. There seemed to be a relationship between response time and mechanical impedance. Therefore, we hypothesized that the response time could be obtained by using mechanical impedance.

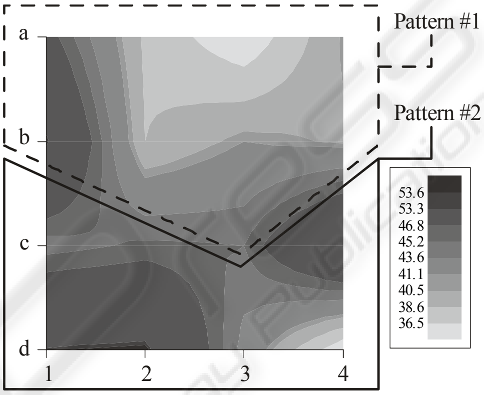

Figure 9: Comparison between response time and mechanical impedance.

4 CONCLUSION

We investigated the relationship between response time and mechanical impedance in this paper. In the near future, we are planning to make an energy conductive model by using mechanical characteristics in order to estimate thermal stimulation response.

REFERENCES

Horio, H., & Wada, C., 2005. Basic research into the development a Deaf-Blind communication device based on the use of thermal apparent motion, *SICE Annual conference 2005*, 348-352.

Itoh, K., Sakai, T., & Sakajiri, M., 2003. Assistive technology in the use of a PC for the deaf-blind(In Japanese), *WIT 2002 of the Institute of Electronics, Information and Communication Engineers*, 25-28.

Wada, C., & Wada, Y., 2003. A proposal for a communication device with a finger and a palm for the deaf-blind, *10th International Conference on Human - Computer Interaction*, 4, 281-285.