The technique for transmitting a sentence by the soles stimulation

Tomoya Kashiwa†
Graduated School of Natural Science and Technology
Kanazawa University, Ishikawa, Japan
Email: tmy81419@gmail.com

Hidetaka Nambo
Graduate School of Kanazawa University, Kanazawa, 920-1192 Japan
Tel: (+81)-76-234-4835, Email: nambo@blitz.ec.t.kanazawa-u.ac.jp

Haruhiko Kimura
Graduate School of Kanazawa University, Kanazawa, 920-1192 Japan
Tel: (+81)-76-234-4836, Email: kimura@blitz.ec.t.kanazawa-u.ac.jp

Abstract. Recently, we often see the braille in Japan. The braille is very convenient to visually impaired person because it makes possible to read a sentence. However, it is difficult for many people to handle braille. Actually, only 10% of visually impaired person are using braille. Therefore, we need more simple method to transmit a sentence. In this paper, we focused cellphone's keypad and flick input of smartphone. It can understand intuitive and it is not difficult to memorize. And then, we modelize these input methods by arranging some vibratory equipment. In addition, we focused soles of foot as the haptics interface. Soles are very sensitive in our body. So we think they can feel the stimulation from vibratory equipment that arranged like a cellphone's keypad and flick input of smartphone. The reason why we use soles is because it is hard to see the sole from outside. So we can transmit a sentence more naturally and secretly by using the sole. Finally, we report a result of experiment to measure an accuracy rate and will make clear the tendency.

Keywords: haptics interface, visually impaired person, sole of foot, vibratory equipment

1. INTRODUCTION

Recently, studies have been conducted using a part of the bodies to transmit the information. For example, human interface that used tongue was developed by Takuya Arakawa [1]. We also developed the human interface using the unusual place in our bodies.

At first, we surveyed haptic interface that is seen in daily life. Then we focused the braille. The braille is configured by six points that are arranged three lines and two rows and it is read by a finger. The visually impaired person uses the braille to read the sentence. Figure1 is Japanese braille example.

Figure 1: An example of Japanese braille

The braille has been used in various places like the guide plate or some books. However, the braille is very difficult for many people to memorize the arrangement and feels by haptic finger, so it is need a long period of training. Actually, only 10% of visually impaired person are using braille [2]. Therefore, we need more simple method to transmit a sentence.

Before that, we should think sensitive place in our bodies. Figure2 is famous brain map of sensory input called the "homunculus". It expresses sensitive or not sensitive by area of the illustration. According to that, soles of foot are very sensitive. So we put equipment under the foot. The reason why we focused soles of foot, not the hand, is because it can cover by shoes. So it can defend visually impaired person from somebody's eye.

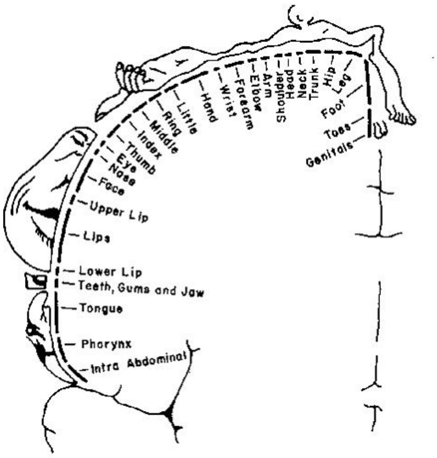

Figure 2: brain map of sensory

2. RELATED RESEARCH

There is a previous study using a sole of foot for language communications [3]. It used magnet that arranging like cellphone's keypad. This equipment put under the arch of foot, and the magnet is raised several times. The number of raised times means some words. However, it has some problem. Because it need many concentration to count the number of raised times, people can't do any other things. So we try to solve this problem by use the two soles of foot and flick input of smartphone.

3. METHOD

3.1 Equipment

We use Arduino-Uno and some vibratory equipment. This vibratory equipment has the radius of 1 centimeter and 3.4 millimeters high.

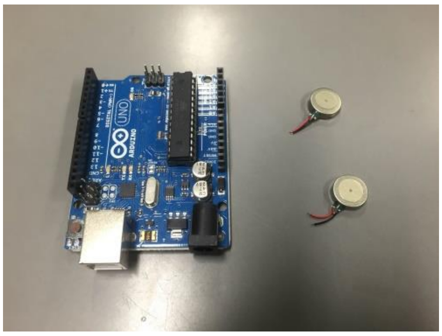

Figure 3: Equipment

3.2 Proposed method

Using the vibratory equipment, stimulation applies the soles of foot. The vibratory equipment is arranged like a Japanese cellphone's keypad and flick input of smartphone (Figure 4).

A	Ka	Sa
Ta	Na	Ha
Ma	Ya	Ra
	Wa	

	U	
I	A	E
	O	

Figure 4: cellphone's key pad and flick input of smartphone

After arranged the vibratory equipment, we set this device under the foot and attach it like figure 5. If "(T, I)" are vibrated, it means Japanese "ち（Ti）".

Figure 5: The place of vibration

Currently, the device attaches the socks and we got result in this method. However, we attach the device into sandals or shoes because user uses the device in usual life.

3.3 Vibration interval

This device has control switch. So, when we sent a sentence, you can get one character after you press the switch. The vibration is conducted three times per one character. For example, if we input "TI", 'T' is vibrated three times. Then, 'I' is vibrated three times. One action consisted of 200ms vibration with 100ms pauses. The vibration of voiced consonant such as 'ga','da' and semi-voiced consonant such as 'pa' are different from normal vibration. These actions consisted of 500ms vibration and two times 100ms vibration with 100ms pauses. Figure 6 explain timing of vibration.

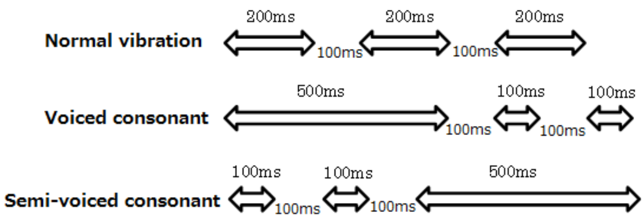

Figure 6: Timing of vibration

4. EXPERIMENT

In this study, we experience two patterns and compared with Pattern A and Pattern B to find a best method.

Pattern A

We input a sentence and vibrate the device. This operation conducted 10 sentences with total 100 characters. When you receive a character, you write it on paper. Then you don't have to predict next a character.

Pattern B

When vibrating the device, center of the device (Figure 5: A and N) is vibrated in order to recognize all of devices location. This action consisted of 300ms vibration with 100ms pauses. The other conditions are same as pattern A.

4.1.1 Experiment detail

The experiments are conducted 6 men aged 20s. We explain vibration rules and conduct training 10 minutes. At first, person a, b and c conduct pattern A, and next time they conduct Pattern B. On the other hand, person d, e and f conduct Pattern B before Pattern A.

Figure 7 Experiment image

4.1.2. Result

Table 1: Accuracy Rate (Pattern A →Pattern B)

person	Pattern A	Pattern B
a	82%	93%
b	96%	83%
c	79%	88%
Average	85.7%	88.0%

Table 2: Accuracy Rate (Pattern B →Pattern A)

person	Pattern B	Pattern A
d	93%	88%
e	94%	96%
f	90%	86%
Average	92.3%	90.0%

Table 3: Accuracy Rate (Pattern A)

person	vowels	consonants
a	98%	83%
b	98%	98%
c	93%	81%
d	94%	94%
e	99%	97%
f	99%	90%
Average	96.8%	90.5%

Table 4: Accuracy Rate (Pattern B)

person	vowels	consonants
a	98%	95%
b	97%	85%
c	97%	90%
d	97%	96%
e	98%	95%
f	97%	88%
Average	97.5%	91.5%

Table 5: Accuracy Rate

	Pattern A	Pattern B
Average	87.8%	90.2%

Table 1 shows accuracy rate of person a, b and c. According to Table 1, accuracy rate is 85.7% in Pattern A, and 88.0% in Pattern B. Table 2 shows accuracy rate of person d, e and f. According to Table 2, accuracy rate is 90.0% in Pattern A, and 92.3% in Pattern B.

Table 3 and Table 4 indicate the accuracy rate of vowels and consonants. Flick input of smartphone signifies vowels and cellphone's keypad signifies consonants.

Table 5 means entire average accuracy rate.

Table 6: Mistakes combinations

(Pattern A, consonants)

Input character	Answer	Number of times
K	N	8
R	H	8
T	M	3
M	W	3
D	N	3

Table 7: Mistakes combinations

(Pattern A, vowels)

Input character	Answer	Number of times
A	O	4
U	A	4
A	I	2
A	U	2

Table 8: Mistakes combinations

(Pattern B, consonants)

Input character	Answer	Number of times
R	H	5
K	S	4
T	D	4
T	M	3
W	Y	3
D	T	3

Table 9: Mistakes combinations

(Pattern B, vowels)

Input character	Answer	Number of times
A	U	2
O	E	2

Table 6 and Table 8 show the character combinations which missed more than three times. Table 7 and Table 9 show the character combinations which were missed more than two times.

4.2.1 Additional Experiment

If we use the device under normal circumstances, we need to memorize characters and predict the sentence. So, we conduct the additional experiment. The difference between this and previous experiment is user never writes on the paper about input characters. Instead of writing, user tells operator input characters and operator records characters in order to survey accuracy rate. Then user can predict a next character and finally, user say the entire sentence. Experiment is carried out for only one person.

4.2.2 Result

Table 10: Accuracy Rate

	Pattern A	Pattern B
person	90%	87%

Table 11: Accuracy Rate (Pattern A)

	vowels	consonants
person	99%	83%

Table 12: Accuracy Rate (Pattern B)

	vowels	consonants
person	98%	95%

5. CONSIDERATION

At first, we consider about the Table 1, Table 2 and Table 5. According to Table 5, the accuracy rate of Pattern B is over 90%. Pattern B has higher accuracy than Pattern A by Table 1 and Table 2. Calculation of the t-test didn't confirm that the higher accuracy was significant (P=0.505). It is because that the person b has extremely low accuracy in Pattern B and extremely high accuracy in Pattern A; that is opposite to other men. Person b said vibration of center equipment distracts the attention.

There is a tendency that high accuracy appears due to using device on long time. Therefore, person who conducted the Pattern A in second half (person d, e, f) had higher accuracy even Pattern A.

In this study, user can't change former answer. So if the user can change the answer, accuracy rate would have been higher.

Additional experiment indicates that even if the load is applied to the concentration, it is possible to produce high accuracy.

Pattern A took 1.8s to send a character. Pattern B took more times because center of equipment vibrates period of 0.4s. We tried to more less vibration time, but it was not good due to the vibration of equipment is finished before maximum vibration. And then we used both of legs, so user's actions is restricted than related research [3].

Therefore, we need put the device into sandals or shoes from now on.

5.2 Mistakes tendency

There is a tendency that the consonants ware often confused than vowels. According to Table 6, 8, 9, 10 the vibration equipment that was ordered in a vertical like (K, N) or (R, H) was often confused. However, Table 8, 10 indicate that tendency a little decreases in Pattern B because center of the equipment makes clear entire of equipment locations.

Voiced consonant and semi-voiced consonant was often missed. Especially, because of large number of vibrations, errors were frequency happen in Pattern B.

6. CONCLUSION

In this study, we developed the technique for transmitting a sentence by the soles stimulation. The accuracy of user recognized a character is about 90%.

The device couldn't send a character again. If we can send a character repeatedly, accuracy rate would be more increase. In this experiment, user could do training at 10min. So if user has more time to training, accuracy rate would be higher than this result.

It was indicated that the soles have potential to use to transmit some information.

REFERENCES

[1] Takuya Arakawa, Ryosuke Kawauchi, (2006) *Human-Computer Interface Using Mandibular and Movement.* Japan Science and Technology Agency. 94-100

[2] Ritsumeikan University survival Academic Research Center report Aoki MakiTaro ed. "The visually impaired student support technique enlarged and revised edition"

[3] HILL, Erik, et al. (2014) *Haptic foot interface for language communication*. In: Proceedings of the 5th Augmented Human International Conference. ACM, p. 9.