Original Article

Development of an information transmission system through soles for prevention of texting while walking

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Abstract

With the fast spreading of mobile devices, especially smartphones, they are usually brought and used during going out because they are very useful. However, they cause some problems such as texting while walking(TWW). For example, when visiting a place for the first time by walking, some navigations, such like the Google Map are needed. Then, it is necessary to keep looking at the mobile device when walking to the target place. Nowadays, the TWW problem has become worldwide. According to this problem, many persons crash or fall down, even fatal-accidents occur in some cases. In this paper, it is attempted to develop an information transmission system. The system transmits information by stimulating the user's foot soles. Therefore, users can obtain simple information without looking at the monitor of a mobile device during walking or operating. Therefore, it is considered that this system is able to be used for navigation without TWW. A prototype system was constructed and an experiment to transmit literal information by this system was conducted. The speed of transmission and the accuracy of the system is not high, however, it was confirmed that information can be transmitted by this system.

Keywords

navigation, haptics, smartphone, sole stimulation, TWW

1. Introduction

With a progress of mobile devices, for example smartphones, many users are frequently going out with such devices. Mobile devices are very useful for various situations and navigation is one of them. For example, when visiting an unknown place, it is usual to use a navigation application such as Google Map to reach the target place. Typical navigation application uses GPS and Map information and it guides the user to where they should go or which direction they should turn at a corner. This function is indispensable to go to a tourist site for the first time. The tourists who are walking while looking at their smartphones are frequently found at a tourist site. Additionally, based on the location of tourists, some smartphone's application will provide information about sightseeing in real time. Japan Tourist Agency introduces many applications in their web site [Japan Travel Agency, 2016]. Also, many tourists use smartphones in their tourism [Japan Travel Agency, 2013]. According to these topics, tourists often go to tourist sites while looking at the screen of their smartphones.

However, using mobile devices such as mobile phones when walking is very dangerous. It is said that concentration is reduced while using smartphones.

Therefore, many accidents of falling down or crashing are occurring. Even serious or fatal accidents also occur [Nasar and Troyer, 2013]. This problem called "Texting While Walking (TWW)" has become a worldwide problem, nowadays.

In this paper, a system to transmit information from a smartphone to a user with tactile stimulations is developed. Because it does not use visual information, it can be thought that the affect on our concentration will be reduced when using a navigation application while walking. Further, this system uses foot soles as a target of stimulation. In short, in this system, information from a smart phone is received by soles and transmitted to the user. The reason for focusing on soles is that soles are a sensitive part in the body. In the body, there are receptors that react to mechanical pressure or distortion. Especially, a lot of receptors exist on the sole to control posture or inclination of the body using the information from the sole [Miyajima et al., 2012]. In short, soles have very high sensitivity. It is well known that hands also have very high sensitivity, however, it is inconvenient if a stimulation receiver always occupies a hand. Furthermore, it is expected that it is possible to use shoes as a house of the instruments of the system. Therefore, it may be considered that using soles has an advantage compared to other parts of the body.

This paper is organized as follows: Section 2 reviews related research; Section 3 describes the proposed system; Section 4 shows experiments to evaluate the system and the result; Section 5 describes considerations; finally, a conclusion and future work are given in Section 6.

2. Related research

In a previous study, the paper [Hill et al., 2014] also developed a transmission system using a sole of the foot. It uses magnets as actuators to stimulate the sole. And, actuators are arranged in the layout of a cell phone's keypad. They are put under the arch of the foot, and they move vertically several times when a letter is transmitted. Which actuator is moved and the number of movement times represent a letter. Therefore, a user has to distinguish the moving actuator and has to count the number. It requires a lot of concentration and users cannot do any other things.

In this present method, both soles of the feet are used. Therefore, the number of actuators for one sole Actuators are arranged on a pad and two pads are put under the arches of the feet. Letters are separated into vowels and consonants, then each of them are transmitted simultaneously through both soles. Using two soles reduces the user's load compared to using one sole only.

3. Proposed method

3.1 Developed instrument

In this study, an instrument to stimulate user's soles was constructed.

Small vibrators were used as stimulators, and an Arduino Uno, that is a small computer system with microcomputer and I/O interface, was used as a controller of the stimulators. For a stimulator, LBV10B-009 (NIDEC COPAL Corp.) was used.

These devices are shown in Figure 1.

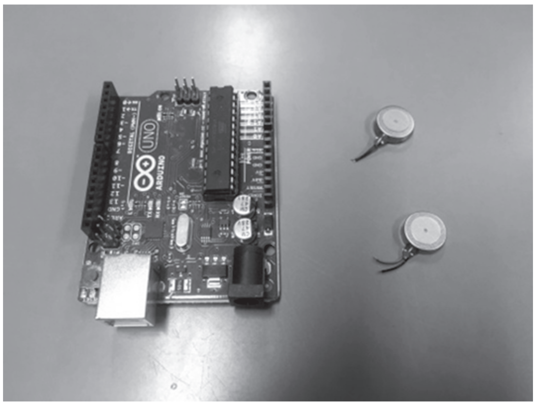

Figure 1: The Arduino Uno and stimulators

Stimulators were arranged in a layout based on the layout of keypad used for a smartphone. When Japanese letters are input on a smartphone, a flick input is one of the methods. In the flick input, it consists of two processes to input one letter. First, one consonant is chosen from a keypad shown in the left keypad in Figure 2 (a), then, flick to the direction corresponds each vowel. The direction and vowels are shown in the right in Figure 2 (b). In this system, stimulators layouts are based on these

(a) Consonant pad

(b) Vowel pad after a consonant was chosen

Figure 2: Flick input on a smartphone for Japanese

A	Ka	Sa
Ta	Na	Ha
Ma	Ya	Ra
	Wa	

	U	
I	A	E
	O	

Figure 3: Stimulators location

Figure 4: Correspondence stimulators and foot soles

two keypads in Figure 3. A consonant layout is for the left sole, and a vowel layout is for the right sole, as shown in Figure 4. To transmit a letter, two stimulators, one for the consonant and the other for the vowel, vibrate in order.

3.2 Stimulations to soles

When one letter is transmitted to the system, corresponded stimulators vibrate. To send certainly, the vibration is conducted three times per each letter. For example, when 'TI' is transmitted, the consonant 'T' is vibrated three times, then the vowel 'I' is vibrated three times. Each vibration consisted of 200 ms vibration and 100 ms pauses. If a transmitted letter has a voiced consonant, such as 'GA' or 'DA', the length of the first vibration of three is changed to 500 ms vibration, and the length of the other vibrations are changed to 100 ms. Also, if the letter has a semi-voiced consonant, such as 'PA', the length of the last vibration is changed to 500ms and the others are changed to 100 ms. Figure 5 shows the combination of vibrations. In the current system, small letters are not supported, they are replaced by capital letters.

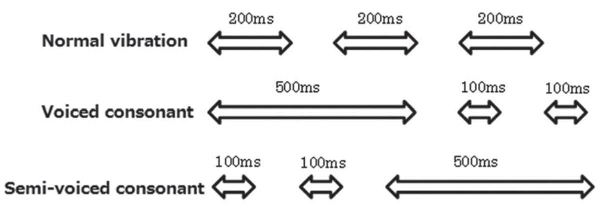

Figure 5: Combination of vibrations for each kind of letters

4. Experiment and results

4.1 An environment of experiment

To evaluate the possibility of transmission using this proposed system, an experiment was conducted. In this experiment, the system is connected to a PC. A sentence input to the PC is separated into letters and these are sent to the system one by one. The whole diagram of this experiment is shown in Figure 6.

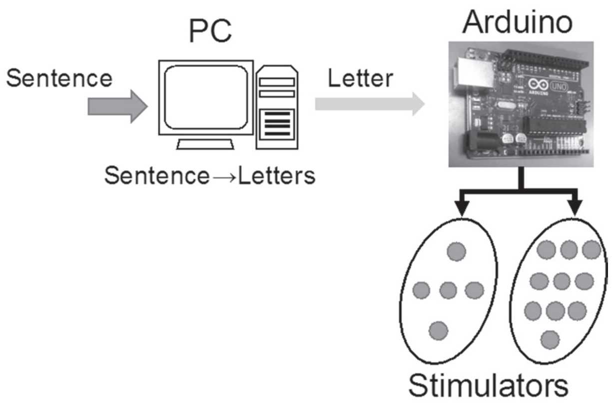

Figure 6: The system diagram in the experiment

In the experiment, 10 sentences were used, and 100 characters used in total. Sentences are input by an operator, and the subjects do not know the content of the sentences. Subjects are 6 men aged 20 s, and they are university students. During the experiment, the subject sits on a chair and keeps his soles on the pads. When a letter is transmitted and subject recognizes the vibrations, he writes down a recognized letter on a paper. Figure 7 shows a picture of a subject conducting the experiment. After all sentences are transmitted, the letters written by subjects were compared to the original sentences. Then, their accuracy was evaluated.

Figure 7: A picture of subject in experiment

4.2 Results

Table 1 shows the result of the experiment. An average accuracy is 87.8 %. A letter consisted of a vowel and a consonant, and they correspond to each sole. Therefore, the accuracy of each sole was evaluated. Table 2 shows accuracies of vowels and consonants. The average accuracy is 96.8 % and 90.5 % respectively.

Table 1: Recognition accuracy for letters

Subject	Accuracy
A	82 %
B	96 %
C	79 %
D	88 %
E	96 %
F	86 %
Average	87.8 %

Table 2: Recognition accuracy for vowels and consonants

Subject	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 %

5. Consideration

According to Table 1, although recognition accuracy is not low, more than one letter per 10 letters is misrecognized. Then, according to Table 2, the recognition accuracy for consonants is lower than the one for vowels. The reason is considered that the number of kinds of consonants are more than the kind of vowels. Therefore, it is easy to misrecognize. Table 3 and 4 show misrecognition patters for consonants and vowels, respectively. According to Table 3, misrecognitions occur between a consonant and next consonant. Furthermore, from the subject's opinions, they sometimes lose their feelings of relative position between the soles and stimulators. In other words, misrecognition occurs between the next row or next column on the stimulator layout. This opinion corresponds with the result of Table 3. Therefore, a way to inform a reference point to the user should be considered.

From another opinion, it is difficult for some subjects to recognize voiced or semi-voiced consonants. Because vibra-

Table 3: Combinations of misrecognition for consonants

Inputconsonant	Answer	Times
K	N	8
R	H	8
T	M	3
M	W	3
D	N	3

Table 4: Combinations of misrecognition for vowels

Input vowels	Answer	Times
A	O	4
U	A	4
A	I	2
A	U	2

tion length is only different from the original consonants, it is necessary to concentrate to recognize these difference. It is troublesome work for the subject. Therefore, the vibration pattern for voiced or semi-voiced consonant.

It is expected that if these two problems are solved, the recognition accuracy will be improved.

6. Conclusion

In this study, a system to transmit information using stimulations to the foot soles was proposed, then it was attempted to transmit literal information by this system. The recognition accuracy was not enough, however, it was confirmed that the system works well. It is expected that the system will be applicable for a navigation system while walking without TWW. If only navigation is focused on, the number of kinds of letter needed for navigation is smaller, therefore the accuracy will be improved. Recently, many information, for example about a good restaurant or a good souvenir shop, is provided to user's smartphone at tourism site. Therefore, this system can be applied not only for navigation but for other purposes such as receiving tourism information.

In future work, it is necessary to improve the recognition accuracy and the speed of transmission.

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(Received August 3, 2016; accepted October 31, 2016)