Effective Combination of Haptic, Auditory and Visual Information Feedback in Operation Feeling

Keiko Kasamatsu[1], Tadahiro Minami[2], Kazuki Izumi[2], and Hideo Jinguh[2]

[1] Tokyo Metropolitan University, 6-6, Asahigaoka, Hino, Tokyo, Japan
[2] Kanazawa Institute of Technology, 3-1, Yatsukaho, Hakusan, Ishikawa, Japan
kasa@neptune.kanazawa-it.ac.jp

Abstract. This research designed the means to offer the haptic feedback to the touch panel by producing the pen-shaped vibratory device. The task performance and the feeling of push touch using this device was experimented by the sensory evaluation. The psychological effects concerning the difference in the feeling of push touch and the acceptance of the device was evaluated by giving the haptic feedback compared with the visual and the auditory feedback. As a result, not only the haptic sense but also the effectiveness of two or more sensory integration was taken as an operation feeling. The goodness of the operation feeling was confirmed the improvement by a clear impression and comprehensible feedback. It is thought that the goodness of operativeness by the vibratory stimulation is connected with the sensibility such as the feeling of comfortable and security.

Keywords: feeling of push touch, haptic feedback, psychological effects.

1 Introduction

There are some products of the information transmission that uses the vibrating alert of the cellular phone and the vibration of alarm clock. These are often used in a limited situation of presence of the vibration under the situation set beforehand. And, these are not often distinguished depending on the kind of the vibration. The improvement of a further usability is expected by adding sense of touch information. It can propose the quality composition in which the mind is moved by adding the element that promotes positive use "I want to use it" and "It is pleasant" and "It is possible to use it naturally" in addition to the satisfaction in the usability. The vibratory stimulation is not a supplementary role of the information transmission and is used as the main role. This promotes an improvement of the usability and positive use. Then, it is necessary to examine the relation to vibration pattern and human sensibilities. The product using the touch panel is widely widespread now as the operation machines such as ATMs and information terminals. This has been a focus of attention as an interface that takes the place of the mouse and the keyboard on the computer.

There are a lot of advantages in the touch panel for the operator. For example, the combination with Graphical User Interface (GUI) can have a variegated function, and the change in the function is easy. There are a lot of advantages in the touch panel for the user. For example, it is possible to operate by touching the operation object

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directly, and to operate it intuitively. However, there are the following problems in the touch panel. It is not easy to recognize whether it was possible to input it accurately because feedback to the input is poor. It is difficult for the optically-challenged people to operate it, because the recognition of the controlling elements depends on the visual contents. When the button is pressed in the real world, the visual, auditory, and haptic feedback can be obtained. However, the button displayed on the touch panel cannot obtain these feedbacks unlike the button in the real world. The visual and the auditory feedback are presented in the touch panel product used now. For example, animation into which the color of the button changes and the button dents and operation sound has been reproduced when the button displayed in the touch panel is pushed. However, there is little case to present the tactile feedback in a current touch panel.

The researches on the touch panel and the sense of touch pen have been a focus of attention. Forlines and Balakrishnan [1] evaluated the direct input using tabletPC and stylus, and the indirect input using CRT monitor and stylus. The differences by presence of haptic and visual feedback were analyzed by selection time, error rate, and Fitts' law. Lee et al. [2] produced the Haptic Pen with pressure-sensitive tip which was simple and low cost. Kyung et al. [3] developed the Ubi-Pen II, a pen-shaped haptic interface and presented empirical studies on Braille, button, and texture display.

In this research, A pen-shaped vibratory feedback device was produced, and the system that offered the haptic feedback when the touch panel was used was designed. The task performance examined and the feeling of push touch using this device was experimented by the sensory evaluation. The psychological effects concerning the difference in the feeling of push touch and the acceptance of the device were evaluated by giving the haptic feedback compared with the visual and the auditory feedback.

2 Pen-Shaped Device with Haptic Feedback

This pen-shaped device is simple, low cost and easy control. A pen-shaped device with built-in voice coil motor (VCM, Audiological Engineering Corp.) was made as a device to present the haptic stimulation (Fig. 1). Feedback to the operation can be given to the finger by touching the touch panel with this pen. The high response can be expected of VCM compared with the vibrating motor like the DC motor used for the vibration function of the cellular phone. Moreover, there is no influence on the

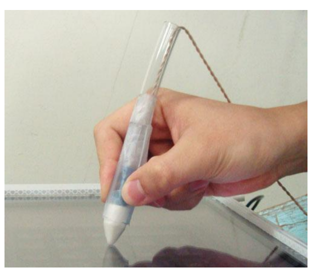

Fig. 1. The pen-shaped device with haptic feedback

vibration time by inertia, and the control of the vibration of various strength and the frequencies etc. is easy. The size of the pen-shaped device was 150mm in length and 18mm in diameter. The parameter of the vibration as haptic information prepared the amplitude, the frequency, the presentation timing, and the vibration duration.

The experiment system was made by using Visual Studio.Net. The image processed based on the picture image of ten keys was displayed at the center of the screen. When each button of ten keys is pressed, this system can present the haptic, auditory, and visual feedback. The presence of feedback can be switched respectively independently. It is possible to input it by operating each button of ten keys displayed on the display with a pen-shaped device with haptic feedback. The input characters are displayed in the textbox in the upper part of ten keys.

3 Experimental Methods

The mode of expression of the feeling of push touch with a pen-shaped haptic device in addition to a past visual and auditory in the device was examined, and evaluated. The experiment participants were ten men of 21~23 years old.

3.1 Measurement of Vibration Differential Threshold on Pen-Shaped Device with Haptic Feedback

The differential threshold of the vibratory stimulation in the pen-shaped haptic device was requested by the method of limits. As a result, the differential threshold of the vibration was 13.1Hz.

3.2 Feedback Stimuli

The vibratory stimuli were five conditions of 100, 180, 200, 220, 260Hz. When the button was pressed, the vibration was presented. The auditory stimulus was the sound of pushing the key.

3.3 Experimental Task

The experiment accomplished the figure input task for ten minutes. Ten figures a trial were input as early as possible, and the task was done continuously for ten minutes. The image of ten keys was displayed on the touch panel, and each button of 0~9 of ten keys was made to touch with a pen-shaped device.

3.4 Measurement Indices

The operation time and the error rate on a trial as measurement indices were measured. The evaluation items concerning the feeling of push touch were 14, and evaluated it by seven stage method.

3.5 Procedures

The figure displayed on the touch panel was input touching with the pen-shaped device. After the operation to each stimulus had finished, the operation feelings to the stimulation were evaluated. First, the experiment of the effect of five stimuli of 100~260Hz was conducted, and the stimulus with the best evaluation and performance was examined. Afterwards, three kinds of haptic stimulation and two kinds of auditory stimulus were selected, it experimented on five combination conditions as shown on Table1, and feeling of push touch was evaluated.

4 Results

The best frequency was examined as task performance and feeling of push touch among five of 100~260Hz vibratory stimuli. The error was excluded and mean operation time was requested as operation time. As a result, it was the longest in the vibratory stimulus of 100Hz at operation time, and shortest in 220Hz(Fig.2). The error rate was highest in the vibratory stimulus of 180Hz, and about 3% in other stimuli(Fig.3). The result of the evaluation concerning the feeling of push touch is as shown in Fig.4. The evaluation with 200Hz and 220Hz were high, and the evaluation of 100Hz had lowered. The analysis of variance was to examine the difference between five stimuli. As a result, there were significant differences at 5% level in "clearly", "pleasantly", "comfortable", "texture", "expectation", "feeling of luxury", "feeling of push touch", "reality", "easiness", "discrimination", "user-friendliness". As a result of the multiple comparison, significant differences were recognized between 100Hz and 200Hz, 100Hz and 220Hz.

Table 1. The combination conditions of vibratory and auditory stimuli

Conditions	Vibratory stimuli			Auditory stimuli
	220Hz	100Hz	no	
A	○	-	-	○
B	○	-	-	-
C	-	○		○
D	-	○	-	-
E	-	-	○	○

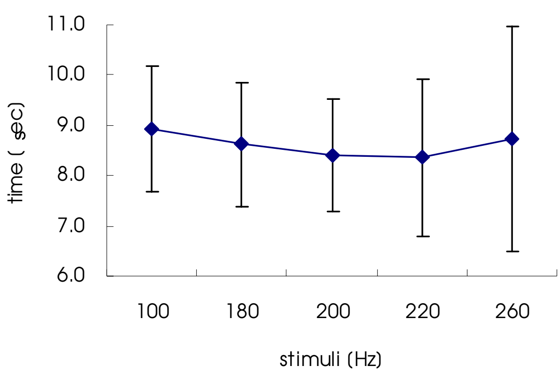

Fig. 2. Operation time on five vibratory stimuli

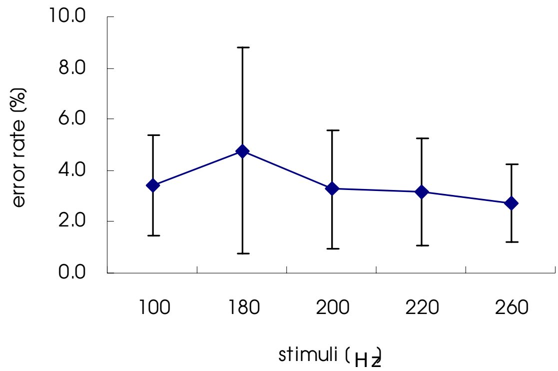

Fig. 3. Error rate on five vibratory stimuli

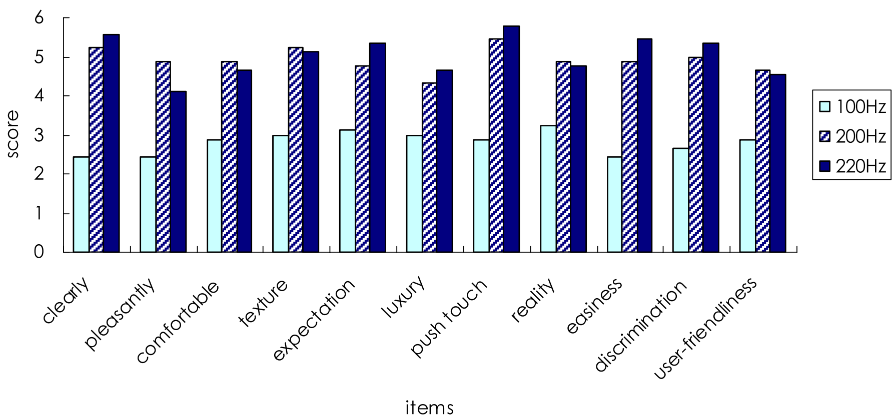

Fig. 4. The sensory evaluation on vibratory stimuli

Therefore, it was suggested that the vibratory stimulus of 220Hz was a haptic feedback to be able to work comfortably. The evaluation of the vibratory stimulus of 100Hz was the lowest in these stimuli.

Next, the auditory stimulus was added to the vibratory stimuli of 220Hz and 100Hz. The effect of combined sensory was examined using these stimuli. The used conditions are shown on Table 1. The operation time was the shortest on the condition C, and the longest on the condition D(Fig.5). The error rate was the highest on the condition D(Fig.6). There was no significant difference on any conditions. The results of the evaluation concerning the feeling of push touch were the best on the condition A, the worst on the condition D(Fig.7). The analysis of variance was to examine the difference between five conditions. As a result, there were significant differences at 5% level in "clearly", "pleasantly", "comfortable", "feeling of luxury", "feeling of push touch", “relief”, "easiness", "discrimination". There were significant differences at 10% level in "texture", "expectation", "reality". The results of the multiple comparison recognized significant differences between A and D, C and D.

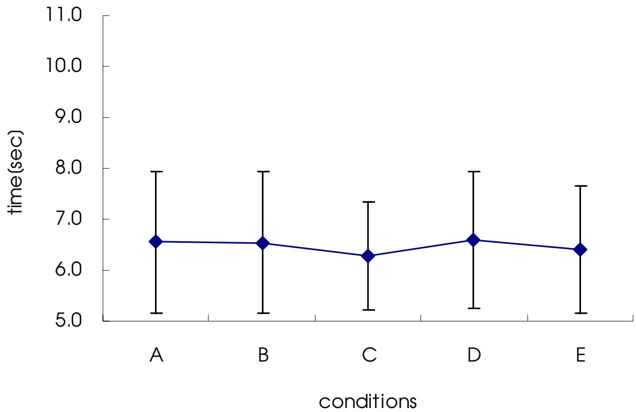

Fig. 5. Operation time on vibratory and auditory stimuli conditions

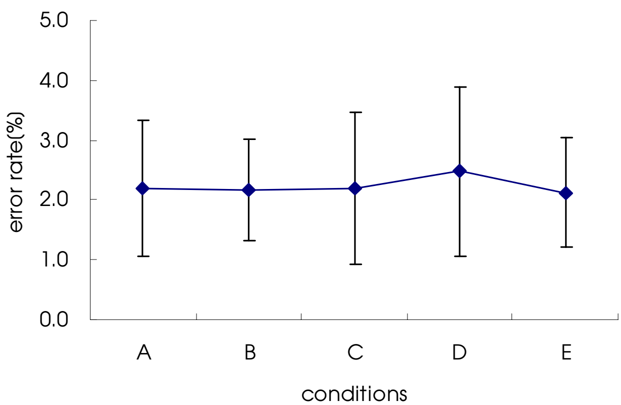

Fig. 6. Error rate on vibratory and auditory stimuli conditions

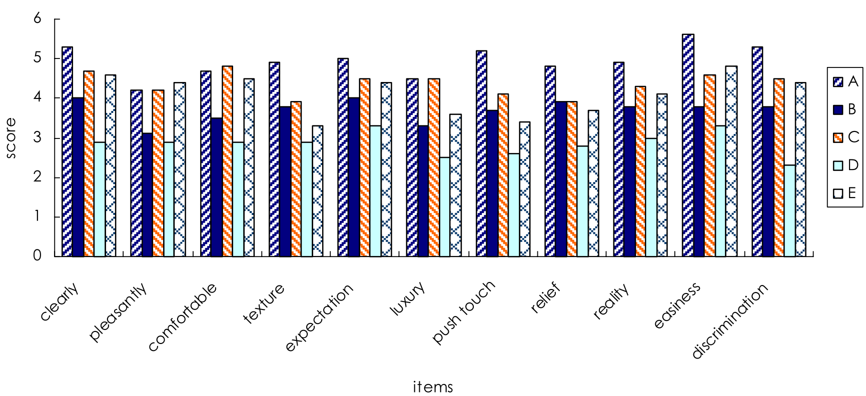

Fig. 7. The sensory evaluation on vibratory and auditory stimuli conditions

5 Discussion

The best vibratory stimulus as feeling of push touch was examined from respect of the task performance and the sensory evaluation. It was shown that the vibratory stimulus of 220Hz was a haptic feedback to be able to work comfortably. The vibratory stimulus of 220Hz was judged as a vibration with clear and feeling of luxury, and it was suggested to feel pushing by clearness to be strong, because the evaluation of it was high score in “clear”, "expectation", "feeling of luxury", "feeling of push touch", "easiness", "discrimination”. Moreover, the vibratory stimulus of 220Hz had high task performance. On the other hand, the vibratory stimulus of 100Hz had low task performance and the evaluation of feeling was low. Therefore, it was suggested to influence the task performance by the difference of the vibration only for the haptic feedback.

Multimodal integration adding the auditory stimulus to the haptic feedback of vibratory stimulation brought the effect on the task performance and the sensory evaluation. Multisensory integration has the possibility of improving the comfort in task. There was no significant difference between the condition B and C, however, the evaluation of the condition C was the better than the condition of B on every items. This showed that the evaluation of the tactile feedback with a not good evaluation that adds the auditory stimulus is higher from the best tactile feedback. There is a possibility that multisensory integration with a not good precision feedback become more preferable than excellent simple feedback on task performance and a psychological evaluation.

There was no influence for the occurrence of error though the multisensory integration tended to have a negative influence at the task speed. However, the improvement of easiness and clarity was taken by the sensory integration as a psychological effect.

6 Conclusion

A pen-shaped vibratory feedback device was produced, and the task performance was measured and the feeling of push touch using this device was experimented by the sensory evaluation in this research. The psychological effects concerning the difference in the feeling of push touch and the acceptance of the device were evaluated by giving the haptic feedback compared with the visual and the auditory feedback. As a result, he vibratory stimulus of 220Hz was a haptic feedback with comfortably and good task performance. The vibratory stimulus of 220Hz was judged as a vibration with clear and feeling of luxury, and it was suggested to feel pushing by clearness to be strong, because the evaluation of it was high score in “clear”, "expectation", "feeling of luxury", "feeling of push touch", "easiness", "discrimination”. It was shown to improve the comfortably and performance in task by adding the sense.

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