Investigation of Improving Perceptual Accuracy using Instantaneous Opposite Presentation of Virtual Force Sensation

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***Abstract*— Virtual force sensation is a virtual-perception of force through illusion. It can be generated by applying asymmetric vibration to the human skin using an actuator. The accuracy of virtual force sensation perception decreases as the presentation direction increases. In this study, momentarily virtual force sensation in the opposite direction is generated just before the desired direction. Then the accuracy of virtual force sensation perception is improved in the desired direction.**

I. INTRODUCTION

Virtual force perception is generated by presenting asymmetric vibrations to the skin of the fingertip. Amemiya [1] proposed a virtual force presentation device using a crank mechanism. The correct response rate for the two-directional presentation (front and rear) with this device was 92%. Rekimoto [2] proposed a method of presenting two axial directions by combining two actuators. The correct response rate for the 8-way presentation was about 20%. Kazashi[3] et al. improved the accuracy of perception by synchronizing the vibration of multiple actuators. The correct response rate for the 8-way presentation was about 54.6%. The results were improved compared to Rekimoto's results. In the present study, we improve the accuracy of perception by presenting an instantaneous virtual force in the opposite direction before presenting the virtual force. This enables device design with a high degree of freedom independent of actuators placement. The device used in this study is shown in Figure 1. The shell of the actuator shown in the right side of Fig. 1 was created by a SLA 3D printer. A coil is wound around it, a magnet is placed inside, and rubber membranes are attached to both sides. This is attached to the shell of the device shown on the left in Figure 1 using tape. The device is grasped with the thumb, index, middle, and ring fingers. The opposite direction is presented for 300 ms just before the presentation of the virtual force sensation. The time was set to 300 ms as a rule of thumb. On the other hand, there is no limit to the presentation time of the virtual force in the direction to be perceived.

II. EXPERIMENT AND DISCUSSION

We examine how the accuracy of the perception of the four directions (up, down, left, right) is affected by presentation of the opposite direction or not. The subjects were four male subjects in their 20s. They wore headphones with white noise of sufficient volume to prevent ambient noise. The number of trials was 8 in each direction for a total of 32 trials. The average correct response rate without and with reverse presentation of virtual force perception was 63.3% and 81.3%, respectively. A p-value of 0.036 was obtained from a paired t-test, indicating a significant difference. Figure 2, which shows the confusion matrix between the direction of presentation and the direction of response, also indicates that the correct response rate was higher when the opposite direction was presented. One challenge is the 8-direction discrimination [3]. It is that the perception accuracy of the diagonal direction shifted by 45 degrees is lower than that of the 4-direction direction. Therefore, we will attempt to improve the perceptual accuracy of 8-direction discrimination using the proposed method.

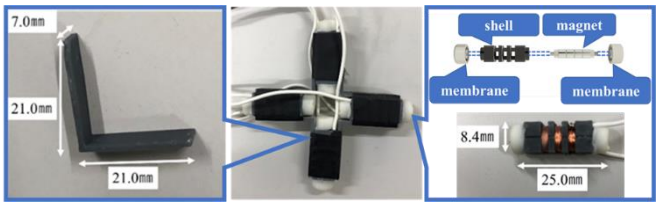

Figure 1. Device
(Left: Shell, Middle: Device, Right: Actuator)

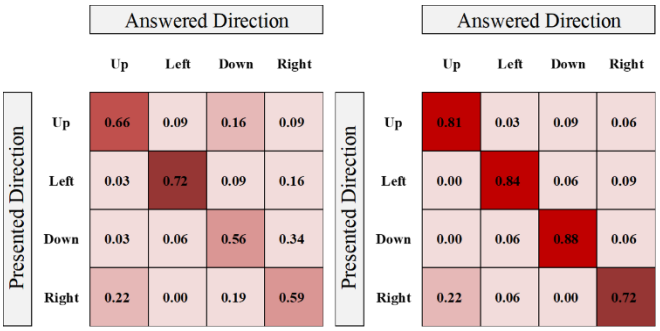

Figure 2. Confusion Matrix
(Left: Without Opposite Direction, Right: With Opposite Direction)

REFERENCES

[1] T. Amemiya, H. Ando, T. Maeda, "Phantom-DRAWN: direction guidance using rapid and asymmetric acceleration weighted by nonlinearity of perception," in Proc. 2005 Int. Conf. Augmented Tele-existence, ACM Press, 2005, pp. 201-208.

[2] J. Rekimoto, "Traxion: A Tactile Interaction Device with Virtual Force Sensation,"User Interface Software and Technology 2013 (UIST '13), 2013, pp.427-431.

[3] Y. Kazashi, T. Asano, and T. Nakata, "Extension of Direction by Vibration Synthesis of Virtual-force Devices," TVRSJ, vol. 24, no. 4, 2019, pp. 401–411.

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