3D Shapes Presentation by Combining Electro-tactile Stimulation and Force-feedback

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Abstract. Quick and accurate transmission of 3D shapes in virtual space is essential for skillful handling of virtual objects. In this study, we investigated the contribution of simultaneous presentation of a force cue using a force-feedback device and a cutaneous cue using an electric stimulator to the accuracy of discriminating primitive 3D shapes.

Keywords: virtual 3D shapes, haptics, virtual reality

1 Introduction

Haptic feedback enriches the realism of virtual reality (VR) experiences and increase the immersion of the experience. In particular, interaction such as touching or grasping a virtual object requires tactile feedback in the shape of the virtual object. In addition, it is important to transmit the shape of the virtual object quickly and accurately in order to perform such interactions naturally and skillfully.

Existing force-feedback devices have already enabled precise force rendering of virtual object shapes; however, precise reproduction of the cutaneous sensation is still difficult due to the low resolution of the presented stimuli. On the other hand, Kajimoto[1] proposed an electro-tactile display as a useful method for high-resolution cutaneous sensory presentation. This display provides cutaneous sensations at 2mm intervals to the fingertips and the small size of it makes it easy to attach to the end of an existing force-feedback device.

In this paper, we attempted to present the 3D shape of a virtual object by force rendering using a force-feedback device and cutaneous sensation using an electric stimulator. Then, we performed a 3D shape recognition task using the presented stimuli and examined the efficacy of the simultaneous presentation.

2 Method

We used Touch X USB (3D Systems) to present the force sensation of a 3D shape. The OpenHaptics API [2] was used for force rendering of 3D objects visually presented with the Unity engine. A mounter in the shape of a finger sack was attached to the end-effector to enable force-feedback to a single finger.

As a cutaneous sensory presentation of the 3D shape, we used a device with an electrode arrangement in the shape of a finger, with a mechanism similar to that of the electro-tactile display kit for fingertips [1]. It was attached to the mounter of the force-feedback unit. The actual electrode size and arrangement were reproduced in Unity, and moved by following the pointer of the force-feedback device. Electric stimuli were applied to electrode points that were in contact with a 3D object in a Unity scene.

The shape recognition task was designed based on previous research [3]. First, participants observed and touched the visually presented object to learn its shape features. Next, participants identified the shape using only tactile cues. Participants were asked to identify the shape as quickly and accurately as possible, and their response times and responses were recorded. Four types of 3D shapes were presented: cone, cube, cylinder, and sphere. Each shape was presented three times under two conditions: force-only and force plus electrical stimulation (Force + Elec), for a total of 24 presentations.

3 Results and Conclusion

Fig. 1 shows results of shape recognition task with 10 participants. These results suggest that combining electrical stimulation and force-feedback might improve the efficiency of cone exploration, but overall results are quite similar between the two conditions. The high correct answer rate indicates that the task might have been too simple, and we will conduct future trials with more complex shapes.

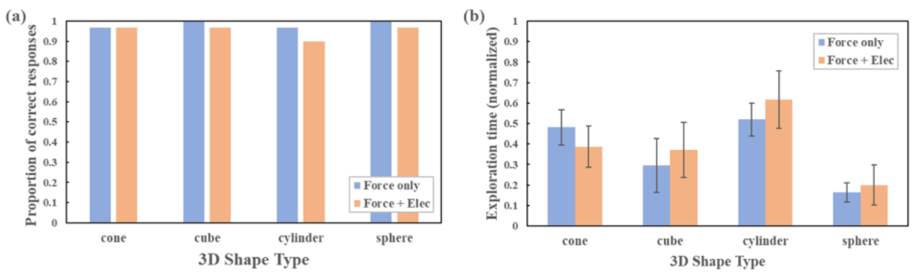

Fig. 1. Results of Shape Recognition Task

References

1. H. Kajimoto, “Electro-Tactile Display Kit for Fingertip,” 2021 IEEE World Haptics Conference, 2021, 587-587.
2. B. Itkowitz, J. Handley and W. Zhu, "The OpenHaptics/spl trade/ toolkit: a library for adding 3D Touch/spl trade/ navigation and haptics to graphics applications," First Joint Eurohaptics Conference and Symposium on Haptic Interfaces for Virtual Environment and Teleoperator Systems. World Haptics Conference, 2005, pp. 590-591.
3. J. Martínez, A. García, M. Oliver, J. P. Molina and P. González, "Identifying Virtual 3D Geometric Shapes with a Vibrotactile Glove," in IEEE Computer Graphics and Applications, vol. 36, no. 1, pp. 42-51, Jan.-Feb. 2016.