Inter-joint Vibrotactile Phantom Sensation on the Human Arm

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***Abstract*— Despite the numerous efforts to find appropriate parameters for the phantom sensation, the literature still lacks data on perceptual effects if the phantom sensation includes joints. To assess the potential of the inter-joint phantom sensation rigorously, we let participants wear a sleeve on their left arm that was designed in two pieces: a forearm sleeve including five actuators and an after-joint sleeve including one actuator. The participants answered the perceived location and the perceived number of actuators on the test signals. The results showed that the inter-joint phantom sensation could deliver the perceived location but showed less accuracy and felt as two stimulation in comparison to the phantom sensations including no joints.**

I. Introduction

The vibrotactile feedback has provided a highly immersive and realistic experience in virtual reality (VR) via realistic vibrations [1] and co-located feedback [2]. Some researchers take this importance into account and try to find appropriate parameters for rendering spatially accurate phantom sensations, and Elsayed et al. rigorously estimated the spatial characteristics of the static phantom sensations over the whole body sites [3]. However, the effects of the joint-included phantom sensations are not sufficiently reported in the literature yet. Therefore, we designed a user study for estimating the inter-joint static phantom sensations on the human arm.

II. Experiment

We implemented a two-piece sleeve-type device including six voice-coil actuators (Tactile Labs; Mark II TL002-09-D) as in Figure 1a. To rigorously assess the perceptual characteristics of inter-joint phantom sensation, we designed a two-day experiment for 1260 phantom sensations with 21 target locations, 2 arm sides, 2 rendering methods, 3 frequencies, and 5 repetitions. Twelve participants (all males; avg. 22.08 years old) were recruited and the order of the arm side was balanced by using the Latin Square. In the experiment, the 1260 sensations were randomized and the participants answered the number of perceived stimulation and the perceived location for each test stimulus.

After the experiment, we calculated single perception count (SPC) and spatial accuracy from the responses and plotted them in Figure 1b, c. As a result, the phantom sensation of **Ventral-Linear-100Hz** condition showed better performance in both SPC and spatial accuracy than other conditions. Our initial observation of the results showed that the inter-joint phantom sensation was less accurate and tended to be perceived as two stimulation in comparison to the phantom sensations including no joints, but we need in-depth analysis for deriving conclusions.

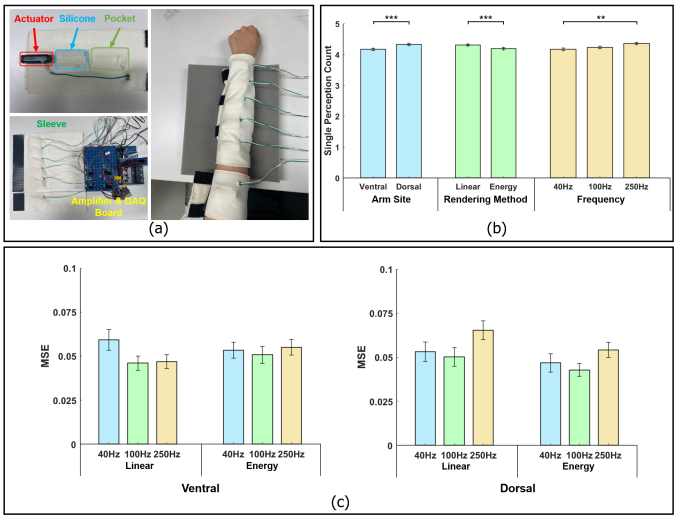

Fig. 1. (a) Configuration of the inter-joint phantom sensation system with a two-piece arm sleeve. (b) Plots of the mean single perception count with standard errors by the arm side, rendering method, and frequency, respectively. (c) Plots of the mean MSE of all conditions within two-interval stimuli for the ventral side (left) and the dorsal side (right). Bars represent the standard errors. (*: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$)

III. Discussion & Future Work

Our result indicated that the static phantom sensation on the human arm could be rendered accurately with the condition of **Ventral-Linear-100Hz**, however, the effect of inter-joint static phantom sensation still requires further analysis. In our future work, we are going to investigate the effect of the joint in both the static and dynamic phantom sensations while considering the posture of the human arm.

References

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