Psychophysical Magnitude Function of Vibratotactile Stimuli with Similar Physical Characteristics to Laser Stimulus

Hojin Lee[1], Jongman Seo[1], and Seungmoon Choi[1]
[1]Department of Computer Science and Engineering, Pohang University of Science and Technology (POSTECH), Pohang, Gyungsangbuk-do, Republic of Korea
E-mail: {hojini33, cjman224, choism}@postech.ac.kr

Abstract—**We compared several vibrotactile stimuli with high frequency and short duration in a perceptual space by conducting a psychophysical experiment. Then, we acquired a candidate vibration which can be comparable to a non-contact laser stimulus. The result of our experiment can facilitate further investigations of the perceptual properties of laser stimulus.**

Keywords— **Laser stimulus, Vibrotactile stimulus, Perceived Intensity, Psychophysics.**

I. INTRODUCTION

Laser stimulation can induce non-contact haptic sensations by generating thermoelastic waves that interact with human in several mechanisms [1]. This sensation can be similar to the percept triggered by vibrotactile stimuli. This work is preliminary study on learning perceptual characteristics of laser stimuli. We conducted an experiment to obtain a psychophysical magnitude function of vibrations that have similar physical characteristics of laser stimuli.

II. METHODS AND RESULTS

The main physical characteristics of our laser stimulus are extremely high frequency and short duration. We used a Q-switched laser with 532-nm wavelength and 5-ns pulse duration. A user can perceive a haptic sensation when exposed to the laser stimulus on his/her fingertip. To generate vibrotactile stimuli with similar characteristics, we used a commercial high-precision mini-shaker (Brüel & Kjær; model 4810). Before the main experiment, we conducted a pilot test to select 14 discriminable vibrotactile stimuli. All stimuli included ten repetitions of 10-ms vibrations followed by 90-ms off-period in 1-s duration, but they had different carrier frequencies and amplitudes as shown in Table 1.

Nine university students performed an absolute magnitude estimation experiment for the perceived intensities of the vibrations. Each stimulus was given eight times on the participant's fingertip. From the results, we obtained a psychophysical magnitude function that maps frequency and amplitude to perceived intensity as in [2]. The acquired magnitude function (Fig. 1) based on Steven's power law is $\psi = k\phi^e$ where ψ is the perceived intensity of the stimulus with the vibration amplitude ϕ. The slope $k = \sum_{i=0}^{3} \alpha_i (log_{10} f)^i$ and the exponent $e = \sum_{i=0}^{3} \beta_i (log_{10} f)^i$ were calculated through regressions where f denotes the vibration frequency ($R^2 > 0.99$; α_i and β_i are in Table 2).

Table 1. Carrier Frequencies and Amplitudes of 14 Vibrotactile Stimuli.

Frequency (kHz)	1	3	7
Amplitude (Acceleration in G)	1, 3, 7, 10	2, 5, 10, 15, 20	5, 10, 20, 30, 40

Table 2. Coefficients of the Psychophysical Magnitude Function.

i	0	1	2	3
α_i	0	62.82	-33.86	4.56
β_i	0	3.92	-2.48	0.4129

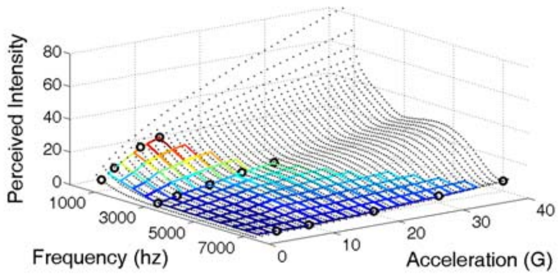

Fig. 1. Perceived intensities and the best fitting surface (Black circles represent the parameters in Table 1).

III. CONCLUSION AND RESEARCH PLAN

This experiment allowed to us to design vibrotactile stimuli that have most similar perceptual characteristics to laser stimuli. We plan to obtain a perceptual space of laser stimuli to further study their psychophysical properties, and the vibrotactile stimuli in this study will be a basis for that future work.

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