Enhancement of Tactile Intensity for Thin Film Vibrators using Lever Mechanism

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***Abstract*— This study presents a lever mechanism mounted on the film vibrator to enhance the tactile intensity for the low-frequency vibrotactile stimuli. We have developed a piezoelectric thin film vibrator that generates displacement. To overcome its perceptually insufficient displacement in the low-frequency (∼100 Hz) domain, we developed the lever mechanism inspired by the tactile contact lens that amplifies the displacement.**

I. INTRODUCTION

Designing a haptic display is a key challenge to enrich the visual and audio experience in virtual reality. As recent interfaces, such as a gaming pad, employ linear actuators instead of eccentric rotating mass, temporal and frequency responses of vibrotactile feedback have been improved. One of the next challenges would be the improvement of spatial resolution, in which multiple actuators would be installed in interfaces or directly on the skins of users.

We have developed a piezoelectric thin film vibrator with a few micrometers of thickness using micro electro mechanical systems technology [1]. Its small size and flexibility allow for attaching to a curved surface, including human bodies, and array arrangement. As a common issue of a thin film vibrator, it is challenging to generate perceptually sufficient displacement in the low-frequency (∼100 Hz) domain.

This study presents a lever mechanism mounted on the film vibrator to enhance the tactile intensity for the low-frequency vibrotactile stimuli. The lever mechanism, inspired by the tactile contact lens [2], amplifies the normal displacement of the surface of the film vibrator to provide a tangential displacement on the surface of the skin. The rest of the paper introduces a system to demonstrate the enhancement of tactile intensity by comparing the film vibrator with and without the mechanism.

II. SYSTEM SETUP

As shown in Fig. 1A, the system consists of a host computer, a vibrotactile display, and an even balance. As shown in Fig. 1B, the vibrotactile display consists of our developed film vibrator [1], a vibrator jig, and a balance jig. The vibrator is connected to a piezo driver (Texas instruments, DRV2667EVM-CT) and fixed with an epoxy adhesive (CEMEDINE, CA-193) onto the vibrator jig. We designed the two types of the surface of the vibrator jig that are contacted with a finger of participants. One is a 24×16-mm plane surface while the other is a surface with the lever mechanism. Based on [2], we implemented the lever mechanism by arraying cylinders whose diameter, height, and interval are 1 mm, 4.2 mm, and 1.5 mm, respectively. The vibrator jigs were modeled with Acrylic resin (Keyence, AR-M2) from a 3D printer (Keyence, AGILISTA-3200).

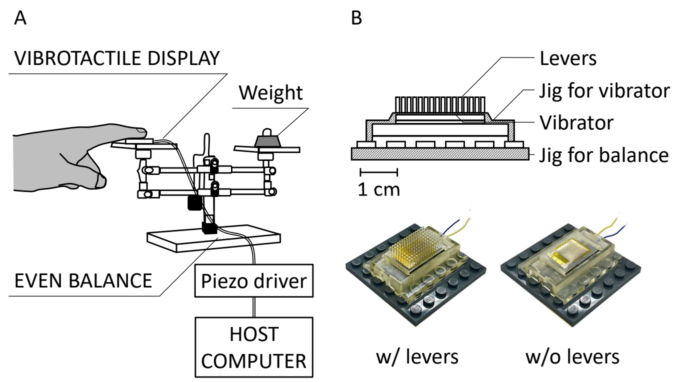

Fig. 1. Setup: A) system configuration; and B) vibrotactile display

The balance built based on Isogawa's Lego brick model [3] controls the contact force between a finger and the vibrotactile display by putting a weight on the side opposite to the vibrotactile display. The computer drives the vibrator through the piezo driver using audio signals (sinusoidal waves). The constant peak-to-peak voltage (40 V) is applied to the vibrator while the frequency (10-300 Hz) can be controlled through the graphical user interface.

We conducted a psychophysical experiment using this system. Our preliminary test showed that the lever mechanism enhances the tactile intensity in the low-frequency (∼100 Hz) domain.

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