

Reinforcement of Kinesthetic Illusion by Simultaneous Multi-Point Vibratory Stimulation

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Figure 1: Left: positions of vibrators and trackers. Right: an image of the induced kinesthetic illusion.

ABSTRACT

The kinesthetic sensation is important in terms of creating presence in virtual reality applications. One possible way of presenting the kinesthetic sensation with compact equipment is to use the kinesthetic illusion, which is an illusion of position and movement of the one's own body, generated by vibration. However, the kinesthetic illusion observed currently is an illusion of neither large nor rapid movement. To resolve this issue, we propose simultaneous stimulation of numerous tendons and muscles related to arm movement. Our investigation of the chest, lower arm, and upper arm finds an intensity change of the illusion when multiple points are stimulated.

CCS CONCEPTS

• **Human-centered computing** → **Virtual reality**; *Haptic devices*.

KEYWORDS

tendon vibration, kinesthetic illusion, haptic interface

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1 INTRODUCTION

The kinesthetic sensation is indispensable to improving a presence in virtual reality applications. The system to present kinesthetic sensation usually requires a large space for user's actual motion. It could be made more compact by using kinesthetic illusion, which is an illusion of the position and movement of the one's own body without physical motion. A kinesthetic illusion is known to be evoked by applying about 100 Hz mechanical vibration to tendons [Goodwin et al. 1972]. However, for practical use in virtual reality, the illusion is generally quite subtle.

Several methods have been proposed for enhancing the illusion, including the optimization of the vibration frequency [Roll and Vedel 1982], simultaneous stimulation of tendons at both ends, and stimulation of tendons of synergist muscles [Yaguchi et al. 2010]. However, the intensity of the illusion in preceding studies is still not enough, possibly because the studies stimulated tendons at a limited number of points. In this paper, we investigate how the illusion changes when tendons of more than two synergist muscles are stimulated at multiple points to further enhance the illusion.

2 METHODS

2.1 Setup

Seven vibrators (Acouve Lab Vp 210) were attached to the arm and chest of each participant by supporters (Figure 1, left). These vibrators presented a 70Hz sinusoidal vibration, which is the frequency inducing an illusion of relatively rapid movement [Roll and Vedel 1982]. The amplitude was preliminarily adjusted in the range from 80 to 100 m/s^2 when the vibrators were attached to the experimenter's body. The input signal was generated by audio processing software (Cycling '74 Max7) and amplified by audio amplifiers (FX-AUDIO-FX-202 A/FX-36 A PRO). Trackers (HTC Vive Tracker) were attached to the contralateral (other) shoulder and wrist (Figure 1, left) of each participant to measure the movement.

