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SCA: Soft Coil Actuator for Tactile Feedback with Multi-Frequency in Virtual Environments

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***Abstract*—We developed a Soft Coil Actuator (SCA) that allow to reproduce rich and realistic tactile sensations similar to those experienced in the real world. SCA has four individual soft tube coil vibrators, so it is possible to provide complicated mechanical vibrations that consist of multiple frequencies. In this demo, guests will interact with virtual 3D surface with natural and artificial 3D texture.**

Keywords—Haptic Display, Soft Actuator, Soft Material

I. Soft Coil Actuator (SCA)

As visual experiences through head-mounted displays in virtual reality environments become increasingly widespread. There has been also growing interest in reproducing tactile sensations through tactile displays. Existing wearable haptic displays often deliver vibrations intended for tactile communication [1][2]. However, these devices typically provide only single-frequency vibrations and do not account for reproducing the complex surface textures characteristic of real-world objects.

The goal of this study is to develop a tactile display capable of generating tactile sensations similar to those experienced in the real world. Humans perceive surface vibrations through small contact areas, such as the fingertips. These vibrations include a range of frequency components. To reproduce this sensation, it is necessary to provide multi-frequencies simultaneously within a localized region.

We developed a Soft Coil Actuator (SCA). Fig.1 shows an overview of the SCA. Fig.2 illustrates its operating principle. It consists of several soft tubes filled with liquid metal and wound around a magnet. The SCA is a direct-drive actuator driven by electromagnetic force. Applying electric current to the liquid metal generates electromagnetic force. This force displaces the soft tube in the magnetic field. A square wave current causes the electromagnetic force to change periodically. This enables the SCA to generate vibration. The flexible tube allows large displacements, even when both ends are fixed. Furthermore, the SCA is capable of independently driving multiple tubes.

This enables the simultaneous delivery of multi-frequency vibrations. As a result, the SCA can produce tactile feedback corresponding to surfaces with rich frequency components. This might enable interactions with multiple mechanoreceptor types by delivering vibrations across a range of frequencies. For instance, the SCA is capable of producing vibrations at 50 Hz and 200 Hz. These frequencies may correspond to the activation ranges of specific tactile receptors such as Meissner and Pacinian corpuscles.

Fig. 1. SCA

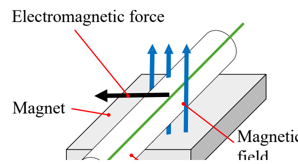

Fig. 2. Operating principle

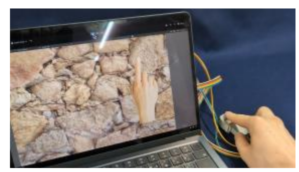

Fig. 3. Demonstration

II. Demonstration

In the demonstration, participants are able to freely trace and touch virtual objects in a 3D space. Fig.3 shows a participant interacting with the system. The SCA is attached to an optical sensor, forming a wearable haptic display. As the sensor tracks the user's position and motion, a virtual fingertip moves accordingly in the virtual environment. The SCA can provide multiple frequencies simultaneously to a localized area of the fingertip by independently driving multiple tubes. As a result, users experience realistic sensations. It can feel as if they are touching real objects with their fingers.

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References

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