Haptic Marionette: Wrist Control Technology Combined with Electrical Muscle Stimulation and Hanger Reflex

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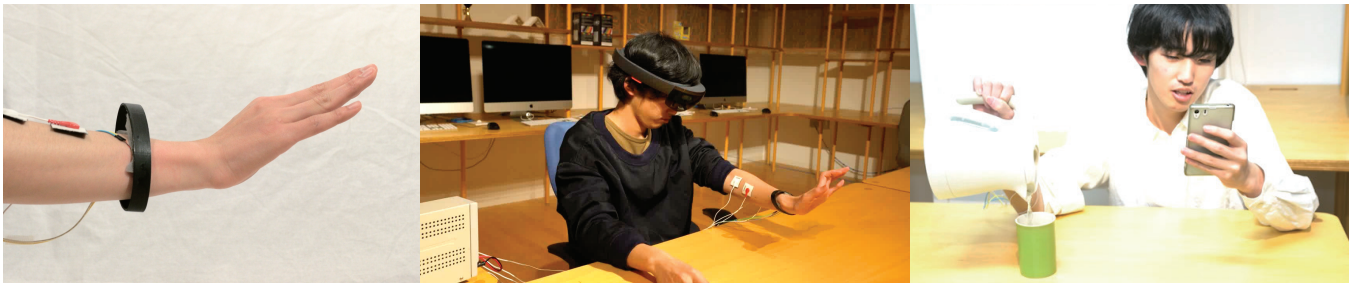

Figure 1: Combination of EMS and Hanger Reflex (left), and application images using our system (center, right).

ABSTRACT

Many devices and systems that directly control a user's hands have been proposed in previous studies. As a method for controlling a user's wrist, Hanger Reflex and Electrical Muscle Stimulation is often used. We propose a method combined Electrical muscle stimulation and Hanger Reflex. We use Hanger Reflex to elicit the supination and pronation, and EMS to cause the flexion and extension. We believe that the proposed method of this study contributes to the exploration of new devices and applications on the fields of haptics, virtual and augmented reality, mobile and wearable interfaces.

CCS CONCEPTS

• **Human-centered computing** → **Haptic devices**;

KEYWORDS

EMS, Hanger Reflex, Feedback

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1 INTRODUCTION

Many devices and systems that directly control a user's hand have been proposed in previous studies. For example, they have been proposed for playing an instrument, giving feedback, drawing and so on. As a method for controlling a user's wrist, hanger reflex and electrical muscle stimulation (EMS) is often used.

The hanger reflex is a phenomenon that causes force sensation and involuntary head rotation when the head is fastened with a wire hanger. The similar phenomenon has been observed on the wrist as well, and it has been used to control the wrist. [Nakamura et al. 2014] Hanger reflex can cause wrist supination and pronation. Pronation of the wrist is a rotational movement where the hand and upper arm are turned inwards. Supination is the opposite movement where the forearm or palm are rotated outwards. It means that hanger reflex can realize control of the wrist on the roll axis.

On the other hand, EMS uses electrical impulses to elicit contraction on the muscle, and causes the involuntary contraction of the user's muscles. This technique has also been used for controlling user's hand. [Lopes et al. 2015], [Ebisu et al. 2017] EMS can control the wrist on the pitch axis very accurately, since it is very effective to stimulate muscle for causing Flexion and Extension.

However, both hanger reflex and EMS has limitation as a method for controlling the wrist. In case of hanger reflex, it can control the wrist on the roll axis, but it is difficult to control on the pitch axis.

Moreover, EMS is efficient in controlling the wrist on the pitch axis, but not accurate on the roll axis, since the muscle for causing the wrist supination and pronation is too complex to stimulate inner muscles directly.

To address these problems, we propose a method combined electrical muscle stimulation and hanger reflex. (Figure 1 left) We use Hanger Reflect to elicit the supination and pronation, and EMS to cause the flexion and extension. We confirmed that this system can independently control the wrist on both roll and pitch axis. (Figure 2)

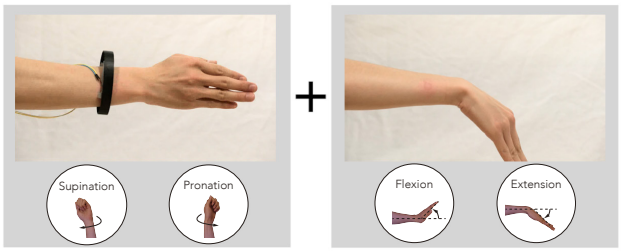

Figure 2: The proposed method combined EMS and Hanger Reflex to control the wrist.

2 IMPLEMENTATION

The proposed system includes two technologies; EMS, and Hanger Reflex. Therefore, we implemented a different hardware for each part.

2.1 EMS for Flexion and Extension

The circuit that generates EMS applies voltage pulse into the muscles of a participant using 2 pairs of electrodes. The strength of electric muscle stimulation from the electrode is controlled independently by micro-controller (Arduino Mega) changing the impedance of digital potentiometers (MCP4131). Each digital potentiometer is connected to micro-controller with SPI interface. The voltage of EMS can be changed in the range of 0-50V.

The circuit generates EMS pulse, whose pattern is controlled by the micro-controller (Arduino Uno). The waveform of EMS is set as 40Hz periodic pulse signal with pulse-width of 200 μs.

2.2 Hanger Reflex for Supination and Pronation

We design wristband for invoking the hanger reflex, and output it with a 3D printer. It is reported that the perceptual force from the hanger reflex is enhanced when a vibration is also presented. [Nakamura et al. 2016] We attached vibrators to the wristband to change the speed of wrist's reaction computationally.

3 APPLICATION

The combined control method is applicable to medical rehabilitation, VR/AR entertainments, redirected walking [Ishii et al. 2016], and display of instructions. (Figure 3, Figure 1 center, right) In the field of medical rehabilitation, a therapist can utilize the wrist control method to reactivate the patient's muscles of the wrist that have been affected during surgery and start to trigger the muscle memory.

Figure 3: (right) feedback to a player using the system, (left) practice of a rhythm pattern for musical performance.

In addition, this technique has possibility to explore novel VR/AR applications. In virtual games, user enjoy interactions with objects and characters. The capability to control the user's wrist allows user to feel more immersive experience in a lot of interactions (eg., shaking hands, touching objects, etc.).

This method can be also utilized to give users feedback of instructions when they use complicated products that are hard to understand how to use.

4 CONCLUSION AND FUTURE WORK

In this paper, we proposed a novel method to control human hand posture by combining conventional methods. We believe that the proposed method of this study contributes to the exploration of new devices and applications in the fields of haptics, virtual and augmented reality, mobile and wearable interfaces. As future work, this method still needs to be investigated in terms of the accuracy of angle control, and what interactions it can accomplish.

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