Stimulated Percussions: Techniques for Controlling Human as Percussive Musical Instrument by using Electrical Muscle Stimulation

Ayaka Ebisu* Satoshi Hashizume Kenta Suzuki Akira Ishii Mose Sakashita Yoichi Ochiai
University of Tsukuba

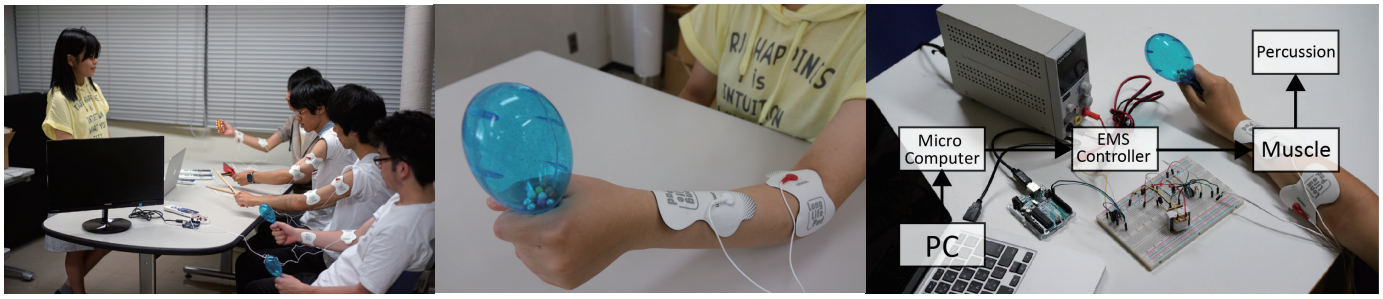

Figure 1: *Left: participants having a combined session with our system. Middle: EMS signal stimulates the muscle, the user's arm reacts, and generates percussive sound from held maracas. Right: overview of our system.*

Abstract

We propose Stimulated Percussions, a new method designed to beat out rhythm by controlling human bodies with percussions using electrical muscle stimulation (EMS). Numerous studies in the fields of both science and art have been carried out to expand the possibilities for untrained people to be able to play musical instruments. Especially, in some studies, EMS capable of controlling the human body is applied to play a particular musical instrument. However, these studies have focused on movements of the human body for playing one specific instrument that requires movement of the whole body. Therefore, in this study, we used EMS to evaluate the body movements associated with different muscles. Moreover, we set up individual rhythms to these body movements and discussed the instrument that could be played by using these rhythms. We believe this design method would be able to expand the possibility for support to play a musical instrument.

Keywords: Musical performance, electrical muscle stimulation (EMS), supporting untrained people

Concepts: •**Human-centered computing** → **Human computer interaction (HCI);** *HCI design and evaluation methods;*

1 Introduction

As the basis of playing musical instruments, humans move their body following the principle of producing a sound. Therefore, we have to spend a long time to acquire the skills such that we are able to produce the intended sound. Interfaces to enable an untrained person to produce musical performance have been explored in both the scientific and artistic fields. Some of the research relating to these interfaces aims to promote the rapid acquisition of musical performance skills. In this study, we propose Stimulated Percussions, techniques for controlling humans as percussive musical instruments by using EMS. This enables a person to play a percussive instrument by moving a particular muscle in the body in response to an EMS signal even if s/he is untrained. In terms of the objective of this study, which is to design a method for playing ensemble to the rhythm by evaluating the motion corresponding to stimulation of a particular position, especially, the results of this study can be applied for training performance requiring a sense of rhythm.

Previous studies were concerned with applying EMS to playing a musical instrument. For example, Possessed Hand [Tamaki et al. 2011] applies EMS to the arm muscle to enable the Japanese harp to be played. The Bio Sensing System [Nagashima 2003] presents a biofeedback system, and applies this to musical performance. This study proposes the application of EMS to playing a percussion instrument as an example.

In contrast, our study does not aim to achieve motion in a particular part of the body for playing an instrument; instead, it aims to achieve various body motions that would apply to more than one instrument. Furthermore, we evaluated each motion in terms of the instruments it would enable the person to play. Consideration of the design of a method whereby musical instruments could be played by using EMS could extend the possibility of support for playing the musical instrument.

2 Implementation

In the preceding study, the stimulation pulse frequency was set to 40 Hz, the pulse width was 0.2 ms, and the pulse height (voltage) was in the range of 17 - 29 V because it is adjusted to the human impulse required to exercise muscle [Tamaki et al. 2011]. We set the stimulation pulse frequency to 50 - 70 Hz, and the pulse width to 0.8 ms. The pulse voltage can be modified because it depends on the users or muscles earmarked for movement.

Stimulated Percussions consists of a circuit, a microcomputer (Ar-

*e-mail:twill.fig1125@gmail.com

SA '16, December 05-08, 2016, , Macao
ISBN: 978-1-4503-4540-8/16/12
DOI: http://dx.doi.org/10.1145/3005274.3005324

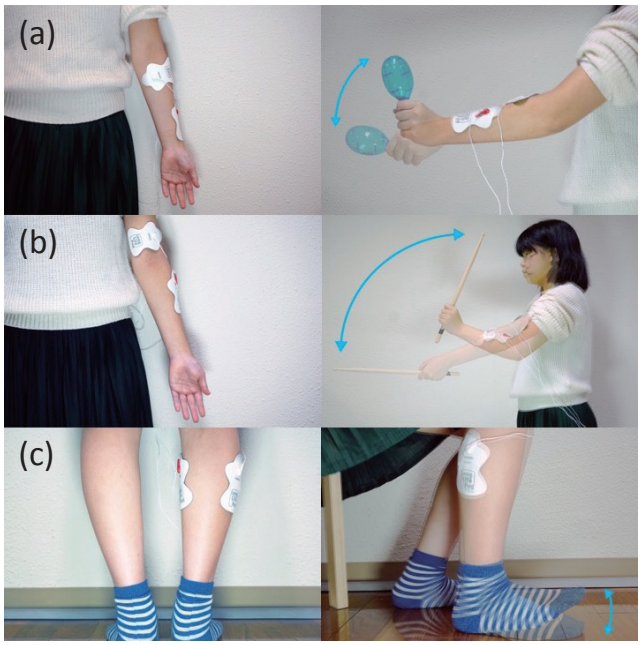

Figure 2: *Pad positions of EMS and movement. (a) extension of the wrist joint. (b) flection of the elbow joint and extension of the wrist joint. (c) plantar flection of the foot joint.*

duino), a PC, DC stabilized power source equipment and electrode pads (OMRON HV-LLPAD) (as shown in Figure 1 (right)). In the circuit, we used a 555 timer to generate pulses and a transformer was used to increase the voltage. When the voltage of direct current stabilized power source equipment increases, the electrical stimulus strengthens and the response of the human body is enhanced.

3 Arm movement and pad position design

We searched for the right pad position to reproduce the movement made by a user who plays the percussion instruments by considering the movement of the muscles as shown in Figure 2. Pad position (a) shows the location for stimulating the extensor carpi radialis longus and brevis. These muscles have the function of extending the wrist joint. We consider this pad position to be suitable for playing the triangle or the maracas. Pad position (b) shows the location for stimulating the biceps muscle of the upper arm, brachioradial muscle, and extensores carpi radialis. The biceps muscle of the upper arm and brachioradial muscle have the function of flection of the elbow joint. Because the forearm and the wrist move, this would enable a person to beat with drumsticks. Pad position (c) shows the location of stimulating the gastrocnemius muscle which has the function of achieving plantar flexion of the foot joint. When stimulating the gastrocnemius muscle by the state in which you place your heel on the floor and point your foot upwards, it is possible to obtain rhythmic movement by the foot.

4 Application

Stimulated Percussions aims to propose a design method to enable untrained people to play a musical instrument. Therefore, this method should help to acquire musical performance skill for a certain instrument. The method is very effective in that everyone can play the instrument regardless of the presence or absence of a rhythmic sense because music performance using this system is approved without being performer conscious as shown in Figure 1(left). In addition, it is possible to play an extemporary musical instrument for a similar reason. It should be possible to apply Stimulated Percussions widely to musical performance because it would allow people to even perform unknown music without any preparation. Our System is illustrated in Figure 3.

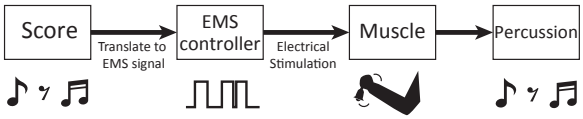

Figure 3: *System image for Stimulated Percussions*

References

NAGASHIMA, Y. 2003. Bio-sensing systems and bio-feedback systems for interactive media arts. In *Proceedings of the 2003 Conference on New Interfaces for Musical Expression*, National University of Singapore, Singapore, Singapore, NIME '03, 48–53.

TAMAKI, E., MIYAKI, T., AND REKIMOTO, J. 2011. Possessed-hand: Techniques for controlling human hands using electrical muscles stimuli. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, ACM, New York, NY, USA, CHI '11, 543–552.