# Building a Feedback Loop
between Electrical Stimulation and Percussion Learning

Ayaka Ebisu
Digital Nature Group,
University of Tsukuba
ayaka.ebisu@digitalnature.slis.
tsukuba.ac.jp

Satoshi Hashizume
Digital Nature Group,
University of Tsukuba
hashizume@digitalnature.slis.
tsukuba.ac.jp

Yoichi Ochiai
Digital Nature Group,
University of Tsukuba
Pixie Dust Technologies, Inc.
wizard@slis.tsukuba.ac.jp
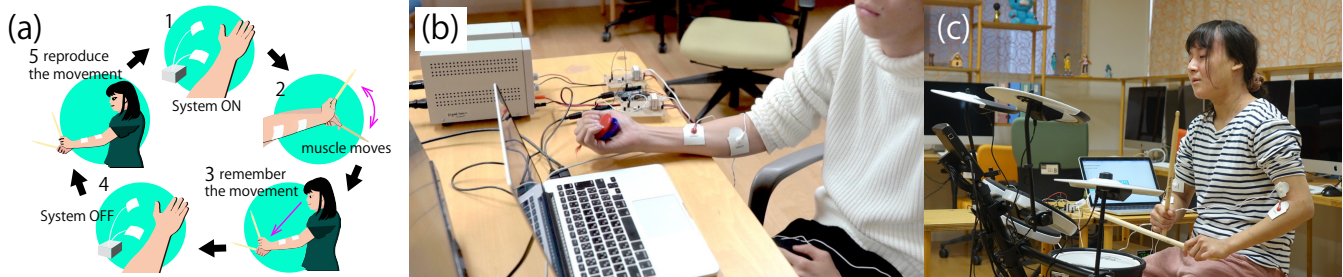
Figure 1: (a) Process of Rhythm Learning, (b) The user plays the castanets with his right hand stimulated by the Stimulated Percussions, (c) The user tries to remember the movement of her limbs and a drum rhythm pattern

ABSTRACT

A sense of rhythm is essential for playing instruments. However, many beginners learning how to play musical instruments have difficulty with rhythm. We have proposed "Stimulated Percussions," which is a musical instrument performance system using electrical muscle stimulation (EMS) in the past. In this study, we apply it to the learning of rhythm. By the movement of muscles stimulated using EMS, users are able to acquire what kind of arms and legs to move at what timing. In addition to small percussion instruments such as castanets, users can play the rhythm patterns of drums that the require the simultaneous movement of their limbs.

CCS CONCEPTS

• **Human-centered computing → Human computer interaction (HCI)**;

KEYWORDS

electrical muscle stimulation (EMS), rhythm, drums

1 INTRODUCTION

A sense of rhythm is indispensable for playing instruments. However, many beginners learning how to play musical instruments have difficulty with rhythm. In some cases, some people hesitate to start playing instruments, because it is difficult to read a musical score and play the correct rhythm. If a player does not understand the rhythm, the player will not be able to performance with confidence, the volume will be reduced, and the tones will change.

With electrical muscle stimulation (EMS), the muscles contract involuntarily and the arms move. By stimulating the muscles according to the rhythm users want to play, EMS can act as a teacher and teach them the rhythm through their own body. There are several studies that have applied EMS to music performance [Tamaki et al. 2011]. We focus on the learning of rhythm and demonstrate rhythm learning as an application of "Stimulated Percussions," which was proposed in a previous study [Ebisu et al. 2017].

2 RHYTHM LEARNING ASSISTANCE BY ELECTRICAL MUSCLE STIMULATION

2.1 Implementation

The basic hardware implementation is the same as "Stimulated Percussions" [Ebisu et al. 2017]. Arduino with a USB-MIDI device[1] was used to control the electrical stimulation generation circuit and generate pulses. The system configuration is as shown in Figure 2.

We implemented a step sequencer user interface that allows users

---

[1] dualMocoLUFA Project Copyright (C) 2013,2014,2015 by morecat_lab https://github.com/kuwatay/mocolufa (last accessed May 16th, 2018)
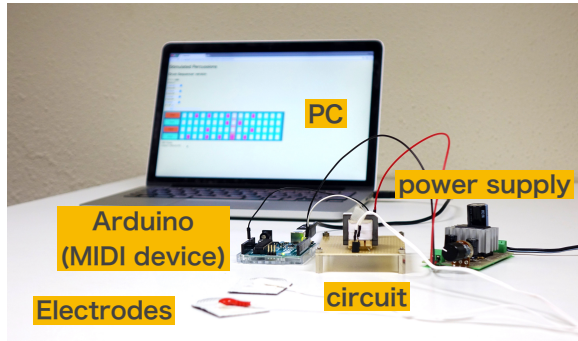
Figure 2: Configuration of the Stimulated Percussions

Figure 3: Screenshot of the sequencer user interface

to enter their own rhythm patterns using the WEB MIDI API (Figure 3). With this UI, it is possible to control multiple Arduinos. In addition, the rhythm input and the ON / OFF of the electric stimulation can be switched to each Arduino. By sending an electrical stimulus before the step is visually indicated, the hitting tone will sound at the timing of the step. Two examples of drum rhythm patterns sent as input to the UI are shown in Figure 4 with the associated score.

2.2 Rhythm Learning Process

Using this system, the muscles move according to the rhythm stimulated by the EMS. As a result, users will remember the timing of the movement. After users are able to remember the movement, the movement can be reproduce without the system. Users repeat this process to acquire rhythm as shown in Figure 1 (a).

By adding EMS while listening to a sound or reading musical notes as a visual aid, the timing of the movement of each limb becomes easy to understand. Once the timing of the movements is learned, it will be easier for users to practice without the aid of this system.

Users who practiced drum performance using this system provided the following feedback. *"By using electrical stimulation, I was able to feel the beat in my body and it is easy to understand when each limb should be moved. When I play the beat, my stroke matches the stimulus if I hit on the timing to hit, so I know that I struck at the correct timing. It felt more fun and easier to hit than when watching a movie of lesson on how to play drums."* "By using electrical stimulation, it was good that I was able to think separately from the rhythm pattern of the foot and hand."

3 APPLICATION

Users can not only learn the rhythm with one hand (Figure 1 (b)) but also the rhythm that uses both arms simultaneously. For example, polyrhythm (2:3, 3:4 etc.) where the right hand and the left hand simultaneously beat different beat are generally difficult rhythms.

In addition, it is possible to learn playing drum rhythms that require a player to not only use the arms but also the feet at the same time. As the order and timing of movement of limbs can be
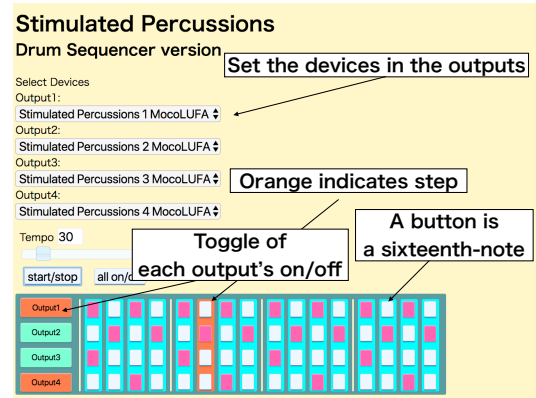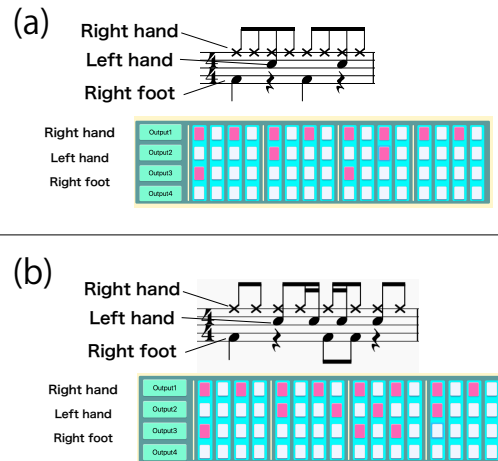

Figure 4: Drums rhythm patterns: (a) Represents eighth note beats, (b) shows shuffle beats

acquired, this system is considered to be effective for a rhythm pattern in which multiple limbs, such as polyrhythm and drums, are separately moved at the same time. Our study shows that this system even work for a user who is a non-drummer and has very little experience with playing musical instruments. By practicing with dozens of minutes of EMS, it became possible to hit eight beats. The user shown in Figure 1 (c) has a little drum playing experience. She was not able to beat patterns such as a changing bass drum pattern. By practicing with Stimulated Percussions, she was able to learn the rhythm.

REFERENCES

Ayaka Ebisu, Satoshi Hashizume, Kenta Suzuki, Akira Ishii, Mose Sakashita, and Yoichi Ochiai. 2017. Stimulated Percussions: Method to Control Human for Learning Music by Using Electrical Muscle Stimulation. In *Proceedings of the 8th Augmented Human International Conference (AH '17)*. ACM, New York, NY, USA, Article 33, 5 pages. https://doi.org/10.1145/3041164.3041202

Emi Tamaki, Takashi Miyaki, and Jun Rekimoto. 2011. PossessedHand: Techniques for Controlling Human Hands Using Electrical Muscles Stimuli. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '11)*. ACM, New York, NY, USA, 543–552. https://doi.org/10.1145/1978942.1979018