Exploring the Myo Controller for Sonic Microinteraction

Alexander Refsum Jensenius, Victor
Gonzalez Sanchez, Agata Zelechowska
University of Oslo, Department of Musicology
Oslo, Norway
[a.r.jensenius, v.e.g.sanchez,
agata.zelechowska]@imv.uio.no

Kari Anne Vadstensvik Bjerkestrand
Oslo, Norway
ka@bodymindflow.com

ABSTRACT

This paper explores sonic microinteraction using muscle sensing through the Myo armband. The first part presents results from a small series of experiments aimed at finding the baseline micromotion and muscle activation data of people being at rest or performing short/small actions. The second part presents the prototype instrument MicroMyo, built around the concept of making sound with little motion. The instrument plays with the convention that inputting more energy into an instrument results in more sound. MicroMyo, on the other hand, is built so that the less you move, the more it sounds. Our user study shows that while such an "inverse instrument" may seem puzzling at first, it also opens a space for interesting musical interactions.

Author Keywords

EMG, micromotion, biosignals, microinteraction

ACM Classification

H.5.5 [Information Interfaces and Presentation] Sound and Music Computing, H.5.2 [User Interfaces] Input devices and strategies.

1. INTRODUCTION

This paper is concerned with very small human motion, and how we can use such *micromotion* in electronic instrument design. We here use micromotion (typically shorter/smaller than 10 mm/s) to denote human motion on the boundary between the voluntary and involuntary. Consequently, *sonic microinteraction* may be seen as the level of control between the conscious and the unconscious [3]. While sonic microinteraction is common in music performance on acoustic instruments, there are fewer examples of the systematic usage of micromotion in electronic instrument design.

The lack of micro-level control in many digital musical instruments may be blamed on technological constraints, but today's interaction technologies are certainly capable of detecting human micromotion [9]. Rather we believe that there may be some self-imposed conceptual restrictions among digital musical instrument designers. It is also a problem that we lack theories and methods for talking about and using the micro-level systematically in digital musical instruments.

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Figure 1: The Myo armband with the sensor numbering according to Thalmic Labs.

In this paper we continue our exploration of human micromotion in general, and sonic microinteraction in particular. While our previous research, to a large extent, has been based on motion capture data [3], this paper is focusing primarily on surface muscle activity, using electromyography (EMG) as the sensing method. Even though acquisition of EMG has become widespread in recent years across a number of research fields, the cost, portability and accessibility associated with existing systems limit their use in interactive applications. Still, there are several examples of using both motion and muscle activity signals for controlling electronics in general [11, 4, 5, 7], and also in musical interaction [6, 1, 10, 8, 9]. Most of these examples, however, are based on recognizing fairly large-scale motion sequences, actions and gestures, and there are fewer studies that have focused on micromotion.

We first present a set of experiments aimed at finding the baseline muscle activity for human micromotion, in different static and dynamic positions, using the Myo armband from Thalmic labs Inc.[1] This commercially available device contains 8 EMG sensors, evenly spaced in a ring around the arm of the user, as well as an inertial measurement unit containing a 3D accelerometer and a 3D gyroscope (Figure 1). Next we present the prototype instrument MicroMyo, and evaluate its usefulness in musical interaction.

2. ANALYSING MICROMOTION AND MICROACTIONS

This section describes two series of small experiments aimed at (1) finding baseline data of micromotion and microactions, (2) examining the precision with which the activity from particular muscles is detected by Myo's electrodes.

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[1] `https://www.myo.com/`

2.1 Retrieving Data

Raw EMG and accelerometer data from multiple Myo armbands was acquired through a program written in Processing.[2] Unitless muscle activation data from the Myo's EMG sensors (8 channels) was recorded and band-pass filtered (zero phase shift, 4th-order Butterworth, 500 Hz low-pass, 10 Hz high-pass cut-off) and full-wave rectified to obtain the envelope of the EMG signals. Similarly, recorded signals from the accelerometer were band-pass filtered (200 Hz low-pass, 10 Hz high-pass cut-off) and full-wave rectified.

2.2 Procedure

2.2.1 *Experiment 1*

Data was gathered simultaneously from three female participants, each wearing a Myo on the right arm. The position of the Myo was consistent for all participants, at approximately 3/4 length of the forearm, with the LED logo (sensor 4, see Figure 1) placed on the dorsal aspect of the forearm.

Six 50-second experiments were conducted with the following scenarios (Figure 2): (a) standing still with arms relaxed, hanging lateral, (b) sitting still on a chair with the feet on the floor, and palms resting on the knees, (c) sitting still, arms extended, held perpendicular pointing ventrally, elbows flexed, (d) sitting still, fists clenched strenuously, arms extended to the front of the body, (e) standing still, slowly raising both arms to the full upward extension, (f) sitting still, palms raised above the knees facing the ceiling, fingertips rhythmically tapping against the tip of the thumb, sequentially from index to little finger, at a frequency of approximately 2 taps/s.

Figure 2: Scenarios for Experiment 1 (from left to right: a–f).

EMG and accelerometer data was recorded for 60 seconds per experiment, and 50 seconds of the recorded data were analysed to identify the baselines and ranges for the EMG and accelerometer signals.

2.2.2 *Experiment 2*

Experiment 2 was aimed at analysing the consistency and repeatability of the EMG data from a standardised Myo position relative to a number of extrinsic muscles located in the forearm. Data was gathered from two participants, one male and one female. The positioning of the Myo on the right forearms of the participants was based on specific arm landmarks following the identification of the muscles of interest from the literature [2]. With the wrist extended, the location of the extensor digitorum was identified on the top of the forearm of both participants and it was aligned to sensor 1 as a reference muscle. The following sensors (2–8) were aligned clockwise, in line with the manufacturer's numbering (Figure 3).

Figure 3: Placement of the Myo for Experiment 2.

The experiment consisted of two main scenarios: (1) sitting next to the table with the right arm resting on the tabletop, (2) standing still with arms relaxed and parallel to the axis of the body. In each scenario, six actions were tested (Figure 4): (a) finger extension, (b) finger flexion, (c) wrist flexion, (d) wrist extension, (e) ulnar deviation, (f) radial deviation. Each action lasted for approximately 3 seconds and was repeated three times. Two recordings of each action in both scenarios were analysed. EMG signals from the Myo were assessed based on the placement of individual sensors relative to identified extrinsic arm muscles.

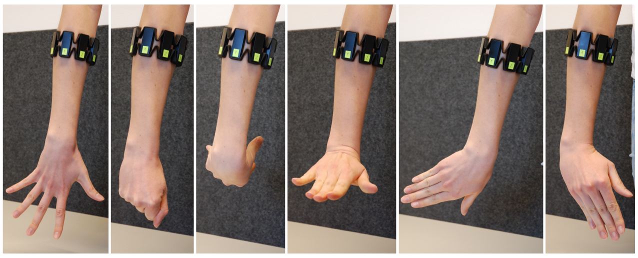

Figure 4: Scenarios for Experiment 2 (from left to right: a–f).

The overall amount of muscle activity used throughout each trial was determined by calculating the mean magnitude of the filtered EMG signals from the 8 channels.

2.3 Results

2.3.1 *Experiment 1*

Descriptive statistics from the filtered EMG signals were used to characterize the baseline and ranges used for implementation in the prototype instrument (Table 1). Analysis of variance was performed on the EMG data and showed no statistically significant differences between means across participants ($p < 0.005$).

Table 1: EMG results (mean, standard deviation and maximum values) for three participants across all tasks in Experiment 1 (unitless values).

Task	Mean	Std	Max
FingerTip	0.64	0.68	5.44
Fist	0.71	0.64	4.72
Raising Arms	0.17	0.23	1.60
Sitting Arms Extended	0.20	0.25	1.38
Sitting Still	0.08	0.07	0.41
Standing Still	0.05	0.02	0.19

Data from the accelerometers was shown to be less sensitive to the selected types of actions, with unclear patterns across tasks and participants. However, the EMG data reveals activation patterns related to the type of task, with 'standing still' and 'sitting still' having a consistently lower magnitude of muscle activation signals when compared to the 'fist' and 'raising arms' activities (Figure 5).

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[2] `https://github.com/vicgos/Micromotion1/`

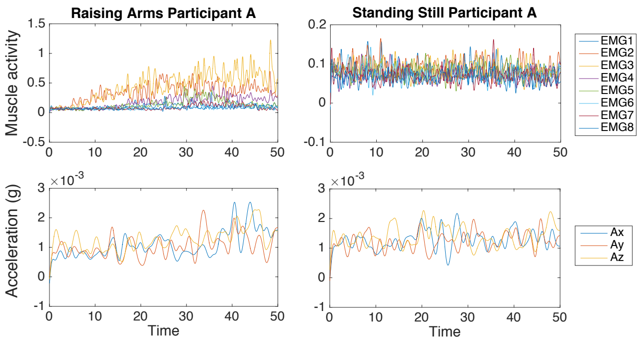

Figure 5: Filtered EMG (unitless activation) and accelerometer (g) curves from participant A. Left: 'raising arms' task. Right: 'standing still' task.

2.3.2 Experiment 2

A two-sample t-test was used to estimate differences between the averaged EMG samples extracted from both participants in all scenarios. No significant differences were observed between participants across tasks. Analysis of variance was used to assess statistically significant differences between EMG channels across tasks ($p < 0.005$), with results showing statistically significant differences for both 'Wrist Extension' conditions (Table 2).

Table 2: p-values from ANOVA for all tasks.

Task	F	p-value
Finger Extension/Standing	6.57	0.0082
Finger Extension/Table	5.05	0.0182
Finger Flexion/Standing	3.53	0.0489
Finger Flexion/Table	2.34	0.1281
Radial Deviation/Standing	1.10	0.4448
Radial Deviation/Table	4.93	0.0197
Ulnar Deviation/Standing	0.57	0.7647
Ulnar Deviation/Table	2.52	0.1098
Wrist Extension/Standing	26.85	<0.001
Wrist Extension/Table	18.60	0.0002
Wrist Flexion/Standing	2.81	0.0856
Wrist Flexion/Table	5.34	0.0156

In order to identify differences between specific pairs of means, a multiple comparison test was conducted for all tasks. Results from the multiple comparison of means show that sensors 1 and 8 had statistically significant larger muscle activation magnitudes in tasks involving flexion and extension. 'Ulnar deviation' and 'radial deviation' tasks, however, had small differences across sensors, as shown by the high p-values observed from ANOVA (Table 2, Figure 6).

3. THE MICROMYO PROTOTYPE INSTRUMENT

3.1 Conceptual idea

The conceptual idea of MicroMyo has been to develop an instrument that "forces" the user to slow down and explore one's own micromotion and muscle activity. To achieve this, we have focused on creating mappings that explicitly discourage large-sized actions. As such, MicroMyo is quite different from "normal" instruments in which motion and/or force is applied to produce sound. Here it is the opposite; motion will effectively silence the instrument, while sound will gradually appear when the user comes to rest. This helps the user to focus on detailed sound-modification through muscle activation, as well as through some effects controlled by (slow) arm rotation and lifting. While the instrument is sensitive enough for solo performance, the current mappings are mainly targeted at installation usage, during which people will be able to create interesting sounds in a short amount of time.

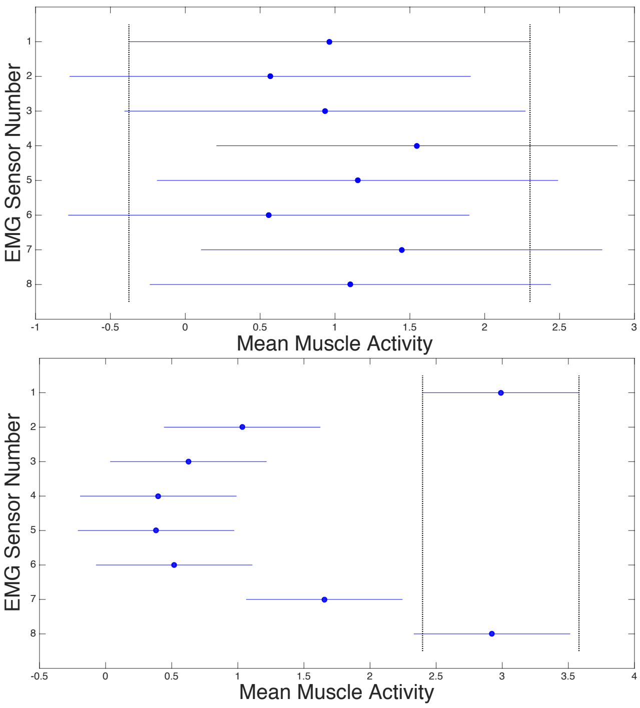

Figure 6: Multiple comparison of means. Mean EMG and confidence interval for significant differences. Top: 'ulnar deviation' (standing). Bottom: 'wrist extension' (standing).

3.2 Implementation

MicroMyo is developed in Max,[3] using the third-party external `myo` for interfacing with the armbands.[4] The patch is currently set up for the use of four Myos at the same time, which seems to be the maximum number of devices we can connect to one computer (MacBook) without too many connection problems.

An overview of the mappings are shown in Table 3. Each Myo controls an individual sound engine, built around an oscillator bank (`oscbank~`). The timbre is controlled with muscle activation, mapping data from the eight EMG sensors to the amplitudes of the eight sound partials. Since all the EMG signals have a similar range, we scale the values by a decreasing constant (1.0–0.2) for each partial, to secure a well-balanced tone. The amplitude of the sound is inversely controlled by the quantity of motion, so that larger quantities of motion generate smaller sound amplitudes. The quantity of motion is calculated as the first derivative of the magnitude of the accelerometer data. The pitch of the tone (F0) is controlled by arm rotation, while moving the arm up/down will modify a subtle reverb effect.

All of the control elements in the sound engines have switches between continuous and discrete mappings (implemented with `speedlim`) on the incoming control signals. This allows for switching from (a) full continuous control of all parameters, to (b) a discrete and sequencer-based sound control. We have deliberately not implemented any possi-

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[3] `https://github.com/alexarje/MicroMyo/`

[4] `https://github.com/JulesFrancoise/myo-for-max/`

Table 3: Mappings from action to sound

Sound effect	Motion/force	Sensor
Timbre	Muscle tension	EMG (individual)
Amplitude	Arm motion (inverse)	Accel. (XYZ)
Pitch	Arm rotation	Accel. (Y axis)
Reverb	Arm lift	Gyro (Z axis)

bility to switch between these modes during performance, as we do not want the instrument to "change" in operation. Rather, the different modes allow for reconfiguring the setup for different types of users. The continuous mode is probably more interesting for experienced performers, while the discrete modes sound more "popular" and would fit a younger installation audience better.

3.3 Testing and Evaluation

The instrument has been tested by individuals as well as in small groups. We have tried different types of speaker setups, ranging from individual speakers for each performer to using spherical speakers (Figure 7). The latter has worked particularly well when performing in groups, since it creates a visual and sonic focal point, while at the same time allows for each performer to get localised sound.

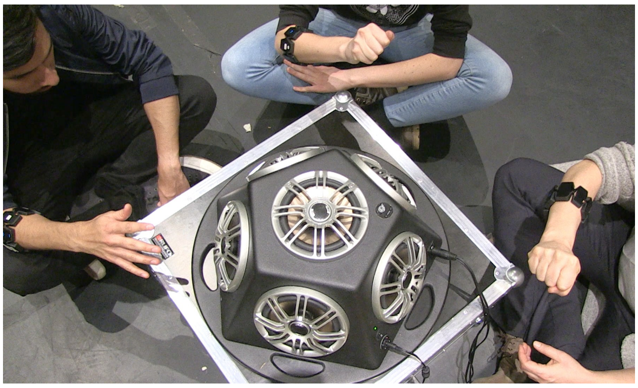

Figure 7: Group improvisation with MicroMyos.

Testing has shown that the current mappings are consistent and reproducible. Different performers are able to put on the armbands and get full control over the instrument within seconds, without any type of calibration. Fortunately, both the temporal and spatial sensitivity of the armbands are high enough to achieve microinteraction, and all users have commented on the feeling of being in control of the sound production and modification. While we first thought that users would find it odd to control sound production by not moving, this has actually not been a problem. Rather, users have commented that exactly this feature is what makes the instrument interesting to play with.

4. CONCLUSIONS AND FUTURE WORK

The paper has shown the Myo armband's potential as a controller for sonic microinteraction. The results from the baseline experiments provide developers with a basic understanding of the Myo's raw signals extracted from standardised sensor placements, and show the potential use of simultaneous acquisition from multiple armbands.

The prototype instrument MicroMyo is built around the idea of "inverse" sound-producing actions, that is, the less you move the more sound you create. This may seem odd at first, but has proven to be exciting to work with musically. It also forces the user to slow down and focus on using muscle activation to control the sound.

There are numerous elements to improve in future versions of the instrument, including:

- further characterization of Myo's signals, using data from larger samples and in-depth comparison between sitting and standing conditions
- extending the setup to include more than four performers
- developing more (advanced) interaction modes
- more systematic musical exploration and testing
- more performances and installations

Nevertheless, MicroMyo has still proven that playing with very little may create exciting musical interaction.

5. ACKNOWLEDGEMENTS

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