Sounding Feet
Sonifying Foot Pressure for Dance

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ABSTRACT

The project *Sounding Feet* explores the creative possibilities of interactively controlling sound synthesis through pressure sensitive shoe inlays that can monitor minute body movements. This extended abstract provides a brief overview over early experiments in designing pressure sensitive shoe inlays, the mapping of pressure values to two different sound synthesis models, and the testing of the setup in an improvisational setting with two dancers.

CCS CONCEPTS

• **Human-centered computing** → *Interaction design process and methods*; *Gestural input*; • **Applied computing** → *Performing arts*; *Sound and music computing*;

KEYWORDS

Dance Technology, Interactive Sonification, Music and Movement

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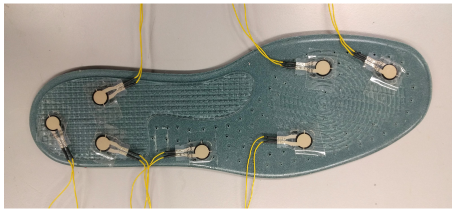

Figure 1: Sensor Placement. Seven force resistive sensors are taped on a shoe inlay.

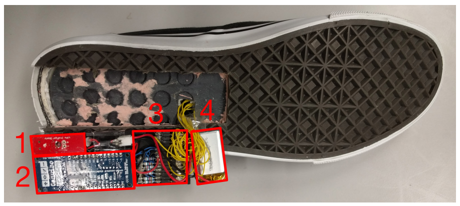

Figure 2: Integrated Electronics. The electronics are tilted away from the cavity in the shoe sole into which they are normally integrated. The electronics consist of 1) battery charger, 2) micro controller 3) voltage dividers 4) LiPo battery. The shoe depicted here is an early prototype.

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INTRODUCTION

The project *Sounding Feet* explores how small postural changes can be used to control music. From an artistic point of view, such an interactive relationship is interesting since it links the musical outcome of interaction to the proprioceptive awareness of a dancer and it exposes to an audience through the auditory modality a dancer's minute movements that might be visually hidden. The project follows an approach that combines musical ideation, dance improvisation, interaction design, and engineering. Through this combination the development and design decisions (e.g. the characteristics, number and position of force resistive sensors) can be informed by artistic criteria.

PRIOR ART

The study of the pressure distribution between the plantar surface of a foot and a supporting surface forms part of the field of Pedobarography. Several examples exists that employ sonification to render the analysis of foot pressure audible. But most of these examples employ only a small number of force sensors and use mappings for simple sound triggering. This limits their usefulness for creative purposes in music and choreography. In the context of this project, the following examples are notable. The project entitled *SONIGait* [2] employs shoe inlays that are equipped with seven force sensors. These inlays are employed to sonify gait via a variety of different sound synthesis models with the ultimate goal of developing a system for rehabilitation. An earlier project [1] combines two force resistive sensors in shoe inlays with inertial measurement units and goniometers. The sonification of the sensor values through sound synthesis is evaluated with respect to its effectivity for dance teaching. A recent project [3] that involves artists, scientists and engineers explores how a combination of wearable sensors including pressure sensitive shoe inlays can be employed for therapeutic approaches.

HARDWARE

Within this project, of a pair of pressure sensitive shoes with integrated electronics for wireless communication via Wifi has been developed. The criteria for the hardware design were as follows: high sensor sensitivity to small forces, easily reconfigurable sensor placement, integration of all electronic components into shoes to avoid hindrance of movement, and high frequency (50 Hz) and low-latency wireless sending of sensor data. The hardware consists of a shoe inlay onto which seven force resistive sensors are reversibly taped (see figure 1). The sensors (FlexiForce Model ESS301) have been chosen due to their robustness and low force range (4.4 Newton). High robustness seems crucial for prolongued sensor use under stressful dance conditions. High sensitivity to small forces enables the detection of small changes in body balance. The electronics (see figure 2) consists of a micro controller (Arduino MKR1000), a Lithium Polymer battery (350 mAh), a battery charger (SparkFun LiPo Charger Basic), and a set of voltage dividers (14 kOhm resistors). All these components are fully integrated into a cavity between the foot bed and the shoe sole.

Figure 3: Dancer A controls with small movements a subtractive sound synthesis model

Figure 4: Dancer B controls with large movements an additive sound synthesis model

SONIFICATION

Sonification of sensor data is based on two models for vocal sound synthesis that have been developed in the Supercollider programming language. One model employs additive sound synthesis, the other subtractive sound synthesis, and both models are combined with wave shaping techniques. These vocal sound synthesis models have been chosen since they can produce a wide range of sonic results.

For controlling sound synthesis a simple parameter mapping scheme is employed. Either each individual force sensor value or all force sensors values of one shoe combined are mapped on synthesis parameters. The first approach aids in the audible distinction of different pressure distributions across each foot whereas the latter part simplifies the distinction between left and right foot activities. Some of the synthesis parameters used for mapping are: vibrato, tremolo, formant frequencies, formant bandwidths, and resonant frequencies. The mapping also controls audio spatialisation in an octophonic speaker array where the directionality of the sonic output controlled by each sensor corresponds to the relative location of the sensor with respect to the center of the shoe inlay.

IMPROVISATION

Two different dancers, one at a time, were allowed to experiment through improvisation with different relationships between feet pressure and sonification. Four short video excerpts of these improvisations are available online: Dancer A controls with small movements a subtractive synthesis model [1](see figure 3), Dancer B controls with small movements an additive synthesis model [2], Dancer A controls with large movements a subtractive synthesis model [3], Dancer B controls with large movements an additive synthesis model [4](see figure 4).

[1]https://vimeo.com/257548604/196df294e3

[2]https://vimeo.com/257550554/6c3b75d9f9

[3]https://vimeo.com/257546657/329c89de07

[4]https://vimeo.com/257549875/1ac8d9b6b2

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