De-MO : Designing Action-Sound Relationships with the MO Interfaces

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Abstract
The *Modular Musical Objects* (MO) are an ensemble of tangible interfaces and software modules for creating novel musical instruments or for augmenting objects with sound. In particular, the MOs allow for designing action-sound relationships and behaviors based on the interaction with tangible objects or free body movements. Such interaction scenarios can be inspired by the affordances of particular objects (e.g. a ball, a table), by interaction metaphors based on the playing techniques of musical instruments or games. We describe specific examples of action-sound relationships that are made possible by the MO software modules and which take advantage of machine learning techniques.

Author Keywords
Music; Digital Art; Sound; Technology; Interactive; Interface; gesture; HCI

ACM Classification Keywords
H.5.5 [**Sound and Music Computing**]: Methodologies and techniques.

General Terms
Design, Experimentation, Performance, Human Factors

Introduction

Research on new musical interfaces has grown substantially over the last ten years, fueled by the increasing availability of motion sensing devices and electronics. Nowadays, game interfaces (such as the Wiimote and Kinect) and mobile technologies can easily be adapted to create tangible or motion based interfaces. Nevertheless, the interaction design linking bodily action to sounds is often limited to the triggering of musical events (i.e. MIDI notes, sound samples) or to simplistic mappings from sensor data streams to sound synthesis parameters simulating knobs and sliders control. As pointed out by several researchers [4], concepts such as sound embodiment or sound imagery can lead to apprehend action-sound relationships at a higher cognitive level. An ocean wave, a shaker, a rainstick, and a bouncing ball are examples that illustrate how we can spontaneously associate objects and actions, motion and sound.

We developed hard- and software modules, called MO, to support the exploration and experimentation with such action-sound associations. This demonstration will focus on the software modules that integrate machine learning techniques, digital signal processing, and simple physical models. Extracting expressive features from sensor data and from recorded sound materials, the MO software modules allow for creating interactions between motion/touch and sound textures/musical structures.

Related Works

Research topics related to musical interfaces based on motion and touch are comprehensively covered by the NIME conferences. The focus of our contributions concern specifically the development of software for gesture-based interactive audio synthesis. An important aspect of our approach concerns the use of machine learning techniques, such as gesture recognition [1] and the automatic analysis of recorded audio content [9]. Such an approach seems to have gained recent interests, and some new systems have been made available. Among several examples, the Wekinator [2] is an free software package to facilitate rapid development of and experimentation with machine learning in live music performance and other real-time domains. The SARC EyesWeb Catalog (SEC) is a machine learning toolbox that has been developed for musician-computer interaction [3].

MO - Modular Musical Objects

The Modular Musical Objects (MO) represent an ensemble of both, hardware and software components [6, 7][1]. Each sound can be linked to a physical action, performed with a tangible interface or free body movements. As briefly described below, the MO hardware and software modules are designed to support such an approach.

Wireless Interfaces

In collaboration with NoDesign.net and Da Fact, wireless interfaces that allow for motion and touch sensing were designed and built. The main *MO atom*, as shown in Fig 1 contains a 3D accelerometer and 3-axis gyroscope, two buttons and 9 LEDs. Additional sensors can be added to both extremities using a I^2C bus, such as piezo sensors through the use of dedicated *MO accessories*. The wireless transmission is performed using the IEEE 802.15.4 protocol (Zigbee belongs to this protocol) to a receptor that communicates via OpenSoundControl (OSC) with a host computer running the MO software modules.

[1] Originally created by the Interlude consortium, the MOs were presented in the exhibition *Talk to Me* on communicating objects at the New York Museum of Modern Art (MoMa), and won the Margaret Guthman Musical Instrument Competition in 2011

The *MOnano* is a bare and smaller version of the *MO atom* , without any push buttons or LEDs for visualization.

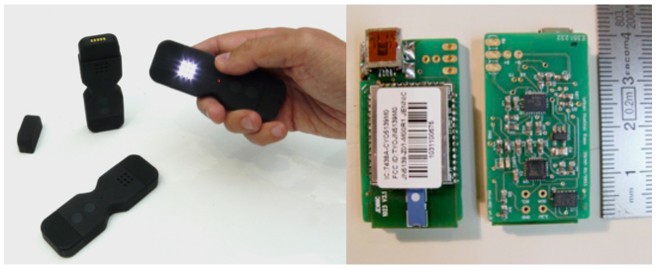

Figure 1: left: MO interface, right MOnano interface.

Software Modules

The MO software modules implement various algorithms for the real-time processing of motion data and sound. They are integrated into the Max environment[2] using the MuBu library [8].[3] Standard signal processing techniques can be used for computing low level features such as the average accelerometer intensity and kick detection from raw accelerometer and gyroscope data. More sophisticated analysis techniques involve machine learning techniques such as k-NN and Hidden Markov Models [1]. The sound synthesis is mainly based on the analysis and annotation of recorded sounds. Generally, sounds are segmented and each segment is characterized through a set of sound descriptors (i.e. energy, pitch, and timbre). Various resynthesis techniques, for example granular or concatenative synthesis, are then applied to the annotated sounds.

[2]http://cycling74.com/

[3]The MuBu modules are freely available through the IRCAM Forum at http://forumnet.ircam.fr/product/mubu/

Scenarios

In this section we shortly describe some examples of the motion-sound relationships.

Grain Stick

In this scenario, initially developed for an interactive sound installation by Pierre Jodlowski, a MO hardware module is combined with an object that can act as a rainstick (e.g. a tube or a stick). Tilting the object provokes a cascade of small sound events like the particles inside a rainstick. The scenario can use pre-annotated materials or live recorded sound that are automatically segmented and analyzed to re-synthesize granular sound textures controlled by the movements of the sensor module.

Sound Shaker

Here, shaking an object (with an embedded sensor module) creates rhythmic patterns like a shaker or maracas. Originally designed with vocal beat-boxing sounds, this scenario works with any recorded sound. The sound material is automatically segmented into percussive sound events and recomposed to form rhythmic sequences depending on the shaking intensity.

Sounding Surface

In this scenario, the user plays on the surface of a table. Different gestures and touch qualities, such as caressing or scratching, are detected through a machine learning algorithm and mapped to corresponding sound textures from a database of recorded sounds.

Throw a Ball

A ball has strong affordances that could invite for a large range of musical applications. We designed several scenarios where sound illustrates the ball trajectory or where musical sequences are generated according to the passes in a multi-player game (as described in [5]).

Figure 2: *Top-Left:* GrainStick *Top-Right:* Sound Shaker *Bottom-Left:* Sounding Surface *Bottom-Right:* Throw a Ball (Photos: Nodesign.net)

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