Hexapad: A Piezo-Based Instrument to Create and Perform with Ten Discrete Channels of Audio Using Non-Traditional Instrument Interaction Methods

ABSTRACT

Multi-channel music compositions are able to create interesting and exciting spatial effects that exceed the potential of music in stereo. However, capturing live audio for use beyond stereo is difficult due to the fact that most electronic instruments, such as electronic keyboards and synthesizers, only output two independent channels of audio. To capture audio in up to ten channels, a piezo-based microphone array has been created that can be played in a multitude of ways to capture ten independent streams of audio. This device has been named the "Hexapad Controller" or "Hexapad" for short. The Hexapad allows a performer to excite up to ten piezo microphones in non-traditional methods when compared to conventional musical instrument interaction; this can be with a brush sweeping across the piezos or any other interaction method a performer can devise. The Hexapad is modular in that it is able to incorporate different objects laser cut from wood to be placed over the piezos for different interaction methods.

1. PRIOR WORK

Contact microphones have been used in experimental music for many decades. For example, John Cage used record player cartridges as contact microphones from as early as 1960 with his *Cartridge Music*. In this work, performers were requested to insert various objects into record player cartridges. Objects previously inserted include "pipe cleaners, matches, feathers, wires," etc. [1]. Later, after the discovery of new kinds of piezoceramic materials, "piezo" sensors became more prevalent and became more frequently integrated into experimental music practice. Such practices and methods are described in a chapter of Nicholas Collins' book [2].

More recently, the Pebble Box [3] has been an example of a previously designed device to facilitate sonification of parameters captured by interaction with physical materials. Similar to the Hexapad, the Pebble Box uses a small microphone embedded into an object, in this case a box, that can be interacted with in any non-specific way to generate audio signals from interaction with the microphones. Other instruments have used piezos to excite digital waveguide models of strings. For example, Berdahl and Smith made such an instrument with a small number of strings [4], and Schlessinger and Smith made another instrument the Kalichord with a larger number of strings [5]. In addition, [name anonymized] is currently working along these lines with percussion-based instruments.

Percussive gestures made to contact microphones are of particular relevance. This concept is also explored in the paper "A Comparison of Sensor Strategies for Capturing Percussive Gestures," which explores research and evaluation of the current strategies for capturing percussive gestures [6]. One of the technologies evaluated is piezo microphones. This paper concluded that *piezos can be effective if they are isolated from other piezos and their impact locations to minimize the vibrations or nearby strike zones.*

Contact microphones can also be used for amplifying string vibrations. Piezo pickups are commonly used with acoustic guitars, and some related approaches are discussed on a paper on augmenting an electric cello. This project also used MasMSP to give a performer gesture control with a digital interface [7].

2. HEXAPAD

2.1 Overview

The main focus of the Hexapad is to have a multichannel piezo-based instrument that can generate signals at an audio sampling rate for spatial audio applications. The Hexapad accomplishes this by making use of ten piezo microphones each mounted to the device. To avoid direct contact with each microphone, a pad of neoprene sits above each piezo (see Figure 1). The pads also aid in isolating each piezo from one another effectively reducing unwanted vibrations from neighboring piezos. Each piezo is wired to its' own individual audio output connector to be plugged into any audio device that supports audio input.

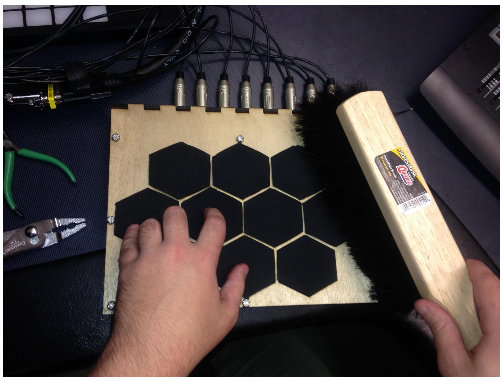

Figure 1. Performers can easily play the Hexapad using the fingers or a brush.

2.2 Modularity

The Hexapad is constructed in a modular fashion. This makes it possible to substitute out the neoprene pads, which are used by default, and to replace them with other laser-cut hexagonal pieces. Then, any percussion-like implements desired can be attached to the replacement hexagonal pieces. This allows for quick, on-the-fly substitution of components connected to the piezos, and they could even be substituted in the middle of or as part of a performance.

In the demonstration video for this project, hexagonal pieces are shown that have screw-eyes inserted into them. This enables for mechanical interaction with the screw eyes instead of neoprene pads. In any case, the mechanical construction of the hexagonal pieces affects the timbre, so it can be desirable to utilize different materials in different circumstances. A demonstration video can be viewed below. [1]

3. INTERACTION METHODS

3.1 Fingertips

Using one's fingertips on the pads is a percussive way of interacting with the Hexapad, similar to the percussive interaction discussed in [6].

3.2 Brush

Using a brush like the one pictured in Figure 1 is the primary way that the first author interacts with the Hexapad. Dragging the brush around creates an image in the speakers that mirrors the brush's direction of motion when multiple outputs are mapped to multiple speakers. The audio created is an interesting grinding sound similar to scraping objects along a rough surface.

3.3 Snare Cables

Using different cut-outs with screw eyes for the Hexapad allows for the use of snare cables as an interaction method. These cut-outs have rings drilled into birch wood that the performer can drag snare cables through to transfer vibrations to the piezos. Similar to the brush, dragging the cables through these rings creates movement of the sound sources in the speakers when the outputs are mapped to multiple speakers. The timbre of the sound is similar to metal scraping against other metal surfaces.

3.4 Springs and Casters

The authors have also attached springs and miniature caster wheels to the hexapad. Rolling the casters produces a familiar sound that nonetheless does not precisely repeat. In contrast, the plucking of a spring (not shown here) results in a somewhat more eerie sound.

4. VIII TRACTUUM

The Hexapad can provide audio signals to excite DSP flow diagrams. For example, in the work *VIII Tractuum* by the first author, the Hexapad is used to feed into a network of delay lines. Eight piezos are used as inputs. The signal from each of these piezos is fed to its own feedback delay loop, from there into a digital waveguide for potentially imbuing the signal with a pitch, and from there to its own loudspeaker. Therefore, in concert, *VIII Tractuum* is connected to eight different loudspeakers. As the performer moves the brush around the piezos, rhythms are created in time and in space.

5. CONCLUSIONS

Contact microphones have long been used in experimental music, but they have usually been used in a simple fashion for sonifying vibrations. The Hexapad on the other hand, pushes the concept of a contact microphone to a whole new level. It captures the sound vibrations in a variety of independent axes, and its modular construction allows for many new ways of capturing audio in multiple channels. These signals can then be used in a multitude of ways to synthesize sound, realize new instruments, realize measurement equipment, and more. Ultimately, the authors believe that the Hexapad will enable a series of new music compositions to be created, of which *VIII Tractuum* is the first.

6. REFERENCES

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