The soniCube: A New Instrument for Explore Timbre

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ABSTRACT
The majority of instruments commonly used allow musicians to manipulate three parameters of a note: volume, pitch and sustain. Many other qualities of sound remain constant. In particular, the timbre of most instruments seldom differs, and is limited by physical constraints. In order to allow for timbre to be explored in an instrument, we designed the soniCube, which maps exploration in a physical space to variation in the timbre space. The interaction of the soniCube emphasizes changing timbre expressively, while allowing for other manipulations common to instruments.

The soniCube is played with two hands while moving around in an X,Y plane. These two interactions allow control of the onset and pitch played, as well as a wide range of timbres to be expressed in one instrument.

Keywords
NIME, timbre, additive synthesis, infrared, accelerometer, demonstration, instrument, wireless

INTRODUCTION
Inspiration for this project came out of a desire to understand and explore the abstract idea of timbre. This project attempts to create an intuitive and simple interface for a user to discover what colors a sound, and find new timbres that lie between pre-defined ones. Overall, the main goal of this project is to create an instrument that is easy to use and provides an interesting timbre-space for a user to explore.

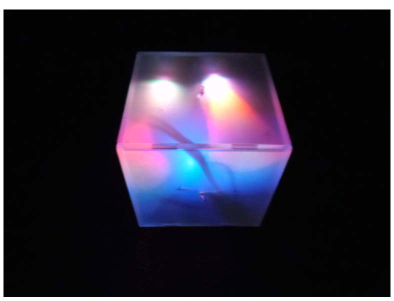

Figure 1: The soniCube in its on state, with visual feedback on orientation

DESIGN
Hardware/Physical Design
The instrument consists of three components: the soniCube, a Nintendo Wiimote, and a bluetooth-enabled computer.

The soniCube is controlled by the Arduino Nano ATmega328 microcontroller. It receives inputs from a 3-dimensional accelerometer, and outputs the values to the computer via a BlueSMiRF Silver Bluetooth modem. Firmware on the Arduino also controls six 940 nm infrared LEDs, four RGB LEDs, all powered by a 5 volt power source. The case of the soniCube is a frosted plastic cube with 4-inch sides; on each face is a single IR LED protruding from the center, orthogonal to the face. The IR LEDs are detected by the Wiimote to give the XY position of the cube in an explorable space (see software). Inside the soniCube are four RGB LEDs that provide visual feedback based on the current readings of the accelerometer. The accelerometer readings are also transmitted via the Bluetooth modem to a Bluetooth-enabled computer.

The Wiimote is used as a Bluetooth-enabled infrared camera. This device was selected primarily for how inexpensive--in terms of time and money--it was to incorporate. The Wiimote is paired over Bluetooth with the same computer.

We use a MacBook running OSX 10.6, but other operating systems could be used instead.

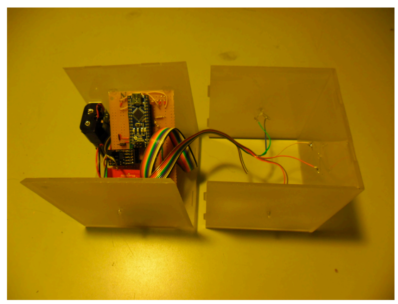

Figure 2: The soniCube electronics were enclosed in a cube, which used the Arduino platform to handle I/O

Software
When the Wiimote detects an IR light it sends the X,Y position of the source to the computer. A program called Osculator is used to pass these locations as OSC (Open Sound Control) messages to Pd (Pure Data.) Pd also receives and parses the serial messages that are being sent from the Arduino inside the soniCube. Pd synthesizes sound based on readings from the accelerometer and the X,Y position of the soniCube within the Wiimote's field of view.

Interaction
The main controls for the soniCube involve the cube enclosure for the arduino and sensors. Each of the six faces of the cube are mapped to a fundamental frequency, which determines which note is played on onset. The pitch produced is determined by which face is upward, allowing for six different frequencies to be played. In order to provide visual feedback on the current note which will be played, a RGB LED produces a different color for each side of the cube. Using the accelerometer, jerk detection is used to determine the node

onset.

During performance, a Wiimote installed facing the performance floor tracks the position of the cube. This allows for the soniCube performer to walk around the space in the view of the Wiimote, with the position of the performer being communicated via IR. The position then is mapped to the timbre that the soniCube produces on onset. This interaction allows for the exploration of a physical space to be mapped to one in the timbre space.

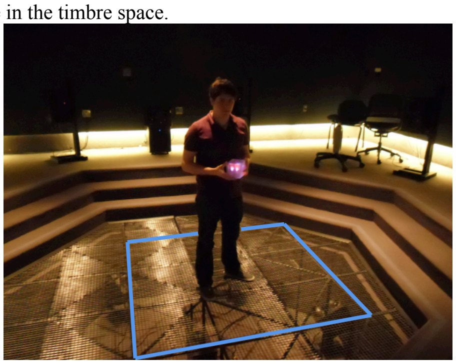

Figure 3: Typical performance setup, with soniCube and Wiimote suspended above (not pictured). The soniCube timbre maps to a 1.5 by 1.5 meter horizontal plane, highlighted in blue.

Sound Design

The synthesized sound in this project has three major components: pitch, timbre, and onset. Pitch is established by the local orientation of the cube, with a fundamental frequency for each face. After initializing the accelerometer to "home" position, thresholds are used to determine which side is facing up, and thus the fundamental frequency. In parallel, the Wiimote communicates the X,Y position of the soniCube to the computer, which uses the information to define the timbre.

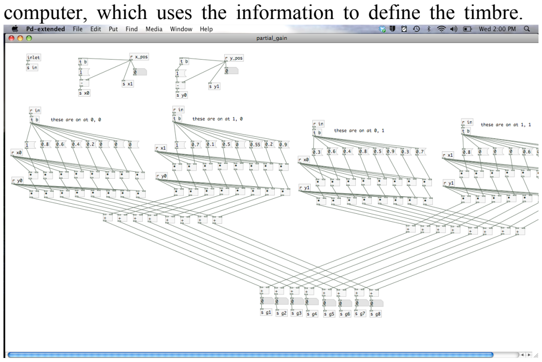

Figure 4: Partial gains patch, showing the mapping of X-Y position to timbre

The timbre space used in this project uses these X,Y values to control a multitude of variables: the gains of the harmonic frequencies, the envelope of the sound, reverberation, and distortion. In each corner of the explorable space is a defined timbre, with set values for each of these variables. As the user moves within the space, the mapping chooses intermediate values to define the timbre. To be more specific, the gains of the harmonic frequencies are mapped linearly between the four points, as are the predefined envelopes. Reverberation is mapped such that it is more sensitive to a change in Y (falls off as distance squared), while distortion is really only defined around a specific corner. As the user moves through space and turns the cube to different faces, the computer constantly updates the current pitch and timbre, and only triggers the sound when an onset is detected. This onset is determined by a jerk of the cube. By filtering the accelerometer signal and applying thresholds, the soniCube only triggers an onset with a quick change in acceleration.

CONCLUSIONS

We designed a physical instrument to enable users to explore a rich timbre space in an intuitive way. Users control the parameters of an additive synthesizer and several digital effects by making gestures and moving in the horizontal plane. This affords a more intuitive and illuminating way to interact with music.

FUTURE WORK

One of the greatest difficulties we encountered in designing and performing with the soniCube was receiving consistent and clean readings from the infrared LEDs. Because of the narrow viewing angle of the IR LEDs, many orientations of the soniCube result in the device being invisible to the IR camera. Furthermore, there are many common sources of IR light that can interfere with the performance, including spotlights, cameras, and natural light. Because IR light is invisible to the naked eye, it is particularly difficult problem to troubleshoot. These two problems could be addressed by using a greater number of cameras and by emitting and detecting a characteristic pulse from the IR lights.

For performance, one direction we considered was extending the use of visual feedback for the user. In addition to indicating which face was being expressed, LEDs could also be used to direct performers to the next note in a song, by providing some visual indication of the next orientation to rotate to. Furthermore, we considered the possibility of encoding songs as paths on the soniCube, where performers could follow a drawn path in order to play a song.

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