The Sound of Touch: A Wand and Texture Kit for Sonic Exploration

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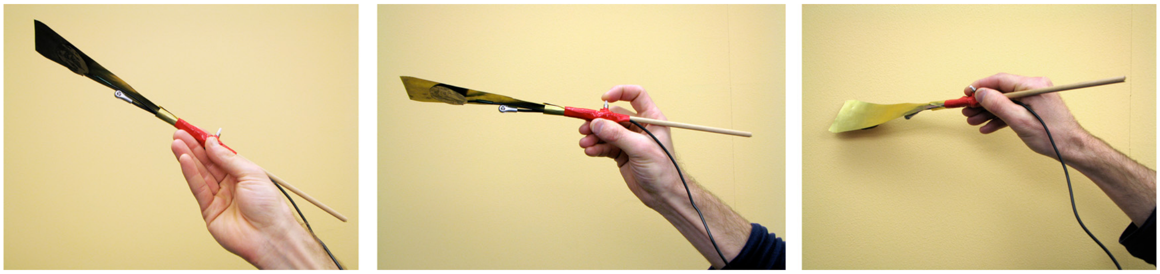

Figure 1: *Capturing and painting with sound onto a smooth texture*

Abstract

In this paper we describe the Sound of Touch, a new instrument for real-time capture and sensitive physical stimulation of sound samples using digital convolution. Our hand-held wand can be used to (1) record sound, then (2) brush, scrape, strike or otherwise physically manipulate this sound against physical objects. These actions produce sound in a manner that leverages peoples existing intuitions about sonic properties of physical materials. The Sound of Touch permits real-time exploitation of the sonic properties of a physical environment, to achieve a rich and expressive control of digital sound that is not typically possible in electronic sound synthesis and control systems.

CR Categories: H5.2 [User Interfaces]: Interaction Styles

Keywords: digital sound manipulation, tangible user interface, electronic music controller, sensing, digital convolution

1 Introduction

Sound exploration and musical activity have been a continual companion to humankind for thousands of years. The desire to expressively create sound in real-time takes advantage of available materials and technologies. Striking together, grinding or breaking objects found in nature is perhaps the simplest way to generate sound deliberately, and was likely the original manner in which materials were leveraged by people to sculpt sounds. However, evidence of hand-crafted musical instruments have been discovered dating as far back as 9000 years ago [Zhang et al. 1999], suggesting that people have long been interested in ways to control musical sound in more articulate ways, by blowing, bowing, striking, picking, plucking and fretting their instruments. The wide range of acoustic instruments that musicians use today, from horns to strings to percussion and more, demonstrates the intellectual energy that has been expended throughout the years to craft better ways to explore and control sounds.

People have a lot of experience listening to the sounds produced when they touch and manipulate different materials. We know doing the action what it will sound like to bang our fist against a wooden door, or what a coffee mug will sound like if it is dropped onto a concrete floor. These intuitions are useful when we want to create a particular sound with objects in our environment, and they can guide exploration if we just to play and experiment with new sounds.

In the last 100 years the growth of electronics and more recent digital technologies have opened up vast new areas of technique for creating and manipulating sounds. Arbitrary waveforms can be synthesized with electronics, making it possible to artificially generate a sound that mimics an acoustic instrument, or that sounds like no acoustic instrument that ever existed.

With found objects and acoustic instruments, the control interface and the sound production mechanism are one and the same - they are the object itself. A drum head vibrates when struck, and a guitar string vibrates when plucked. The relationship between a player's gesture and the resulting sound in an acoustic device is fixed by the physics of the resonant element, whether it is a string, a membrane or a column of air. An electronic instrument however, can be built to implement an arbitrary 'mapping' between gesture and sound, a decoupling that had never before been possible. Moreover, the sound produced by an electronic musical instrument need not (and typically does not) correspond at all to the physical materials that the instrument is built from. This decoupling of control affordances from the synthesis mechanism represented a turning point in musical technology, because musical sounds are now limited only by the skill and imagination of the instrument designer, musician or sound engineer, rather than by the physical properties of materials. The most popular and widespread example of this decoupling is the MIDI communication standard, which allows many different controllers and synthesizers to be used together interchangeably.

Electronic tools afford instrument designers and musicians new and compelling modes of sound production and composition. In particular, the explosion of sampler/sequencers and digital audio production software has allowed musicians to easily compose music by arranging pre-recorded or synthesized sounds for later playback. However these tools have been less successful in perfor-

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mance contexts. Despite the freedom that electronic instruments provide, complaints about their diminished expressive capabilities have dogged them since their inception. Compared to acoustic instruments, musicians report that electronic instruments sound sterile, and that they lack an organic feel that is found in acoustic instruments.

2 Approach

We believe that musicians' dissatisfaction with electronic music instruments is caused at least in part by the fact that electronic instruments have historically lacked the subtle modes of play featured by acoustic instruments. The decoupling of performer gesture and output sound featured by electronic instruments comes at a cost: most musical affordances must be explicitly created by the instrument designer. For a device to respond to pressure on its body, a pressure sensor in the right location must be used. If it is to respond to bending, or blowing, or changes in tilt or temperature, each of these abilities must be engineered with sensing elements and appropriate signal routing or digital data collection. Furthermore, the most common configuration for an electronic music instrument makes each sensing parameter independent of the others, each capable of being actuated separately by a performer without affecting the others. If the control parameters are to feature inter-connected behavior, this too must be an explicitly designed feature. This requirement for explicit design of the device's behavior stands in contrast to acoustic instruments, which feature many 'accidental' or serendipitous modes of play that may not have been foreseen by the instrument's designer. These modes of use fall out of the materials an instrument is built with, and its mechanical construction. For instance, plucked notes on an acoustic guitar can be detuned by physically pushing on the guitar neck, causing it to bend and change the distance between the endpoints of the string. Non-standard modes of play are learned partially through experience with the specific instrument, but are also informed by our life experience manipulating physical materials. Since most people have handled and bent wooden objects before, the fact that a guitar neck is bendable can be intuited directly by looking at the instrument.

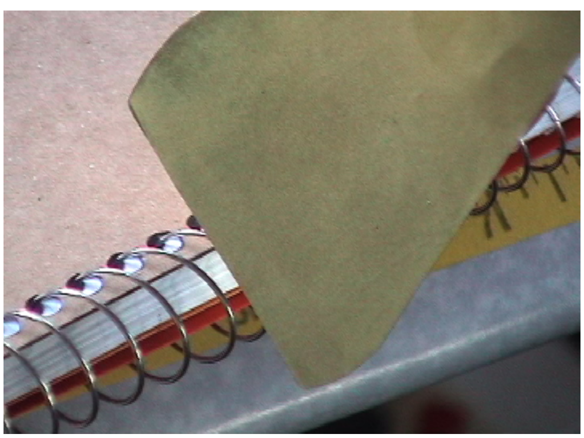

Figure 2: *Scraping the wand across the binding of a spiral notebook. Each movement stimulates the recorded sound sample.*

Hunt et al. investigated the design question of cross-coupled versus independent parameter control in a musical interface, finding a preference for cross-coupled parameters [Hunt et al. 2003]. This preference for a more complex mode of interaction is useful for musical instrument design because it suggests that electronic music instruments might benefit from the kind of cross-coupling that acoustic instruments have had all along. Moreover, it signals a general appreciation for the continuous and subtle properties of interactions with physical objects.

Our wealth of experience handling physical materials does not typically produce much intuition for operating an electronic instrument, given the possibility for arbitrary mapping from gesture to sound. A primary design goal with the Sound of Touch has been to build an interactive system for sound manipulation that will allow people to once again utilize their intuitions about how striking, scraping, or other gestures will sound based on their past experience hearing how materials sound when they are touched. Furthermore, given that our system's sensing technique can be attached directly to different physical materials, it is able to capture some of the cross-coupling and accidental modes of play that acoustic instruments possess, without requiring the explicit design of these affordances.

3 The Sound of Touch System

Figure 3: *Recording a vocal melody into the system using the wand, and stimulating the piezoelectric sensor directly with soft paintbrush bristles.*

Our system is based on Aimi's methods [Aimi 2006] for realtime percussion instruments, which allow a stored digital sound sample to be 'stimulated' continuously by the signal from a piezoelectric sensor attached to a drum brush. The underlying mechanism of this stimulation is a continuously running digital convolution of the stored sound sample and the digitized incoming signal from the piezoelectric element.

Digital convolution is an algorithm that is fundamental to much of digital signal processing [Oppenheim and Schafer 1989]. It is the primary technique by which digital filters are implemented to shape the frequency spectrum of a sampled signal. The basic principle of digital convolution is that two sampled signals are applied to each other in multiplicative manner, and the resulting signal has a frequency spectrum that is a product of the individual frequency content of the two original signals. Sonically, this means that if a presidential speech is convolved (the act of convolution) with a sample of a church bell being struck, the resulting audio sounds like a mixture of the two, as if the speech were being played *through the church bell* or vice versa.

Aimi's work develops a number of 'semi-acoustic' percussion instruments that utilize his technique with pre-recorded samples and the signal from piezoelectric sensors manipulated in real-time, to provide greater realism and intuitiveness to digital percussion.

Our primary contribution is the construction of a standalone wand that incorporates both a microphone for recording samples and the piezoelectric sensor for stimulating the newly-recorded sounds. To record a sample, a user presses a button on the wand, which activates recording. As soon as the button is released, the sample is stored and the piezoelectric sensor stimulation becomes active.

The wand can then be brushed, tapped, scratched, or otherwise manipulated against physical objects. The wand makes acquisition of new samples rapid, lowering the effort required for experimentation with different sounds. Its flat shape allows it to be used as a probe to touch, strike, or scrape objects the world, or it can be held against another object which is itself manipulated. The wand locates all of the relevant components for this activity in a single instrument.

Figure 4: *The texture kit, each element selected for its unusual physical structure.*

Our second contribution is the creation of a 'texture kit' comprised of a number of different physical objects with varying shapes and textures. The purpose of the kit is to enable convenient experimentation stimulating a stored sample with a wide range of physical textures. The kit includes a soft paintbrush, stiff wicker bristles, fabric, plastic, Velcro, and a number of other unusual objects. The kit is a palette of textures that were selected for their diversity in stiffness and surface features, making them a useful basis for experimenting with sound.

Our wand and texture kit facilitate sonic exploration of recorded samples against a wide range of surfaces. The experience of playing with sound in this way heightens our interactions with physical objects, allowing us to explore and exploit their features in a more direct auditory way, providing a new way to intuitively sculpt digital sound samples.

4 Conclusions and Future Directions

We have described the Sound of Touch, a tangible wand, software system and texture kit for real-time sound recording and exploratory stimulation of recorded samples with the signal from a piezoelectric sensor. The Sound of Touch enables a flexible capture and manipulation of sound that is characteristic of digital tools, but in an exploratory and direct manner that approaches the continuous nature of sound-making with acoustic musical instruments and found objects. Additionally, the Sound of Touch allows people to leverage their existing intuitions about how different objects will sound when these objects are touched, struck, or otherwise physically manipulated - a feature also shared by acoustic instruments and found objects. The Sound of Touch is thus a sonic exploration tool that borrows properties from both acoustic and electronic sound creation, bringing them together in a way that leverages advantages of each.

In the future we plan to make the Sound of Touch system more fully mobile, so that sounds and textures from anywhere in a person's physical environment could be used. A mobile version of the system would enable roving musique concrte [1] experiences or performances, and would require adaptation to a mobile computing platform such as a PDA or battery-powered computer. Additionally, the implementation of a palette of sound samples that could be captured on-the-fly, stored, then selected for stimulation easily would make the Sound of Touch wand more of a fully capable instrument. Finally, a two-person performance mode may be particularly appropriate for the Sound of Touch. Such a performance could feature one person playing melodies or percussion on an acoustic instrument, while a second plays the Sound of Touch. The second person would act as a 'remixer', appropriating snippets of sound from the acoustic performance then reformulating them through the Sound of Touch device and a texture kit. This combination of old and new, acoustic and digital, just-played then re-appropriated and manipulated sound would be an exciting and novel show.

5 Acknowledgements

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[1] The practice of making music out of sounds recorded in the 'real world' by first experimenting with them, then abstracting them into musical compositions.