A tabletop waveform editor for live performance

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ABSTRACT

We present an audio waveform editor that can be operated in real time through a tabletop interface. The system combines multi-touch and tangible interaction techniques in order to implement the metaphor of a toolkit that allows direct manipulation of a sound sample. The resulting instrument is well suited for live performance based on evolving loops.

Keywords

tangible interface, tabletop interface, musical performance, interaction techniques

1. INTRODUCTION

The user interface of audio editors has changed relatively little over time. The standard interaction model is centered on the waveform display, allowing the user to select portions of the waveform along the horizontal axis and execute commands that operate on those selections. This model is not very different to that of the word processor, and its basics are usually understood by computer users even with little or no experience in specialized audio tools. As a graphical representation of sound, the waveform is already familiar for many people approaching computers for audio and music composition. Thus, audio editors have become general tools used for many different applications.

Particularly interesting are creative uses of these programs that go beyond their originally devised functionality. In describing 'glitch' music, Kim Cascone wrote:

> "In this new music, the tools themselves have become instruments, and the resulting sound is born of their use in ways unintended by their designers." [4]

In this sense sound editors have revealed specially useful in the production of errors and glitches and in general for experimental sound design. Thus, it may not be surprising that, despite the essentially non-realtime interaction model that typically governs these programs, many musicians have used them in live performances. One example of this was the *Sound Waves* live set by Saverio Evagelista and Federico Spini (9th LEM International Experimental Music Festival, Barcelona 2005) which inspired this project. The use of a standard audio editor on a laptop computer as a sophisticated looper served the performers' minimalist glitch aesthetics. Perhaps more importantly, the projected waveform provided a visual cue that helped the audience follow the evolution of the concert, a simple solution to one of the most criticized problems of laptop based performance.

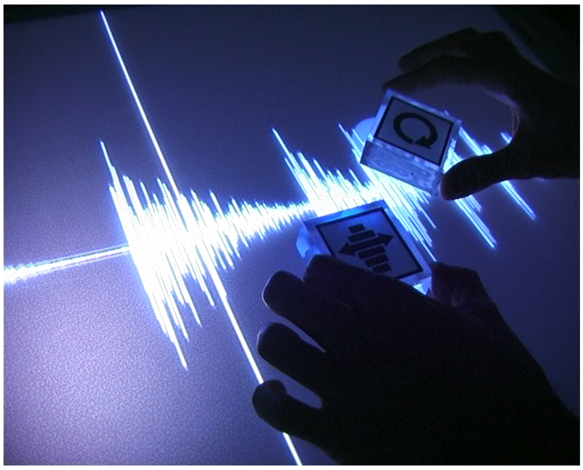

Figure 1: Close view of the *waveTable* prototype.

Tabletop tangible interfaces have gained popularity in recent years by allowing intuitive interaction with computers. In music performance, they bring back this needed visual contact with the audience that is missing in laptop music by making interaction readable [17]. Thus, the availability of low cost means for building multi-touch and tangible interfaces opens the door to a new revision of the possibilities of direct interaction with waveforms.

In this article we describe the *waveTable*, a tangible sound editor that may be used as a sophisticated looping and sample manipulation device for live performance with an intuitive interface that provides feedback to both the performer and the audience.

2. RELATED WORK

The idea of sound generation from hand-made waveforms was already envisioned in the 1920s by László Moholy-Nagy, who proposed that the incisions in wax played by the phonograph could be created by hand (quoted in [9]). In the 1970s, Iannis Xenakis' *UPIC* explored many different techniques for sound generation from drawings, including waveforms and envelopes [8]. Also, one of the first commercial samplers, the Fairlight CMI, included a light pen for the purpose of waveform and envelope edition.

In recent years a number of systems have been developed

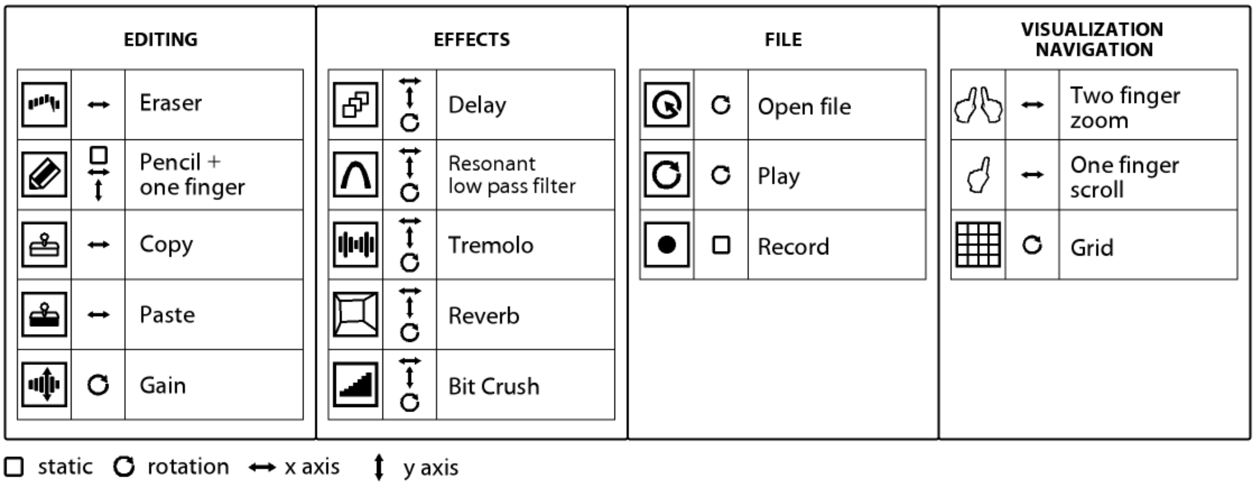

Figure 2: *waveTable* Tools: icons, gestures and functions.

that exploit tangible interfaces based on commodity components for music composition and performance. Most of them are focused on synthetic sound generation or realtime sequencing, but do not directly address the problem of tangible manipulation of waveform data.

One of the applications of Enrico Costanza's *d-touch* [5] library, the *physical sequencer*, represents sound samples as tangible objects in a cyclic timeline. Sounds can be metaphorically loaded into objects through a microphone and several effects can be applied by overdub recording. The *Music Table* [19] allows to compose music patterns by placing cards on a table. Cards are tracked through a camera and displayed on a separate screen with an augmented reality layer overlapped. Copying patterns is supported thanks to a copy card which stores patterns in phrase cards to be reused or edited at any time without requiring the presence of their note cards. The *reactable* [12] has become one of the most popular multi-touch and tangible tabletop instruments. This collaborative instrument implements dynamic patching in the tradition of modular synthesizers. Among many other features, the *reactable* allows to draw the waveform of a wavetable oscillator using one finger. Looping samples is also supported with sampler objects [11]. Using the *reactable* technology, the *scoreTable** [10] explores realtime symbolic composition in a circular stove. Being more focused on the higher-level compositional aspects of music performance, this project takes advantage of the *reactable* round shape to represent a cyclic timeline, allowing users to collaborate in moving physical notes along the stove. Golan Levin's *Scrapple* [15] allows the generation of a spectrographic score using tangible objects laid on a long table, with an augmented reality overlay for visual feedback. This approach seeks a compromise between compositional precision and flexibility in the tradition of spectrogram based composition.

One common aspect of these projects is that tangible objects are used as physical representations of data. Thus, their interfaces imply that manipulating a tangible object is analogous to performing modifications on the underlying model. The main drawback of this approach is that physical objects cannot be created from scratch, nor can they be duplicated. As seen with the *Music Table*, this may lead to break the relationship between the tangible object and the digital model. We propose the utilization of tangibles as tools, which represent functions that operate on data. We show how this approach enables the implementation of basic concepts of data edition available in desktop computers for the case of a tabletop sound editor. The result is a tool that allows the user to sculpt sound in a convenient way so that sound design becomes a realtime composition process.

3. INTERACTION DESIGN

3.1 Toolkit Metaphor

The relevance of metaphor is traditionally recognized in the field of Human-computer interaction and interface design, being also applicable to Tangible User Interfaces (TUI) [7]. Interface metaphors are able to communicate the way users can interact with the system, suggesting or simplifying possible actions [6]. Within tangible interfaces, it has been identified that real-world objects can be used in computer systems to couple physical and digital representations [18]. Thus, metaphor and coupling should provide meaning by helping to establish a a continuous dialogue between the physical and the virtual [6]. This is accomplished in our system by metaphorically mapping tangible pucks to tools [7].

The principal metaphor chosen for interacting with the *waveTable* system is closely inspired by the widely used concept of a tools palette found among graphical desktop applications since the 1980s (e.g. in MacPaint or HyperCard), including some sound editors. This approach may be useful for shaping the waveform graphically employing tangible and iconic tools, establishing an interactive dialogue that uses familiar verbs and nouns (in the sense proposed in [7]). Thus, an effective toolkit is provided that can be easily exploited by musicians, experts or beginners, facilitating the act of editing sound.

3.2 Tools and Gestures

According to Bill Buxton, the natural language of interaction should deal with non-verbal dialogues and highlight the gestures as phrases with their own meaning [3]. The interaction elements used in the *waveTable* are both physical artifacts and fingers, and the properties detected by the system are 2D position, rotation and presence of the objects, as well as one or two finger movements. The toolkit is compounded of tools representing basic operations such as copy, paste or erase, as well as tools that represent audio effects applied in real time. The chosen mapping is one object per tool. There are four main groups of gestures and tools, namely Editing, Effects, File and Visualization/Navigation operations, as shown in Figure 2.

Editing tools represent operations used for basic modification of the sound: *Eraser*, *Pencil*, *Copy*, *Paste* and *Gain*. *Eraser* deletes part of the sample when moving along the x axis. *Pencil* allows freely drawing waveforms with one finger when present. *Copy* stores a fragment selected by dragging over the waveform along the x axis. *Paste* stamps that fragment at the object position and repeats it when moved along the x axis. *Gain* increases or decreases the overall amplitude when turning the object clockwise or counterclockwise.

Effects tools represent common audio effects applied to the sound in real time: *Delay*, *Resonant low pass filter*, *Tremolo*, *Reverb* and *Bit crush*. In all cases position and rotation are detected, modifying respectively the position and shape of an envelope. Each envelope controls the most relevant parameter of its respective effect.

File tools are applied following the VCR metaphor (common buttons present in VCRs or CD players [6]): *Open file*, *Play* and *Record*. *Open file* allows previewing samples from a collection displayed in a radial menu, and loading one by pointing with the finger. *Play* reproduces the sound in a loop when it is present. Turning the object clockwise or counterclockwise increases or decreases the playback rate respectively. *Record* captures the output of the system in real time when present, and then swaps the playback sample for the result.

Visualization/navigation gestures and tools are concerned with displacement and zoom level: *Two finger zoom*, *One finger scroll* and *Grid*. *Two finger zoom* allows navigation between the closest detail and the most general overview of the waveform depending on the direction and distance between fingers. *One finger scroll* provides the option of moving from the starting point towards the end point of the sample scrolling right or left along the x axis. *Grid* shows a pattern of vertical lines in order to facilitate the task of some editing tools, say, eraser, copy or paste.

4. IMPLEMENTATION

Using computer vision software like reacTIVision [13] it is now possible to build tangible and multi-touch interfaces with low cost components. In order to implement the concept of realtime direct manipulation of a looping sample, the *waveTable* system was developed as a program that runs on *reactable*-class hardware using the reacTIVision framework.

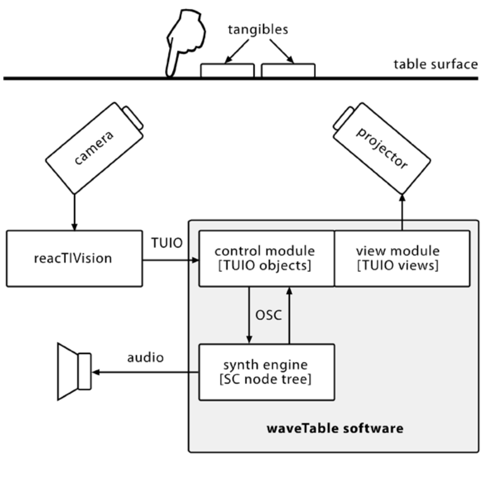

Figure 3: System overview.

Tools for the described operations are simple acrylic plastic pieces with fiducial markers attached on one side and descriptive icons on the other. Tools and fingers are illuminated using infrared leds and captured by a webcam with a visible light blocking filter. Captured video is processed by reacTIVision which tracks position and rotation of fiducial markers, as well as position of fingers. This information is encoded using the Tangible User Interface Objects (TUIO) protocol based on Open Sound Control (OSC) [14] and sent over UDP to the *waveTable* software. Visual feedback is provided through rear projection on the table surface.

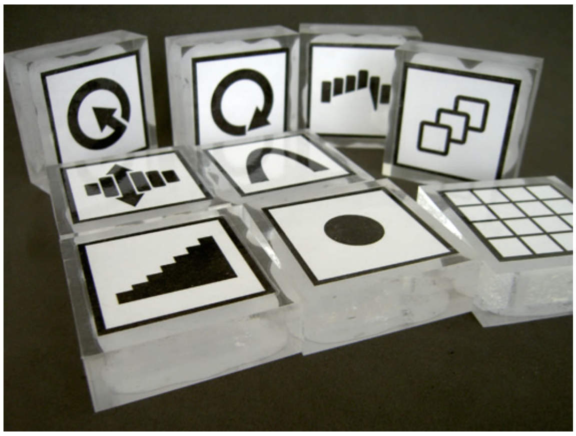

Figure 4: A sample of *waveTable* tools.

The software is written in the SuperCollider 3 [16] language, which is based on a distributed architecture where audio synthesis is carried out by a specialized server process that is controlled using OSC. This environment allows rapid development and very easy implementation and evaluation of all kinds of effects and operations over audio buffers that can be used in real time. Moreover, the Mac OS X version provides a set of graphics primitives and a ready-made waveform display. On the other hand, the distributed nature of the system involves some complications in the synchronization of data between the server and the client. In the current prototype this limitation is overcome by using a RAM disk. Integration with reacTIVision is done through Till Bovermann's implementation of the TUIO protocol [1].

The software is logically divided into control, model and view modules. The control module is composed by a hierarchy of TUIO objects that handle each of the tools, and a class that handles TUIO cursors (fingers). The model is implemented as a SuperCollider server node tree, that runs synth definitions for playing the sound buffer and dynamically applying effects. An overdub record synth definition allows swapping the playback buffer with a recording of the output. The view module is also composed of a hierarchy of objects that implement the graphic representation of tools and envelopes, and a container view that manages the main waveform display.

5. USAGE

The resulting prototype makes it possible to modify a sound sample using fingers and tangible artifacts at the same time it is being played in a loop. This is accomplished by loading a sample with the *Open file* tool. For starting from scratch by drawing a waveform, a sample filled with silence of the desired length may be loaded. The waveform of the sample is then projected onto the table, and can be zoomed and scrolled using finger gestures. Locating the *Play* tool starts looping the sound, and rotating it modifies the playback rate.

At this point edit operations can be used to copy, paste or erase portions of the sound, modify its gain, or draw on it at the desired zoom level. The *Grid* tool may be employed to improve precision if a rhythmic pattern is wanted.

Effects tools add several realtime audio processes nondestructively. When located on the table, each of these tools displays an envelope that controls the variation of the most important parameter of that effect along time. Envelopes are composed of two sinusoidal segments forming a smooth curve. The central point is controlled by the object position, while the height of the extreme points is controlled by the object rotation. Each envelope is represented graphically with a different color by a curve superimposed to the waveform according to the zoom level. This system allows to control a good number of envelope shapes with very simple gestures.

In order to permanently apply the effects, the *Record* tool can be used. Once the tool is on the table, the system waits for the next loop and records it. When the loop is finished all effect tools on the table are deactivated together with the *Record* tool. Their virtual representation disappears to invite the user to collect them. This process may be repeated as desired.

6. CONCLUSIONS AND FUTURE WORK

We have presented a set of interaction techniques and an implementation for a live performance instrument based on realtime manipulation of a sound sample using tangible and multi-touch techniques.

Informal testing of the prototype confirmed our expectations regarding the potential of using a tabletop interface for waveform manipulation as a live instrument. Moreover, the system can also prove useful as an intuitive tool for creative sound design, although with different ergonomic implications than traditional desktop editors. In order to fully support this application, some tools need to be added, yet in a way that the system remains free from verbal interaction. Such newer tools include a *Snapshot* tool that allows to save the sound buffer to the hard disk, and a *Crop* tool to isolate specific segments of larger sound recordings. Another interesting direction is offered by the possibility of implementing a low cost light pen, for example using the Nintendo Wii Remote [2].

7. ACKNOWLEDGMENTS

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