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## Visually Controlled Synthesis using the Sonic Scanner and the Graphonic Interface

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### ABSTRACT

This paper describes the concepts, design, implementation, and evaluation of two new interfaces for music performance and composition and their control of various synthesis algorithms through the visual domain. Both of the interfaces were inspired by the idea of generating music through drawing, but they approach the activity in different ways; while the Graphonic Interface allows you to make music as you are drawing, the Sonic Scanner needs pre-composed graphic material in order to make music. However, both of the devices are real-time controllers that produce sound in an interactive manner, thereby allowing them to be used as performance instruments.

### 1. INTRODUCTION

The transformation of visuals into sound is the motivation behind this work. While such synaesthetic ideas are not new [1], the implementation of these interfaces provides musical translations that have never before been available. What follows is an introduction to the devices themselves, the hardware and software systems developed during their creation, and the mapping of synthesis parameters onto the performance instruments.

The Sonic Scanner (see Figure 1) is an instrument that turns pre-made drawings, pictures, etc. into sound. It uses an old-fashioned handheld scanner as the interface, with the electronics modified to facilitate turning the

visual scan-line into an audio waveform. In addition to translating visual material into audio waveforms, there are several other methods for manipulating audio that the Sonic Scanner affords (as described in section 3.1). There are also extra control inputs on top of the device (Force Sensitive Resistors) that can be mapped to various parameters in the audio synthesis and effects algorithms. However, the basis of interaction is still the visual scan-line, which is captured using internal optics (mirrors/lenses), a wireless video camera (spy-cam type), and a video digitizer connected to the computer. The hardware implementation includes a thumb button, a 4-position mode switch, four pressure sensors (three for the fingers and one for the palm), and a rotary dial that also acts as an offset for the palm pressure sensor.

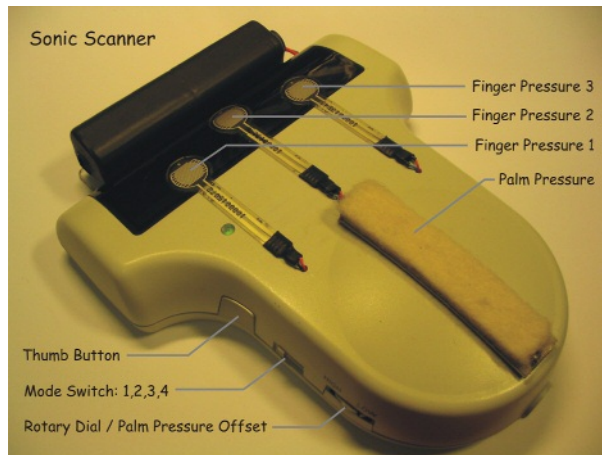


Figure 1. The Sonic Scanner—a new interface for audio manipulation that can turn graphical media into sound.

The Graphonic Interface (see Figure 2) is an instrument that captures the gestures of drawing and translates them into sound as you sketch. It uses a commercial system called a whiteboard tracker that converts input from pen movement to digital data [2]. This data is analyzed in real-time by the computer to produce sound corresponding to your gestures. Instead of using a whiteboard as the drawing surface, the Graphonic Interface employs a large plate of plexiglass as the performance interface. This allows the performer(s) to stand behind the instrument and face the audience while playing, and also functions as a flat-panel loudspeaker membrane through the use of a tactile sound transducer[3]. Thus, the music that is generated from your drawing gestures is amplified and played back through the instrument itself, providing tactile feedback to the performer and effectively turning the Graphonic Interface into a pseudo-acoustic musical instrument.

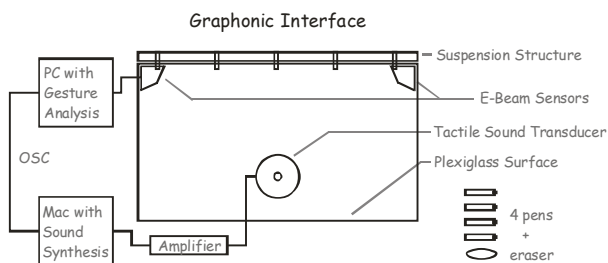


Figure 2. The Graphonic Interface—an interactive surface for music performance and composition.

The Graphonic Interface utilizes a combination of commercial products for the realization of the hardware

side of the system. The custom aspects of the interface are the construction of the drawing surface (along with the mounting of sensors and actuators), and the software to translate performance gestures into sound. The system uses two computers—one to capture user input and analyze gestures, and one to generate sound.

## 2. MOTIVATIONS

There were two primary motivations behind the development of the Graphonic Interface - the first was to create a musical instrument for real-time performance in a concert setting, while another was to design an installation where the Graphonic Interface would be an exhibit allowing users to make music themselves. The Graphonic Interface can of course be used to do both of these things, and to a certain degree it just depends on the space in which it is set up. I chose not to interpret anything but the actions of drawing with the Graphonic Interface, because I didn't feel it would make for a compelling interface to let someone draw a whole sketch and then hit a button that started the process of interpreting their sketch. However, I was still curious about interpreting pre-drawn material—it was this motivation that led to the development of the Sonic Scanner.

The Sonic Scanner cannot interpret the gestures of drawing, but it can use the resulting sketch (or any graphical material for that matter). Because of this, the Sonic Scanner is more versatile than the Graphonic Interface, and it is also more flexible in that it does not use fixed area for the interface but lets the performer move around a space and scan any image or object. This capability was one of the motivations behind the Sonic Scanner—it was envisioned as a portable device, and although there were some initial experiments with a flatbed scanner, the original concept worked best. It also benefited from the ergonomics of the handheld scanner, and the addition of a battery and some extra circuitry made the whole system wireless, giving the Sonic Scanner the element of being completely mobile. Finally, there is a rechargeable battery to make the device practical to use.

## 3. THE SONIC SCANNER

The Sonic Scanner takes optical input and changes it into audible output. The algorithms and software implementation / mappings used to do this are described below.

### 3.1. Synthesis with the Sonic Scanner

The software used to generate audio from the Sonic Scanner is all done in Max/MSP by means of the fairly new Jitter video processing extension. There are four modes you can use to transform your pictures into sound (controlled by the mode switch). The first mode, *Waveform* turns the optical scan-line directly into sound by literally going through the scan-line's brightness levels at an audio rate (see Figure 3).

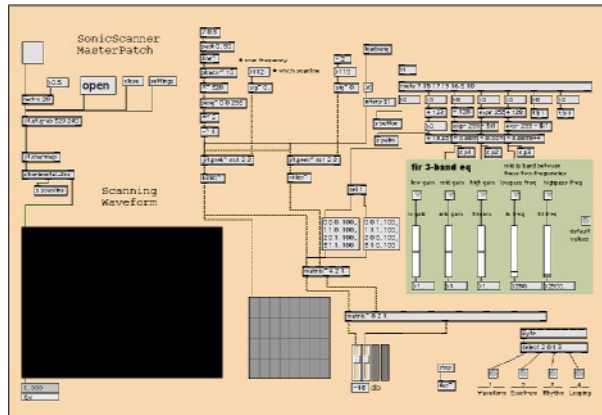


Figure 3. The Sonic Scanner *Waveform* mode.

The second mode, *Spectrum* translates the optical spectrum into the audio spectrum—it does this by mapping the scan-line onto the frequency domain using a FFT algorithm (see Figure 4).

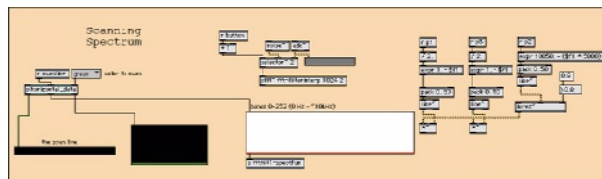


Figure 4. The Sonic Scanner *Spectrum* mode.

The third mode, *Sampler* lets you record a sound and then manipulate its playback with the Sonic Scanner (see Figure 5).

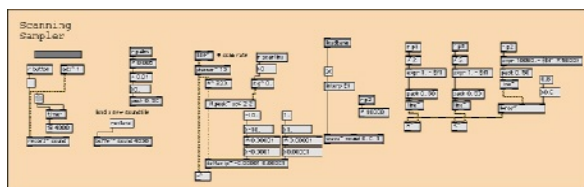


Figure 6. The Sonic Scanner *Sampler* mode.

The last mode, *Rhythm* is similar to the first in that it directly maps the scan-line to audio, but at a much

slower rate in order to pull out the rhythmic content of the scanned material (Figure 6).

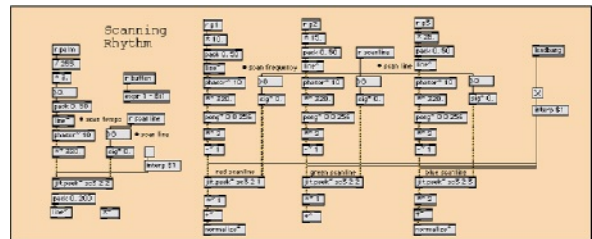


Figure 5. The Sonic Scanner *Rhythm* mode.

Each mapping makes use of the scan-line and other sensors in a different way, appropriate to the synthesis technique. For example, in the *Waveform* mode, the palm pressure/rotary dial controls the scan rate (pitch), and the three finger sensors control the low, mid, and high frequencies of an FIR filter—sound is only produced while you hold the thumb button. In the *Spectrum* mode, palm pressure controls the volume, first and third finger sensors control panning, and the middle finger sensor manipulates the cutoff frequency of a resonant low-pass filter. The thumb button is used to record a new sound to be manipulated in the *Sampler* mode, while the rotary dial sets the playback speed, and the sample pointer is controlled by the scan-line, allowing a performer to scratch through a sound using the Sonic Scanner. The *Rhythm* mode uses the rotary dial to set the tempo, and the three finger sensors control an algorithm that brings out rhythms based on the component colors (RGB).

### 3.2. Evaluation of the Sonic Scanner

The musical expression afforded by the Sonic Scanner can be very intriguing because of both the endless variety of graphical material to scan, and the four modes that provide entirely different results for the same scan-line. One of the most interesting results uses the *Spectrum* mode to process live audio and alter its frequency content through the scan-line's brightness levels—this can be done with either a microphone input or altering the sound of another musical instrument such as a guitar. During a performance, the software can also provide a visual abstract interpretation of the scan-line to the audience via a projector. The current version of the hardware integrates foam pads on top of the pressure sensors to enhance ergonomics and playability. It is the author's opinion that the Sonic Scanner is a very effective musical interface that can turn images into a wide variety of sounds.

## 4. THE GRAPHONIC INTERFACE

The Graphonic Interface captures the gestures of sketching and transforms them into audio output. The algorithms and software implementation / mappings used to do this are described below.

### 4.1. Synthesis with the Graphonic Interface

The Graphonic Interface system makes use of one PC and one Macintosh computer. Input data from the whiteboard tracker is displayed, analyzed, and converted to the OSC protocol on the PC in order to send it to the Macintosh. The whiteboard tracker communicates with the PC via a serial cable, and a custom application written in C++ analyzes the data and sends the resulting OSC packets across the network to a Macintosh running the sound synthesis programming language SuperCollider. The raw data coming from the whiteboard tracker includes the status of each pen (either on or off—drawing or not drawing), which pen is in use (there are four pens plus an eraser) and the x,y coordinates of the tip of the pen. This data is sent to SuperCollider after being converted to OSC—the gesture analysis features will be enhanced in future versions of the PC application. There are also many interesting research issues besides gesture analysis, such as automated performance environments, animated musical scores, and networked performance that I plan to explore and document with the ongoing project.

The synthesis algorithms currently implemented in SuperCollider are ideas that can be taken further with additional exploration, but they are already quite exemplary and effective for simple performance setups. One of the first algorithms experimented with was an FM synthesis mapping in which the x and y coordinates of the control the frequencies of two oscillators. Another mapping uses the x-axis to control the pitch of a wavetable synthesis algorithm, while the y-axis controls both the cutoff frequency of a low-pass filter, and the amount of a ring-modulation type effect. An interesting use of the Graphonic Interface is demonstrated with an effects algorithm in SuperCollider that processes live audio from a microphone and lets you modulate the parameters of a delay, filter, and reverb as you hear and feel your own voice through the pen interaction. There are also several algorithms that have been adapted for the instrument which employ physical modeling and granular synthesis methods. For a performance, it is possible to choose up to five different algorithms/mappings (one for each of the pens

plus the eraser), and switch between them simply by using the different pens.

### 4.2. Evaluation of the Graphonic Interface

The whiteboard tracking system has some inherent limitations that hinder the expressiveness of the interaction, but I feel that the Graphonic Interface is a very effective performance device nevertheless. The two main drawbacks of the whiteboard tracker are the inability to track more than one pen at the same time, and the lack of pressure sensitivity for the pens (something I've considered adding with some extra electronics). Even so, the instrument can be quite expressive with the right mappings, and I feel that the choice to focus on a real-time gestural interaction style matches well with the capabilities of the system.

## 5. CONCLUSION

The Sonic Scanner and the Graphonic Interface are new musical instruments that transform drawing and its associated gestures into sound. They provide novel interfaces for capturing gestures and controlling parameters of various synthesis and effects algorithms. The author plans to continue investigating possible improvements to the hardware and software of these instruments, as well as engaging in musical activities and performances with them. Audiovisual examples of the Sonic Scanner and the Graphonic Interface can be found at the web sites listed with the references [4].

## 6. ACKNOWLEDGEMENTS

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