Figure 1: Eighth Nerve Guitar

The Eighth Nerve Guitar: A Personal Reflection on Instrument Design and Computer-Mediated Performance

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Abstract
This paper describes the Eighth Nerve Guitar, a combined hardware / software instrument designed for computer-mediated improvisational performance. Key conceptual, aesthetic, and technical concerns will be discussed and multiple projects that utilize this live performance instrument will be referenced. A new instrument, the Guitar-Like Object (in development) will also be introduced.

Author Keywords
Interaction Design; Physical Computing; Computational Creativity; Improvisational Performance;

CCS Concepts
• Applied computing~Sound and music computing

Introduction
The Eighth Nerve Guitar is a custom electric guitar that has been fitted with a range of sensors built into the body of the instrument. This interactive system uses physical sensor data, a custom iPad interface, along with an array of real-time audio stream analysis data to control a variety of computer-based digital signal processing manipulations. These sound transformations are applied to the performed sounds of the guitar, as well as a collection of premade sounds

Figure 2: Eighth Nerve Guitar in performance

and field recordings that can be drawn upon in performance. This results in a hybrid extended electric guitar / computer performance system that allows for the exploration of non-traditional playing techniques and sonic transformations provided by sensor controlled interactive digital signal processing.

Motivation

I have long been interested in prepared instruments and have a related project for prepared piano and live computer processing. Prepared piano poses a number of particular technical and logistical issues, so I was interested in exploring other approaches to prepared instruments; in this case, physical preparations combined with digital processing. In terms of practicality, the instrument had to be affordable, portable, and allow continuous access for ongoing development, practice, and performance. I was also interested in an instrument that could use electromagnetic pickups, thereby simplifying the implementation of audio stream analysis and avoiding some of the problems related to acoustic transduction. The instrument would need to be sonically rich and provide access to a wide range of extended playing techniques. The work of seminal guitar innovators, such as Keith Rowe, Derek Bailey, and Fred Frith demonstrates the range of playing techniques and sonic diversity available with the electric guitar. More recent work by Ricky Graham, Adam Wilson, and Kevin Patton provide additional examples of innovative approaches to extended electric guitar.

Hardware Overview

The instrument started out as a Fernandes electric guitar (with a sustainer pickup) which I then fitted with a range of custom sensors, including two rotary potentiometers, two momentary switches, one toggle switch, a pressure sensor that runs the length of the neck, two touch position sensors (one on the front and one on the neck) and a two-axis accelerometer built into the body of the guitar. The sensors are wired to a VGA connector mounted in the body of the guitar that is used to deliver the sensor voltages to an A-D converter. A simple interface box that uses an Arduino microcontroller handles the A-to-D conversion for the sensors.

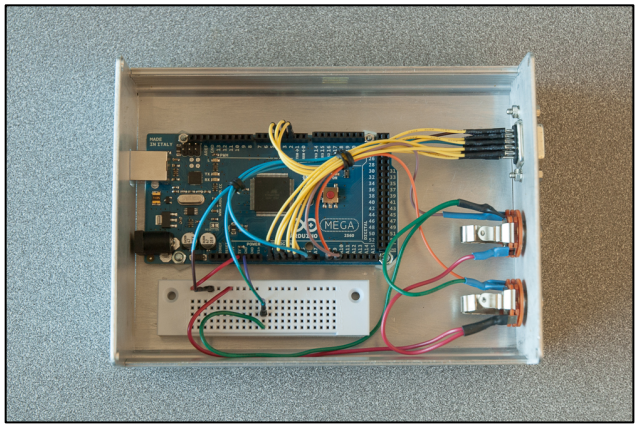

Figure 3: Custom sensor interface

The performance system also uses an iPad interface as well as two continuous foot pedals and a Keith McMillen SoftStep pedal for additional control.

Software Overview

The software for this performance system is very complex, having evolved gradually over a long span of time. On some levels, I no longer concretely understand all the innerworkings or behaviors of the

Figure 4: Eighth Nerve Guitar in performance

software, since the complexity and interdependence of the various functions creates emergent and unexpected outcomes. Predictability has not been an overarching design goal and I embrace this aspect of the instrument, especially in the context of solo improvisations where I am trying to avoid habitual behaviors. While a detailed description of the software design (realized in Max) is beyond the scope of this paper, it can be generally broken down into a few broad categories; there are listening agents which are designed for real-time audio stream analysis, sound processing modules, logic and control modules, sound output and spatialization modules, and various user interface elements.

The audio stream analysis modules track several different parameters including frequency, loudness, envelope, brightness, noisiness, spectral density, time between attacks, and several other salient features. All tracking parameters are also analyzed over various time frames to estimate larger time scale behaviors. The outcomes of these analysis modules (listening to both the input and the output of the system) are shared with the rest of the software and are used to influence both low-level and overall system behaviors.

The sound processing modules provide a wide range of sonic transformations and also include modules that can record and play back materials collected over the course of the performance, as well as sounds and field recordings prepared in advance. Key to the implementation of the signal processing network is the use of a routing matrix which allows all modules to be interconnected (at any gain level) and uses interpolation between high-level routing maps to manage the interconnections.

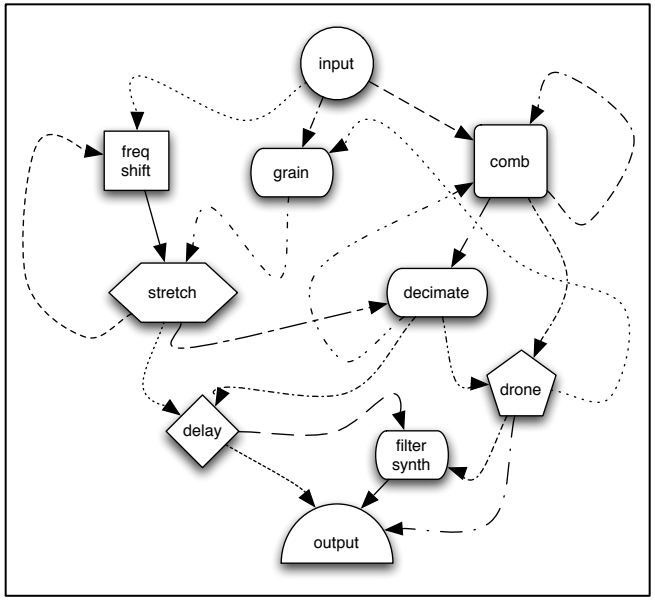

Figure 5: One of many available routing maps
signal gain can be adjusted at each connection point

This approach allows for a wide range of unique sonic transformations without overloading me with low-level management tasks during a performance. Since many of the individual parameters for the processing modules are driven by real-time audio analysis, even a routing map that is used repeatedly will result in unique sonic outcomes. In performance mode, the user interface for the software is minimal, since I do not want to rely too heavily on visual feedback which can be a distraction.

The final stage before output to the speakers is a six input, four output spatializer based on the Spat tools developed at IRCAM. This system provides control over sound source location and motion parameters, as well

as complex room simulation that can be controlled separately for each input. This creates a subtle yet constantly evolving and immersive sound space and gives each input voice its own spatial trajectory and identity.

Performance Context and Reflection

I have been working on and performing with this system for a number of years. It was not originally intended to be a long-term project but staying with it over multiple years has allowed me to develop a deeply intimate and highly personal relationship with this instrument. This is in contrast to the more usual progression where we prototype, develop, then debut a new system, and then move on to the next new technology. Instead, I have been able to continuously develop and refine this instrument and explore the unique performance techniques that it enables. At the same time, it is a highly idiosyncratic instrument with many specific limitations. It was never designed as a general-purpose instrument or as an instrument for others to use, so I see these limitations as design decisions as opposed to deficits.

I have used the instrument in a wide variety of performance contexts, including solo projects and ensembles of various sizes. In ensembles settings, I am able to adjust the software to exhibit less autonomous behavior, so it fits in to the ensemble in a more cohesive fashion. The system does have a certain sonic identity, but it is fairly diverse and pliable. The complexity and responsiveness of the guitar itself, especially through extended and unconventional playing techniques, greatly enhances the overall flexibility of this hardware / software instrument.

Figure 6: In performance with Curtis Bahn

Figure 7: Performing *Silent Movies* for guitar and video

Figure 8: Guitar-Like Object prototype version 2

Future Developments

Having started out as a Fernandes electric guitar, the Eighth Nerve instrument is encumbered by its original physical design and is somewhat difficult to modify and adapt. Since I am not a guitarist as such, I have no specific need for this type of form factor, and have recently started building a new instrument, more or less from scratch. Since it does not need to look or feel like a standard guitar, I am referring to it as the Guitar-Like Object.

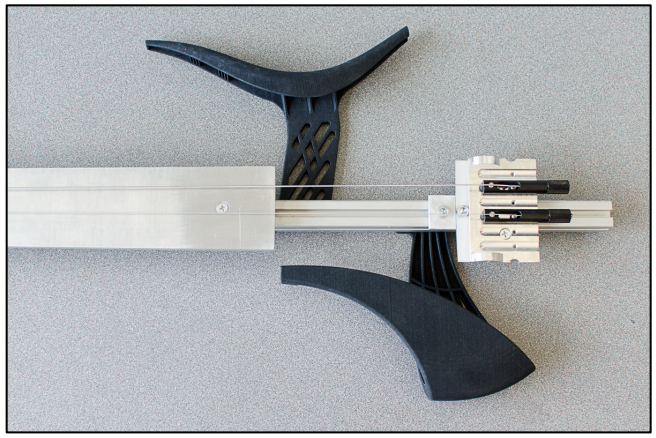

Figure 9: Guitar-Like Object, prototype version 2

For this new instrument I am exploring a range of construction techniques including 3D printing, both manual and CNC milling, and basic hand fabrication. The design will be completely modular and will allow for easy modification and changing out modules and components of the instrument. This modular design will facilitate the testing and integration of a number of new sensing technologies and I am also experimenting with different interchangeable fretted and fretless necks.

Much of the software infrastructure from the previous system will be usable, but the new physical form and new sensors will also encourage a redevelopment of the software design. The Guitar-Like object has been slow to develop, due to the range of technologies and construction techniques involved.

Closing Thoughts

Overall, these performance systems leverage a variety of unique hardware and software design strategies, all geared specifically towards improvisational performance. By combining a tactile, playable sound source with a dynamic interactive software system, the immediacy and richness of the guitar is extended by the power and flexibility of computation. This hybrid design, using physical sensors, generative strategies, audio stream analysis, and complex routing and mapping, creates an unpredictable, complex yet playable improvisational instrument.

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