# Computer-Mediated / Interactive Performance: *Moving Boundary Problem* Case Study

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## Abstract

*Moving Boundary Problem* is a multi-channel, interactive live electronic work for two performers. The piece has developed around a gestural language that explores the sonic and expressive capabilities of a pair of hybrid acoustic / electronic instruments. Utilizing a wide range of human / computer interfaces and signal processing techniques, these composed instruments extend acoustic sound sources including found objects, flutes, and percussions. *Moving Boundary Problem* is a manifestation of the unique acoustic, gestural, and human relationships that emerge from interaction with and through these new instruments. In this paper, we discuss the conceptual, aesthetic, and technical concerns encountered in the ongoing realization of this improvisational live performance project.

## 1. Introduction

Improvisation is a broad and complex topic [1, 2, 3] that places unique demands on its practitioners and the tools they use. As composer / improviser Pauline Oliveros points out, "The improvising musician has to let go of each moment and also simultaneously understand the implications of any moment of the music in progress as it emerges into being" [4]. This type of in-the-moment creation requires a flexible / pliable instrument, and a deep intimacy with the instrument's sonic potential. This is the case whether the instrument is acoustic, electronic, computational, (or some combination), with each type offering unique challenges and possibilities. A number of practitioners have explored a comprehensive approach to improvisation that spans across instrument design, composition, and performance. Bahn and Trueman provide a definition of composed instruments, explaining, "We consider our entire systems, from physical instruments, sensor interfaces, interactive computer music environments to spherical speaker arrays, to be both extended instruments and non-linear compositions: composed instruments" [5]. Commenting on the use of computational frameworks in improvisation, Dean points out, "One of the powers of computer-generated sound is to progressively move along axes that distinguish one sound from another by a variety of morphing processes. Thus one can choose to use a sound world aligned to instrumental sound, to natural sound, or to electronic sound, and to move between such worlds freely, and even gradually" [6]. One of the most enabling aspects of these computer-mediated performance systems is the real-time access to a complex and malleable sound world that is not restricted to the domain of acoustic instruments, but rather combines the processing and transformative power of the computer with the richness and immediacy of the acoustic world.

Our work in *Moving Boundary Problem* draws on related research in the design and realization of composed instruments, and considers the formidable challenges of improvisation in this context. We are designing performance systems that have a range of sonic possibilities that can be navigated or explored in the context of improvisational performance. Playing these extended instruments in a duo context poses new challenges, which then inform the design and refinement of the systems and our performance approach. By continuing to play together over time, both the instruments and the improvisers change and adapt, responding to idiosyncrasies that make us (and our instruments) unique.

In the remainder of this paper we will discuss our individual performance systems, and then articulate the ways in which we use these systems to explore / enact interactive sonic performances.

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## 2. Ciufo: Instrument Design

The performance system that I am currently using has grown out of a lineage of composed instruments designed for live improvisational performance [7, 8]. The overarching system design includes specialized hardware, custom software, and a range of tactile sounding objects that form an integrated live performance system. One important design criteria for this system is a high degree of pliability, which makes it usable in a variety of performance contexts, including solo or ensemble improvisations.

Figure 1. Ciufo in performance

This system uses a microphone and contact mic as the main input devices. This allows me to bring into this system a wide range of sound sources, including found objects, small hand percussion instruments, gongs, bells, and flutes. The hardware design consists of a computer, audio interface, and physical control interfaces, including both switch and continuous control pedals, and a fader based control surface. The output sound is spatialized into a 2D space using either four or eight speakers. The software design, (realized in Max/MSP/Jitter [9]) has evolved over time, and has been described elsewhere [10]. The initial use of this composed instrument was in the context of solo improvisational sound explorations, enacted over time frames ranging from ten minutes to nearly an hour. For *Moving Boundary Problem*, I am expanding and refining my use of this system in a collaborative duo context, and learning how to engage the improvisational approach of another musician.

A flexible signal processing architecture affords a wide range of available sound transformations. Thus, instead of building the sound processing network using a fixed signal flow, this system uses a modular matrix mixing / routing design. All signal processing modules are connected to a two-dimensional signal patching matrix that can route any input to any output at any level. This enables dynamic and continuously variable signal routing and mixing, including serial, parallel, and tree structures, with feedback and adjustable delay times available at each node. An example signal path is shown in Figure 2.

Available signal processing modules include timbre / frequency shifters, signal decimation and clipping, variable rate time stretchers, delay modules, a tunable comb filter, a noise-based resynthesis module, a stereo granulator, and a number of interactive recorder / player modules. This modular design also supports changing out specific processing modules, and reconfiguring the signal flow using simple connection templates. In performance, these templates can be recalled with a single continuous controller used to interpolate between two states, allowing for complex transformations using simple, metalevel controls.

Because of the reconfigurability, complexity, and high number of controllable parameters available with this system, developing and internalizing interaction strategies has been quite challenging. As discussed elsewhere [7] the relationship between autonomous, manual, automated, and analysis-based controls will greatly influence the behavior of a performance system, with certain relationships proving more appropriate to particular types of interaction. While this software is still capable of unexpected results, for *Moving Boundary Problem*, I have scaled-back some of the autonomous system behaviors, choosing instead to focus on the human-to-human interaction that so richly informs our duo improvisations.

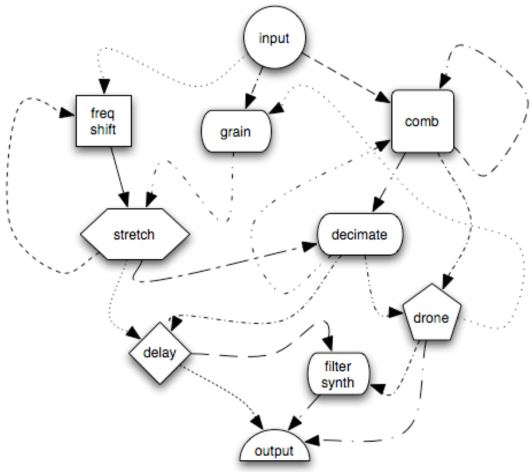


Figure 2. One possible Ciufo signal path

## 3. Birchfield: Instrument Design

Figure 3 shows a hybrid percussion/laptop performance system designed by Birchfield. Central to its design are the concepts of extended and composed instruments. In this instrument I have sought to leverage the expressive attributes of conventional percussion instruments and to reinforce the diverse timbral possibilities of a collection of skins, metals, and woods. The instrument is comprised of a fixed set of source sounds including found objects, folk instruments, and conventional percussion sounds. These include: electronic drum triggers, a large shaker, a block of zebra wood, a suspended Chinese cymbal, a large Indian bell, and a kalimba. Each of the acoustic

Figure 3. David Birchfield in performance

instruments has a piezo-electric contact microphone that is discretely routed to a multi-channel audio interface and into an interactive software framework that is written in Max/MSP. As pictured in the Figure 4, each sound source is manipulated as a separate signal processing chain that is tuned to an appropriate set of processing techniques and parametric controls for each instrument. A set of data control foot pedals and physical slider banks provide the performer with direct control of software synthesis parameters. Multi-

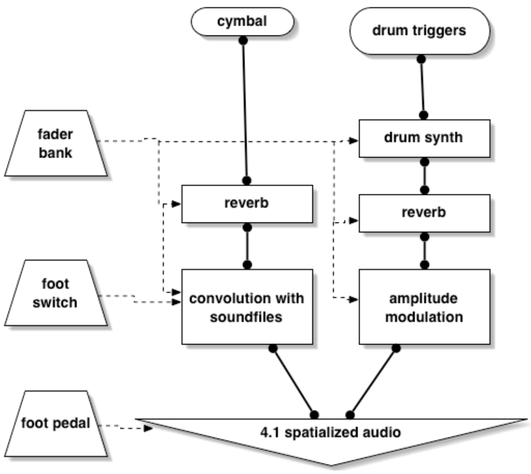


Figure 4. Birchfield instrument architecture

channel, spatialized audio is routed out of the software.

This instrument is designed to engage several aspects of conventional percussion performance. First, the distributed arrangement of discrete instruments is derivative of a conventional drumkit. This physical arrangement supports full body striking motions that coordinate between both hands and feet of a seated musician. Just as in conventional percussion setups, the performer has full access to a large configuration of instruments that can be selectively utilized.

Second, the instrument design seeks to leverage the nuances of physical interaction with these instruments. For example, the Chinese cymbal can be excited by a number of sticks, mallets, or the hands through a variety of physical gestures. Each gesture will yield different spectral shapes and amplitude envelopes. These subtle shifts in physical performance are further colored by the use of flexible signal processing chains in the software. Third, the instrument extends the acoustic sound production paradigm such that if the performer does not provide sound input, the software will not generate sound output. This places control and responsibility on the performer in a manner that is familiar for a percussionist.

In prior work, I have implemented percussion based performance systems that were intended for solo performance [11]. While this prior instrument yielded successful results, it was not well suited for collaborative performance. In contrast, this current instrument is designed for ensemble interactions. It provides a malleable interface to sound that is rooted in physical gesture. Thus, the instrument can be adapted to match or contrast with other musicians and their instruments, and its dependency on physical gesture facilitates human-to-human interaction that is critical for ensemble performance situations.

## 4. Player Interaction

We have described the factors and considerations that underpin the realization of these two extended instruments, and have discussed how these sound interfaces lead to idiosyncratic outcomes that reflect our individual aesthetic and design decisions. Here we describe our process of improvisation and articulate how our collaboration leads to distinct musical outcomes that are rooted in both sonic and physical relationships.

Despite differences in their basic architectures, our instruments are sonically related through overlaps of acoustic sound sources and signal processing techniques. For example, both systems utilize an array of percussion instruments including bells, gongs, bowls, and cymbals. Similar sonic overlaps arise as Birchfield draws on a large database of collected soundfiles that include recordings of bird songs and the voice. These can be recalled to draw associative relationships with Ciufo's acoustic bird call and flutes. Finally, both performance systems utilize a combination of pitched and non-pitched sounds. Ciufo plays a collection of wind instruments while Birchfield employs a bell and kalimba to spawn pitched material.

The use of similar digital signal processing techniques further contributes to our shared sonic language. Specifically, both instruments use granular synthesis, convolution, and delay loops to process acoustic and digital sound sources. The application of shared synthesis techniques that can be applied across a body of related sound sources provides rich opportunities to expand into new sonic idioms that are specific to our collaboration.

Our instruments are physically related through a body of overlapping performance gestures and transparent interfaces to sound. This physicality enriches our human-to-human communication during performance. For example, each instrument includes percussive instruments that can be played in similar ways. Birchfield's instrument features a suspended Chinese cymbal that can be played with the hands, mallets, or sticks with a variety of gestures including striking, sweeping, rubbing, sliding, glancing blows, or rolling. While playing bells, bowls, and gongs, Ciufo uses a similar repertoire of gestures with sticks, hands, or a bow. These physical interfaces communicate a great deal about upcoming sonic events. In many instances we will perform the same physical gesture that may lead to divergent sonic outcomes. For example, sounding a temple bowl with a circular rubbing motion in Ciufo's instrument will sound different from a circular sweeping motion on the cymbal of Birchfield's instrument. Nonetheless, these types of shared physical gestures often serve as important structural moments in our music.

## 5. Outcomes and Conclusions

How does this combination of individual instruments, unique personal aesthetics, and shared player interaction coalesce into a meaningful outcome? How are decisions / choices made in the context of improvisational performance, and what constitutes meaning within this context? In primarily idiomatic improvisation, there may be a variety of formal / contextual frameworks that influence the musicians' choices. Even so, many musicians are not consciously aware of how they improvise. Doc Cheatham confesses, "I have no idea of what I am going to do when I take a solo" [12]. This scenario becomes even more complex in improvisational environments without defined idiomatic boundaries. Even in non-idiomatic, or so called free improvisation, the players bring a range of influences, biases, and preconceived notions to their playing. Additional biases or predispositions are built into most composed instruments.

In *Moving Boundary Problem*, we explore how our individual sound identities and performance aesthetics interact and coalesce into unique and expressive sonic outcomes. The previous section describes aspects of our moment-to-moment interaction, focusing on both physical and sonic gestural relationships. Our work is also built upon a commitment to active, careful listening, and a willingness to follow one another down interesting sonic pathways. This is often a type of associative interaction, in which a particular sound will suggest a certain response, possibly supportive, complimentary, or contradictory.

We often provide complementary responses or extensions to each other's sounds or gestures by leveraging the capabilities of our individual instruments. For example, Birchfield's frenetic full body rhythmic activity may be supported by Ciufo's shifting textural underpinnings. At other times, we may both explore a similar set of sounds, such as bowed or scraped metals, thus blurring the line between the individual performers / instruments and the resultant aggregate sound. Our focus on the manipulation of sounding objects supports dynamic and synchronized interaction that are only possible in the presence of physical gestures.

This back and forth / mutual influence, combined with a sensitivity to overarching development and formal cohesion informs much of our work together. At the same time, there remains an aspect of our work that is indefinable, and even a bit mysterious, occasionally producing totally unexpected results. This seems fitting for a practice that Bailey describes as "the most widely practiced of all musical activities and the least acknowledged and understood" [1].

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