Approaches to Interaction in a Digital Music Ensemble

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ABSTRACT

This paper provides a sample of a LaTeX document for the NIME conference series. It conforms, somewhat loosely, to the formatting guidelines for ACM SIG Proceedings. It is an *alternate* style which produces a *tighter-looking* paper and was designed in response to concerns expressed, by authors, over page-budgets. It complements the document *Author's (Alternate) Guide to Preparing ACM SIG Proceedings Using LaTeX2$_\epsilon$ and BibTeX*. This source file has been written with the intention of being compiled under LaTeX2$_\epsilon$ and BibTeX.

To make best use of this sample document, run it through LaTeX and BibTeX, and compare this source code with your compiled PDF file. A compiled PDF version is available to help you with the 'look and feel.'

The abstract should preferably be between 100 and 200 words.

Keywords

Collaboration, Laptop, WiimoteNIME 2012

1. INTRODUCTION

The Physical Computing Ensemble was formed in order to explore the potential of collaborative performance in a digital music ensemble. This examination of the collaborative potential of digital musical instruments in a performance context is greatly influenced by the work of musicologist Christopher Small. Small argues that "the act of musicking establishes in the place where it is happening a set of relationships, and it is in those relationships that the meaning of the act lies. They are to be found not only between those organized sounds which are conventionally thought of as being the stuff of musical meaning but also between the people who are taking part, in whatever capacity, in the performance."[5] Talking about the Princeton Laptop Orchestra, Dan Trueman notes that "[o]ne of the most exciting possibilities afforded by the laptop orchestra is its inherent dependence on people making music together in the same space."[7] While a rich set of relationships are part of any ensemble performance, a digital music ensemble allows for novel forms of collaborations and ensemble interaction. The Physical Computing ensemble was formed for the purpose of exploring these novel approaches.

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1.1 Collaborative affordances of digital musical instruments

Miranda & Wanderley define a *digital musical instrument* (DMI) as "an instrument that contains a control surface (also referred to as a gestural or performance controller, an input device, or a hardware interface) and a sound generation unit. Both units are independent modules related to each other by mapping strategies."[**?**] In their most common form, both mapping and sound synthesis take place in software. This creates affordances for collaboration due to two factors —Êthe possibility of sharing information with other performers over a network, and the reconfigurability of mapping strategies and synthesis parameters.

While the possibilities of network-based information sharing has been well-documented, the importance of the reconfigurability of DMIs has been less well-documented. Reconfigurability means that a substantial part of the instrument can change in the course of a performance. This has the benefit that instrument design can become *context-specific*, and can depend on the existence of other performers relating to each other in specific ways. While this is not always seen as a good thing (Perry's Principle "Programmability is a curse"[**?**]), it can also, as Perry notes, "[more] can be better! (but hard)".[**?**] It opens up the possibility for certain configurations of instruments that *depend* on each other, or on certain aspects of the performance environment.

In this paper we refer to a *digital music ensemble* (DME) as an ensemble of musicians performing using DMIs. This restriction of instrumentation is important because it allows a DME to focus on approaches to music making which are idiomatic to computer-based instruments.

1.2 Sociological Considerations

Both Small Small1998 and TruemanTrueman2007 observe the correspondence of the development of the western chamber orchestra with the formation western institutions, with Small making the particular comparison to the rise of western industry. Weinberg notes that "musical networks are based on social organizations, which can be informed by 'social philosophies.' "[8] There is no doubt that the relationships formed within ensembles and also within musical movements are influenced by cultural factors. As Marshall McLuhan notes, technology shapes the formation of culture even as culture shapes the development of technology.[**?**] It is beyond the scope of this paper to examine the sociopolitical background of the history of digital music ensembles; rather, an awareness of these factors helped guide the development of the PCE even as the focus narrowed to collaborative possibilities within a DME.

2. PREVIOUS WORK

2.1 The Hub

Describing themselves as a interactive computer network music group, *The Hub*, and before them the *League of Automatic Music Composers*, are notable as the most prominent example of a DME which explicitly focused on collaborative performance and were interested in "new forms of live music performance that enhance the inherent social attributes of music making."[4] Influenced by the process-oriented approach of Cage, Tudor, Oliveros, etc. with it's emphasis on "allowing rules. . . and performers. . . to determine and shape the nature of music," The Hub employed compositional strategies based on strategies of interaction. For example, in the piece "Is It Borrowing or Is It Stealing" "each player played a melody of his choosing and electronically reported to the group what he was playing, whereupon the other players were free to borrow or steal this melodic information and use it in some way."[2] In another example, "The Minister of Pitch", different players were assigned control of different musical elements. This can be described as the parameterization of musical elements, and is one of the approaches employed by the Physical Computing Ensemble. By using parameterization of musical elements one musician may be responsible for setting the tempo and meter of a composition while another may be responsible for determining the pitch material.

2.2 Other References

Laptop orchestras, and the Princeton Laptop Orchestra in particular, have been important primarily for their use of instruments which are developed by composers and directors, in contrast to ensembles like *The Hub* and *Sensorband* in which each performer provides and performs with different DMIs. Atau Tanaka's *Global String*[**?**] and the Beatbugs project[9] share performance data over a network in different ways.

Several papers have explored conceptual approaches to collaborative and network-based interfaces[**?**] [1] [8]; however, further work needs to be done in order to establish a successful performance practice based on these concepts.

3. FOUNDATIONS OF THE PHYSICAL COMPUTING ENSEMBLE

> The laptop orchestra presents a challenging field of opportunity to both explore the appeals of making music in large numbers — people and their relationships are front and centre in this ensemble — and see what might be possible with new technologies. — Dan Trueman[7]
>
> Physical computing is an approach to learning how humans communicate through computers that starts by considering how humans express themselves physically. — Tom Igoe[**?**]

Considering how humans express themselves physically refers to more than just the use of expressive gestures such as hand movements. It also includes the ways in which we position ourselves in space — whether we face each other, move closer and further away from each other — as well as the ways in which we use eye contact and subtle physical cues. These physical expressions are then used as the conceptual frameworks for computer-mediated forms of human communication. In particular, the focus moves away from human-computer interaction and towards human interaction as mediated by a computer.

By focusing on performer action and placement in the physical world, the PCE attempts to honor the sentiments of many computer musicians who feel that the correlation between visible performer gesture and sonic result is an important part of audience experience. Chris Dobrian states that "the expressivity of an instrument is dependent on the transparency of the mapping for both the player and the audience."[3]John Croft has also noted the importance of this consideration in his "Theses on Liveness". Croft states that in order for live performance of electronic music to be meaningful there must be a "causal link between the performer's action and the computer's response."[**?**]

As the Physical Computing Ensemble took shape it developed the following attributes:

- The performer interface should rely on gestures which would be meaningful to the performer, fellow musicians, and audience.
- Performers would each have their own speaker, which would be positioned on stage as to localize each performers' sound in a different place. However, the performers themselves would not be tied down to a specific location and would use a wireless interface. One corollary of this decision is that performers must not use sheet music, as this would tie them to a location on stage.
- The performers' attention should be on their fellow performers, with interaction being the focus. The performer's instruments should not require visual feedback.
- The role of the computer, and it's physical presence, should be minimized in order to direct attention to the performers.
- Each composition should use a different software instrument which utilizes a different approach to performer interaction.

3.1 Technical Notes

Each performer used a Nintendo Wii Remote as a gestural controller in the pieces described below. The three-axis accelerometer and trigger button were the only sensors used. OSCulator was used to route the controller data into Max/MSP. All of the sound synthesis and compositional programming was done on a 2006 intel iMac. We were unable to maintain a consistent connection with six Wii remotes and a single computer's bluetooth, so a second computer was used to receive three Wii remotes' data, which was then routed directly to the primary computer.

The compositions were programmed in Max/MSP and each composition consisted of multiple sections, each with specific parameter settings including pitch material. Vibrotactile cues using the Wii remotes built-in vibroactuator were given to the performers in order to assist them in navigating the compositions. Three kinds of cues were given: start/stop playing; section change; and specific performance instructions. At the beginning of each section performers were cued as to whether they were playing in a section or not. If they were playing, they received 16 rapid pulses. If they were not they received a single long pulse. Each section was cued with a count-in consisting of 8 eighth-notes, followed by the appropriate start/stop cue. In "Just Continue to Move" performers also were given specific cues in the form of 1, 2, or 3 short pulses indicating specific musical cues.

Since there was no visual direction given to the performers in the form of sheet music or visual cues, they were expected to memorize the compositions. In practice, the performers used visual communication with each other to help remember the content of the compositions. The tactile cues also

proved to be indispensable. OSCulator limits control of the Wii remote's vibroactuator to on/off messages, but the cues were effective in conveying necessary information. The performers had occasional difficulty with distinguishing between different pulse patterns, but this was solved largely through the restriction of cues to certain contexts. There were also some problems with performers not feeling cues, which seemed to stem from two sources: the relationship between amplitude of vibrotactile stimulation and hand grip in a handheld gestural interface; and the masking of vibrotactile cues by vigorous physical motion. This did not pose too much of a problem in this context since cues were primarily used as tactile reminders and visual communication with other performers easily compensated for missed cues, but it does point to larger issues with the use of vibrotactile cues.

4. THREE APPROACHES TO INTERACTIVITY

Behind each PCE composition is a different concept of interactivity. The concepts in the compositions examined below are: the parameterization of musical elements, where different musicians are in control of different elements of the same musical event; turn-based collaborative control of sound, where performers share control of a sonic element sequentially rather than simultaneously; and the interaction of systems set in place by each performer. To the degree which these forms of interaction depend upon the capabilities of a computer they are unique to a Digital Music Ensemble. There are other more traditional forms of interaction in these compositions as well, but the success of each piece is dependent upon the qualities of the forms of interaction described above.

4.1 Triangulation

Triangulation is a composition for the PCE which explores the parameterization of musical elements, based on the concept utilized by The Hub in "The Minister of Pitch".[2] There are three pairs of musicians; in each pair one musician deals primarily with pitch and timbre material and the other musician with rhythmic material. Each musician has a basic sound with which they can perform independently. The pitch musician uses the accelerometer in their Wiimote to draw waveforms in three dimensions. When they hold down the Wiimote's trigger button the change in acceleration in each axis is written into a wavetable. When the B button is released, the wavetables are read independently to generate three waveforms which are mixed together and fed to the audio output of the computer.

The rhythm musician has a system which is oriented towards rhythmic events. The acceleration in the x- and y-axes of the rhythm musicianÕs Wiimote is read at fixed intervals (generally 16th notes at 120 beats per minute). Rhythmic events are generated at each interval whose maximum amplitude and duration are derived from the accelerometer values. The rhythm musician thus does not determine where the beat is located but rather determines the characteristics of rhythmic events located on the beats. The data from the x-axis is used to create a percussive gated noise sound, while the data from the y-axis is used to control the amplitude of the pitch musicians sound in those sections where the pitch and rhythm musicians are linked.

4.2 Just Continue to Move

"Just Continue to Move" uses the motions of throwing a ball back and forth as it's primary peformance gesture. The concept of playing catch has many associations (cooperative play, interaction with the environment, skill-based performance, etc.) Throwing a ball is an expressive act with an infinite number of variations and is a very complex act, easy to perform but with room for virtuosity. There is a common desire for a form of computer musicianship that is easy for the beginner to grasp but that rewards expert performance[7][1]; catch is an example of this.

In the PCE implementation, the virtual ball represents control over a 45 second long sample of a spoken anecdote. Performers grasp the ball by holding a trigger button; while grasped, acceleration controls the amplitude of the sample. When the ball is thrown, momentary acceleration and angle at the moment the trigger button is released is measured. A short section of the sample ending at the moment of release is then looped. The release angle is mapped to the beginning time of the loop, from 200-800ms before the time at the moment the ball is released. Acceleration is mapped to the playback speed of the sample from a range of 100-200%. A leaky integrator is then applied to the playback speed such that it takes 20 seconds for the sample to slow from a maximum speed of 200% to 25%, at which point the sample is stopped. The result is a pseudo-doppler effect which aurally conveys the trajectory of the ball.

In performance, the physical location and action of the performers combines with the sonification of the ball's trajectory to inform the performers of the appropriate actions. A full range of catch gestures is employed, including long-bombs, close volleying, and feigned throws. The actual performance followed a predetermined arc, but there was considerable room for personal interpretation; the transparency of metaphor and mapping allowed the performers to have fun and improvise, with enjoyable results.

4.3 Skipping Stones

In "Skipping Stones" individual musicians create musical events whose qualities are derived from the metaphor of skipping stones on a lake. The musician makes a single motion Ñ picking up a stone by pressing the trigger button, throwing the stone by moving their hand perpendicularly to the ground, releasing the stone at the proper place in the throw by letting go of the trigger button. This single motion, however, creates a miniature musical system whose characteristics are determined by the acceleration and angle at the moment of the stone's release. How hard the stone is thrown determines the speed, amplitude, and number of repetitions, or 'skips', of a note. The angle of the stone's release determines the length of the sonic event which constitutes each skip. There is a metric pulse and each skip is one of eight rhythmic subdivisions of the basic pulse, from a 32nd note to a half note. While the subdivisions are quantized, the moment of release is not, which allows for considerable rhythmic interpretation.

The primary form of interaction in this composition is in the creation of systems with different rhythmic subdivisions. Depending on how many musicians are playing at once this takes the form of a duet with easily discernible interlocking rhythms or it can take the form of a complex composite of many different rhythms.

5. IN PERFORMANCE

5.1 Staging

Since one of the goals of the PCE was to highlight the physical relationships between performers, the staging of each composition became an important consideration. The stage setup consisted of six speakers in a semi-circle behind the ensemble, and a large open space for the performers to inhabit. Each performer had a dedicated speaker, near which

they were typically located. Each composition employed varying ensemble configurations ranging from duets to tutti sections. Specific stagings were established in order to highlight the interaction of each configuration. This helped to convey the focus of the composition to the audience and facilitate visual communication between performers. The fluidity of the staging was a hugely important factor, and the open space allowed the performers considerable latitude in physical expression.

5.2 Musical Results

In order to highlight the physical relationships and interaction of the performers, severe limitations were placed on the design of the instruments and compositions. The ensemble consisted of six Masters students: four musicians, one artist, and one choreographer — none of whom had experience performing with DMIs. Limited rehearsal time meant that the instruments needed to make sense to the performers quickly, and the compositions needed to contain simple performance instructions. Rehearsals were mostly conducted in one-on-one instruction and smaller groups. There were two full ensemble rehearsals in the performance space, during which the staging was worked out.

During the rehearsals it quickly became apparent that the intuitive nature of the performance gestures made it easy and fun to learn the instruments. The open-ended nature of the catch metaphor in particular led the performers to have fun experimenting with different performance approaches. Learning the compositions was more difficult, as the musical material was substantially different than the performers had previously experienced and there could be no visual directions on-stage. Several performers ended up writing 'cheat sheets' on their palms to assist them in remembering forms, but for the most part visual communication between performers compensated for any momentary lapses of memory.

The actual performance was a lot of fun for performers and audience alike. The compositional and technological simplicity enabled the performers to concentrate on interaction and helped them maintain a strong connection with the music. The biggest factor in the evening's success, however, was the comfort level of the performers and the ways in which they expressed their personalities onstage. This took the form of individual performance styles and dynamic ensemble interaction.

6. FUTURE WORK

6.1 Theoretical Guidelines

This paper presents three approaches to human interaction in a digital music ensemble. Different approaches have been taken by other DMEs, and there remain many unexplored possibilities. Several theoretical frameworks have been proposed in order to guide effective interaction design[8][1], and I have proposed a dimension space for evaluating collaborative music performance systems in another paper. Further research is needed in order to facilitate the incorporation of effective strategies for musical collaboration into DMI design.

6.2 Intermediate Mapping Layers

Intermediate mapping layers have been proposed as a way of reducing the amount of re-mapping when changing the interface or synthesis algorithm of a DMI.[**?**] This also presents opportunities for changing the mappings of a DMI to enable collaborative performance. Synthesis parameters may be mapped to perceptual variables, for example, and the control input changed from a single DMI to multiple DMIs.

6.3 Musicological Study

The concept for the Physical Computing Ensemble came from the consideration of the role of relationships in musical performance. While the implementation of the PCE focused on technical issues of collaboration, it does not address the sociological implications of DMEs. The emergence of standard approaches to laptop orchestras and the institutionalization of DMEs in academic settings creates an opportunity for a closer examination of these implications. One place to start might be to take a closer look at the role of the San Francisco area's counter-cultural movements in the formation of the League of Automatic Composers and the Hub.

7. CONCLUSIONS

The goal of the Physical Computing Ensemble was to demonstrate an approach to the creation of a DME that considers human relationships first. In order to implement this approach DMIs were designed that took specific advantage of their reconfigurability and networkability.

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8.1 References

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