# Approaches to Collaboration in a Digital Music Ensemble

Ian Hattwick
Centre for Interdisciplinary Research in Music
Media and Technology
Input Devices and Music Interaction Lab
Music Technology Area
McGill University, Canada
ian@ianhattwick.com

Kojiro Umezaki
University of California, Irvine
303 Music and Media Bldg., UCI
Irvine CA 92697-2775 USA
kumezaki@uci.edu

## ABSTRACT

The Physical Computing Ensemble was created in order to determine the viability of an approach to musical performance which focuses on the relationships and interactions of the performers. Three performance systems utilizing gestural controllers were designed and implemented, each with a different strategy for performer interaction.

These strategies took advantage of the opportunities for collaborative performance inherent in digital musical instruments due to their networking abilities and reconfigurable software. These characteristics allow for the easy implementation of varying approaches to collaborative performance. Ensembles who utilize digital musical instruments provide a fertile environment for the design, testing, and utilization of collaborative performance systems.

The three strategies discussed in this paper are the parameterization of musical elements, turn-based collaborative control of sound, and the interaction of musical systems created by multiple performers. Design principles, implementation, and a performance using these strategies are discussed, and the conclusion is drawn that performer interaction and collaboration as a primary focus for system design, composition, and performance is viable.

## Keywords

Collaborative performance, interaction, digital musical instruments, gestural controller, digital music ensemble, Wii

## 1. INTRODUCTION

The Physical Computing Ensemble (PCE) was formed at the University of California Irvine in Fall 2010 in order to explore the potential of collaborative performance in a *digital music ensemble*. The hypothesis behind the formation of the PCE was that one approach to a successful DME performance is through highlighting performer relationships and interaction. During the creation of the PCE considerations which would normally be the primary focus of a performance, such as compositional intent and the expressive facility of individual performers, were de-emphasized in order to focus on the development of collaborative strategies which the performers would be able to confidently employ. Careful attention was given to the clarity of performer's instrumental gestures, and to the correlation between these

gestures and the musical result. Our hope was that this approach would culminate in a performance that was understandable, engaging, and enjoyable. This paper discusses the guiding principles behind the PCE, the implementation of these principles in three compositions, and a performance of the compositions.

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"[16]. 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"[19]. The Physical Computing Ensemble was formed for the purpose of exploring these possibilities.

### 1.1 Collaborative affordances of DMIs

We refer to Miranda & Wanderley's definition of a *digital musical instrument* (DMI) consisting of interface > mappings > synthesis algorithm[15]. Commonly both mapping and sound synthesis take place in software. This creates opportunities for collaboration due to two factors — the possibility of sharing information with other performers over a network, and the reconfigurability of mapping strategies and synthesis algorithms.

While the possibilities of network-based information sharing in musical performance has been addressed [21] [22], the reconfigurability of DMIs for collaborative performance is equally important. 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 performers relating to each other in specific ways. While reconfiguring DMIs is not always seen as a good thing, as noted in Perry Cook's Principle "Programmability is a curse"[6], Cook also notes "[more] can be better! (but hard)"[7]. 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 for an approach to collaborative performance that takes advantage of the characteristics of DMIs described above.

### 1.2 Previous Work

*The Hub*, as the most prominent example of a DME which explicitly focuses on collaborative performance, is one of the primary influences for the PCE. Laptop orchestras, and the PLOrk in particular, have also been important primarily for their use of instruments which are developed by composers and directors [17] [4], in contrast to ensembles like The Hub and Sensorband in which each performer provides and performs with different DMIs [5] [2].

The *Tooka* [10] and *Soundnet* [2] are examples of instrument in which collaborative performance is designed into the hardware. These instruments demonstrate that collaborative control of an interface is a viable approach, although collaboration through software may prove to be more practical in certain contexts and has the advantages that the mode of collaboration may change during performance, and DMIs may also be used in non-collaborative contexts.

## 2. FOUNDATIONS OF THE PCE

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 — and how this affects the ways in which we use eye contact and subtle physical cues. These physical expressions can be used as the conceptual frameworks for computer-mediated forms of human communication. In this scenario the focus moves away from human-computer interaction and towards human interaction as mediated by a computer.

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 should each have their own speaker, which should be positioned on stage as to localize each performers' sound in a different place. However, the performers themselves should not be tied down to a specific location and should 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 its 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.

### 2.1 Technical Notes

Each performer used a Nintendo Wii remote as a gestural controller. The three-axis accelerometer and trigger button were the only sensors used. OSCulator was used to route the controller data into Max/MSP.

The compositions were programmed in Max/MSP and each composition consisted of multiple sections, each with specific parameter settings. Vibrotactile cues using the Wii remotes built-in vibroactuators 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 vibrotactile count-in consisting of 8 eighth-notes, followed by the appropriate start/stop cue at the downbeat of the new section. In "Just Continue to Move" performers also were given specific cues in the form of 1, 2, or 3 short pulses indicating specific musical gestures.

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. While the Wii remote's vibroactuator is limited to on/off messages 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 stemmed from the masking of vibrotactile cues by vigorous physical motion. This did not pose too much of a problem in this context since the tactile cues were primarily used as reminders, and visual communication with other performers easily compensated for missed cues, but it does point to larger issues with the use of vibrotactile systems to provide feedback and guidance during performance.

## 3. 3 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. Full documentation of the compositions is available on the first author's website, ianhattwick.com.

### 3.1 Triangulation

"Triangulation" explores the parameterization of musical elements as utilized by *The Hub* in "The Minister of Pitch"[5]. There are three pairs of musicians; in each pair one musician deals primarily with pitch and timbral material and the other musician with rhythmic material. Both musicians use 3-axis accelerometers to write into multiple data buffers, which are then used as 1) wavetables and 2) amplitude values sampled at 16th notes, respectively. Data is written into their buffers as long as they depress their trigger button.

Since the pitch musician is writing data into a wavetable there is no audible result until the end of their gesture. In contrast, the rhythm musician's gestures are stored and heard simultaneously. In practice this means that their gestures are sequential and meet at the moment of sound generation, which requires visual coordination between the musicians.

### 3.2 Just Continue to Move

"Just Continue to Move" uses the motions of throwing a ball back and forth as its primary performance gesture. The

**Figure 1: A pitch/rhythm pair performing in "Triangulation"**

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 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[19][1][23]; in some ways catch is a simple example of this.

In the PCE implementation, the virtual ball represents control over a long sample of a spoken anecdote. Performers grasp the ball by holding the trigger button; while grasped, acceleration controls the amplitude of the sample. When the ball is thrown, the momentary acceleration and angle of release at the moment the trigger is released are measured. A short section of the sample whose end is the playback position of the sample at the moment of release is then looped. The release angle determines the total length of the loop; acceleration determines the intial speed of the loop. The speed slows to a stop over the course of a few seconds, resulting in a pseudo-doppler effect which aurally conveys the trajectory of the ball. The receiving player "grabs" the ball at the appropriate point in its trajectory.

### 3.3 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 — picking up a stone by pressing the trigger button, throwing the stone by moving their hand perpendicularly to the ground, and releasing the stone at the proper place in the throw by letting go of the trigger button. This single motion 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 flexibility.

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. In contrast to the processes in a typical algorithmic composition, whose parameters are set before the composition begins, in "Skipping Stones" the parameters of the process are set by a gesture extremely similar to a traditional performance gesture. This allows performers to set into motion musical processes which are a reaction in real-time to the processes created by other musicians.

## 4. IN PERFORMANCE

Since one of the goals of the PCE was to highlight the physical relationships between performers, the staging of each composition was 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 which served as their home base. This influenced the performers' location left-to-right more than front-to-back, in an attempt to locate each performer in the correct location in the 'stereo field'.

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. Different stagings also served to suggest different kinds of performance gestures. For example, in "Just Continue to Move" duets in which performers were located at opposite sides of the stage caused the performers to throw 'long bombs', while stagings in which the performers were close more often instigated volleying. The fluidity of the staging was a hugely important factor in the performance, with the open space allowing the performers considerable latitude in physical expression.

The April 22 performance was to an audience of around 80 people who were largely unfamiliar with electro-acoustic music. Once the performance began it quickly became apparent that they were drawn in by the rapport between the performers. By the end of the concert it was apparent that our first two hopes, that it be understandable and engaging, were fulfilled. Anecdotal evidence gathered over the next week suggests that the third hope was fulfilled as well.

## 5. CONCLUSIONS

The hypothesis asserted in this paper is that one approach to a successful DME performance is through highlighting the relationships and interaction of the performers. Principles for DME performance based on this hypothesis were presented, three different systems for collaborative performance were described, and we analyze the use of these systems in concert.

While it is difficult to quantify precisely, it is our belief that the principles laid out in this paper were instrumental to the concert's success. We would also like to emphasize that the reconfigurability of digital musical instruments provides an opportunity for modes of collaborative performance practice to be implemented on a wide variety of instruments. In the concert described above, the use of different collaborative approaches to give each composition a distinct character was greatly beneficial.

## 6. ACKNOWLEDGMENTS

**Figure 2: Performers playing catch at either end of the stage**

## 7. REFERENCES

[1] T. Blaine and S. Fels. Contexts of Collaborative Musical Experiences. In *Proceedings of the 2003 Conference on New Interfaces for Musical Expression*, volume 3, pages 129–134, Montreal, Canada, 2003. National University of Singapore.

[2] B. Bongers. An interview with Sensorband. *Computer Music Journal*, 22(1):13–24, 1998.

[3] B. Bongers. Physical Interfaces in the Electronic Arts: Interaction Theory and Interfacing Techniques for Real-time Performance. In M. M. Wanderley and M. Battier, editors, *Trends in Gestural Control of Music*, volume 6, pages 41–70. IRCAM - Centre Pompidou, Paris, France, 2000.

[4] I. I. Bukvic, T. Martin, E. Standley, and M. MAtthews. Introducing L 2 Ork: Linux Laptop Orchestra. In *Proceedings of the 2010 Conference on New Interfaces for Musical Expression*, number Nime, pages 170–173, 2010.

[5] J. Chadabe. *Electric Sound: The Past and Promise of Electric Music*. Prentice Hall, New York, 1996.

[6] P. Cook. Principles for designing computer music controllers. In *Proceedings of the 2001 conference on New Interfaces for Musical Expression*, pages 1–4, Seattle, Washington, 2001. National University of Singapore.

[7] P. Cook. Re-Designing Principles for Computer Music Controllers: A Case Study of SqueezeVox Maggie. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 218–221, Pittsburgh, USA, 2009. Carnegie Mellon University.

[8] J. Croft. Theses on liveness. *Organised Sound*, 12(01):59–66, Apr. 2007.

[9] C. Dobrian and D. Koppelman. The "E" in NIME : Musical Expression with New Computer Interfaces. In *Proceedings of the 2006 conference on New interfaces for musical expression*, pages 277–282, Paris, France, 2006. IRCAM - Centre Pompidou in collaboration with Sorbonne University.

[10] S. Fels, L. Kaastra, S. Takahashi, and G. McCaig. Evolving tooka: from experiment to instrument. In *Proceedings of the 2004 Conference on New Interfaces for Musical Expression*, pages 1–6, Hamamatsu, Japan, 2004. Shizuoka University of Art and Culture.

[11] S. Gresham-Lancaster. The Aesthetics and History of the Hub : The Effects of Changing Technology on Network Computer Music. *Leonardo Music Journal*, 8:39–44, 1998.

[12] I. Hattwick and M. M. Wanderley. A Dimension Space for Evaluating Collaborative Musical Performance Systems. Unpublished, 2012.

[13] T. Igoe. The FAQs of Physical Computing, 2004.

[14] M. McLuhan. *The Gutenburg Galaxy*. University of Toronto Press, Toronto, Ontario, 1962.

[15] E. R. Miranda and M. M. Wanderley. *New Digital Musical Instruments: Control And Interaction Beyond the Keyboard*. A-R Editions, Middleton, WI, 2006.

[16] C. Small. *Musicking*. Wesleyan University Press, Hanover, New Hampshire, 1998.

[17] S. Smallwood, D. Trueman, and P. Cook. Composing for laptop orchestra. *Computer Music Journal*, 32(1):9–25, 2008.

[18] A. Tanaka and B. Bongers. Global String: A Musical Instrument for Hybrid Space. In *Proceedings of the 1999 Conference on Artistic, Cultural and Scientific Aspects of Experimental Media Spaces.*, pages 299–304, Bonn, Germany, 2001.

[19] D. Trueman. Why a laptop orchestra? *Organised Sound*, 12(02):171, July 2007.

[20] M. Wanderley and P. Depalle. Gestural Control of Sound Synthesis. *Proceedings of the IEEE*, 92(4):632–644, Apr. 2004.

[21] G. Weinberg. Interconnected musical networks: Toward a theoretical framework. *Computer Music Journal*, 29(2):23–39, 2005.

[22] G. Weinberg, R. Aimi, and K. Jennings. The Beatbug network: a rhythmic system for interdependent group collaboration. In *Proceedings of the 2002 conference on New interfaces for musical expression*, pages 1–6. National University of Singapore, 2002.

[23] D. Wessel. Problems and prospects for intimate musical control of computers. *Computer Music Journal*, 26(3):11–22, 2002.