THE CIRMMT/MCGILL DIGITAL ORCHESTRA PROJECT

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ABSTRACT

This paper introduces the CIRMMT/ McGill Digital Orchestra Project, the objective of which was to develop new creative resources for the integration of digital technologies and live musical performance. The authors present five new Digital Musical Instruments (DMIs) designed during the project, and discuss issues surrounding the creation of repertoire and performance practice.

1. INTRODUCTION

The CIRMMT/ McGill Digital Orchestra was a large-scale multidisciplinary project initiated at the Centre for Interdisciplinary Research in Music Media and Technology (CIRMMT) and McGill University (Canada), supported by the *Appui à la recherche-création* program of the *Fonds de recherche sur la société et la culture (FQRSC)* of the Quebec government [13]. From 2005 – 2008, the project brought together researchers from three musical disciplines: performance, composition, and music technology. The Digital Orchestra team addressed issues of digital instrument design, real-time software systems implementation and gesture-to-sound mapping strategies. As a result, a principal output of the project has been the creation of new DMIs that include the FM Gloves, the T-Box, the T-Stick family and the Rulers. The project culminated in March of 2008 with the premieres of two new compositions for these instruments during the MusiMars Contemporary Music Festival in Montreal. *The Long and the Short of It*, a three-movement work by Heather Hindman, featured the extended 'cello and two digital instruments, the T-Box and the FM Gloves. *sounds between our minds* by D. Andrew Stewart featured the Soprano T-Stick, the Tenor T-Stick and the Rulers.

2. THE INSTRUMENTS

The DMIs were built by researchers from the Input Devices and Music Interaction Laboratory (IDMIL) of McGill University in collaboration with the McGill Digital Composition Studios (DCS) and researchers from the performance and composition departments of the Schulich School of Music. *The Mapper* [3] and *The Digital Orchestra Toolbox* [4], [5] were tools specifically designed for the project by music technology research assistants Joseph Malloch and Stephen Sinclair, and employed for the collaborative development of mapping strategies.

2.1. Fortier-Marshall (FM) Gloves

The FM Gloves were developed by Mark T. Marshall, Heather Hindman, Stephen Sinclair, Xenia Pestova and Chloé Dominguez based on an earlier instrument designed by Pierre-Yves Fortier. The left hand employs four force sensing resistors (FSRs) mounted on the fingertips, and a two-axis accelerometer. The right hand uses four FSRs, a bend sensor attached to the underside of the index finger, and an infrared distance sensor on the inside of the wrist (Figure 1). The sensors are connected to a belt pack worn by the performer, which digitizes the signals and transmits them wirelessly to a Kroonde Gamma system. Parameters from the glove controllers are read into Max/MSP as Open Sound Control (OSC) messages. Within Max/MSP, various operations are carried out on the parameters, such as linearization, scaling and smoothing. These modified parameters are mapped to the synthesis system in Logic Pro [8].

2.2. The T-Box

The T-Box is a third generation instrument, based on initial versions by Geof Holbrook and Eileen TenCate. The design employs ultrasonic transmitters and receivers and senses the distance between them using the amplitude of the signal at the receiver, with the incoming signal passed through an envelope follower to extract the amplitude. The current version, redesigned by Mark T. Marshall, uses two microcontrollers, one to generate the square wave to drive the ultrasound transmitters and another to perform the envelope following. The performer wears two handpieces, each containing an ultrasound transmitter and four switches. The output of the transmitters is detected by four receivers on the top of the instrument. The T-Box interfaces to the computer us-

Figure 1. The FM Gloves.

ing a USB connection from an Arduino. Mapping and synthesis for the instrument are provided by a combination of Max/MSP and Logic Pro [9].

2.3. The T-Stick Family

The T-Sticks are a family of instruments designed by Joseph Malloch in collaboration with D. Andrew Stewart, Fernando Rocha, Erika Donald and Xenia Pestova. Four versions of the instrument have been built to date, including Soprano, Alto, and Tenor T-Sticks and a wireless T-Stick developed for control of sound spatialization by a dancer. The instruments are constructed using a structural substrate of ABS or PVC plastic pipe, to which various sensors are affixed [6]. The interface features multi-touch capacitive sensing, five independent axes of acceleration sensing (one accelerometer at each end of the controller), pressure sensing, and a piezoelectric contact microphone for sensing deformation. All sensors are sampled using an internal microcontroller, and the data are sent to a computer using either wired USB, Bluetooth, or ZigBee wireless protocols depending on the T-Stick version [7].

2.4. The Rulers

The Rulers were conceptualised by David Birnbaum at the Banff Centre New Media Institute. A new version was commissioned for this project, with signal processing and sensor calibration routines designed by Stephen Sinclair. The instrument consists of a set of "tines" of differing lengths - strips of metal which oscillate mechanically when set in motion by the performer. Infrared sensors are used to measure the height of each tine, which is sampled by a microcontroller and transmitted to the computer using USB. The tines can be used for direct manipulation of parameters, or as a tangible "low frequency oscillator" [1], [2]

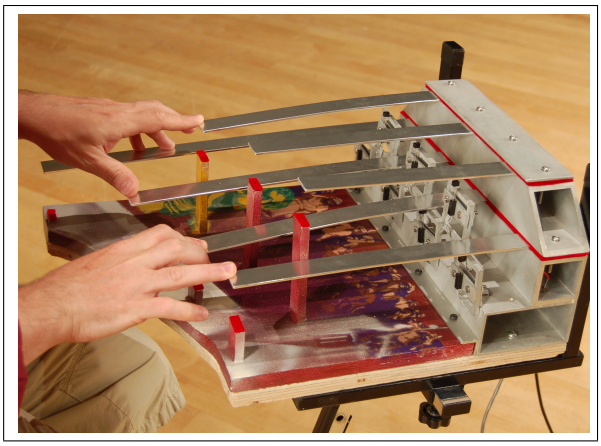

Figure 2. The Rulers with the tines being manipulated.

(Figure 2). Higher-level gesture information is extracted, such as thresholding for triggers and manual damping, signal derivatives for relative tine movement, and leaky integration for short-time energy estimation. These signals are converted to MIDI for use with Logic Pro.

3. COMPOSITION

3.1. The Composers' Tasks

The principal role of the two composition research assistants in the Digital Orchestra Project was to produce new musical compositions for DMI ensemble, including one "mixed" work for DMIs and violoncello. In order to create a "voice" for each instrument, sound synthesis and mapping strategies were developed in collaboration with music technology and performance research assistants. Additionally, notational systems and software for on-screen graphical user interfaces (GUI) were designed for the instruments.

3.2. Notation

Through collaboration with the performance research assistants on the project, composers were able to design systems of musical notation that balance representations of sonic gesture and physical playing gesture. The notation consists of both traditional music symbols and abstract shapes. These are combined with customised symbols that represent physical gestures specific to each DMI. The FM Gloves, for example, employ an intuitive and visual approach. Left-hand finger pressure is marked by the position of the note head on one of the four lines of the custom staff. Timbral control is notated by a direct visual representation of the position of the right hand accelerometer in space, with graphic notation representing reverb and delay activated by pressure sensors on the right hand glove (Figure 3). In notation for the Rulers, the composer also opted to use lines of the staff to show percussive attacks achieved by tines being struck,

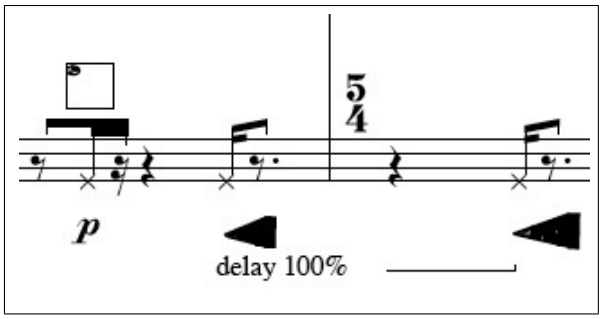

Figure 3. The FM Gloves notation shows left hand FSR attacks (on the staff), accelerometer position controlling timbre (inside the square), and right hand FSR activating delay (wedge shapes).

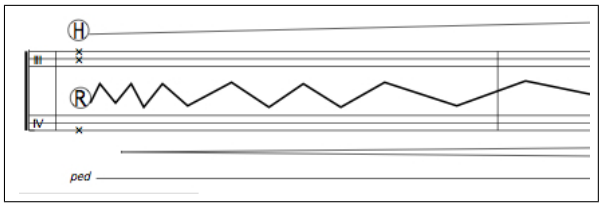

Figure 4. The Rulers notation shows tine positions of initial onset and continued manipulation of the sustained sound by raising and lowering two of the tines at different rates.

in addition to graphic notation representing the vertical manipulation of specific tines used to timbrally modify the resonance (Figure 4).

3.3. The Pieces

3.3.1. The Long and the Short of It

The Long and the Short of It by Heather Hindman is a series of short pieces for solo 'cello with live electronics, the T-Box and the FM Gloves. The title references an idiom used when one wants to state something in the quickest way possible, often resulting in a grotesque or simplistic summarization of a more complex idea. In this work, the 'cello sounds were classified into simple categories of "long" and "short," and then used as the inspiration for the sound design of the DMIs. It was an attempt to deal with music at a skeletal level where materials were first distilled into simplified categories, and then used to construct music within these extreme limitations, maximizing brevity.

3.3.2. sounds between our minds

Possession and enchantment is the subject-matter of *sounds between our minds* by D. Andrew Stewart, scored for the Rulers and the Soprano and Tenor T-Sticks. While drawing on ritualistic aspects of possession trance, the composer envisioned a music of fits and starts, potentially leading to crisis as well as silence. Pulse is an important ingredient of the music, although there is no extant evidence that steady rhythm is a necessity of trance, or of "being possessed." Understanding the components of possession is ultimately a factor in understanding the culture and context to which the possessed belongs. *sounds between our minds* evokes our technologically-dependent culture. In this context, musicians are possessed by the technology, the object, the instrument – in line with a quality of music established by tradition.

4. PERFORMANCE

4.1. The Performers' Tasks

The performance research assistants' roles involved intensive work with the instrument designers and composers on the sounds and playing techniques of the instruments. These objectives were attained through a series of mapping and improvisation sessions, as well as extensive discussion on musical gesture and notation. The lack of performance tradition or "existing body of technique" [10] for these new instruments emerged as an important consideration: most DMIs are not associated with methods, repertoire, or advanced performers. The authors found that when learning to play a DMI, one must be able to access basic features that include starting and stopping a sound and achieving control of rhythms and volume. One challenge was to reduce the potentially infinite sound possibilities presented by new instruments and isolate approachable parameters for practicing [10].

4.2. Gesture to Sound: Challenges and Solutions

4.2.1. Notation: The Performance Perspective

In order to become familiar with the new DMIs and develop systems of notation, composers and performers have to spend time improvising and discovering the capabilities of the instruments [12]. Fixed notation forms can only be established after this period of experimentation. While attempts at notation have been made with this project, these systems can develop further in relation to gesture-to-sound mappings, with which they are inextricably linked.

4.2.2. Latency

Latency was one of several important challenges encountered in individual practice and ensemble rehearsal, in particular in relation to the Rulers and the two T-Sticks in *sounds between our minds*. Synchronization between performers was highly problematic in this chamber music-like context. Several solutions were employed, including software modification and changes to the musical writing of the piece by the composer to make synchronization less crucial.

4.2.3. Ergonomics

Another important concern was the development of ergonomic ways to produce sound. This issue was especially noticeable in practice sessions with the FM Gloves. The instrument's sensors allowed for many possible movements to be mapped, but physical comfort of the performer was also necessary. This meant that the distance of the right hand from the body while using the infrared sensor and the angle of the left hand for the accelerometer required adjustment and modification. In the final version, the gloves themselves were replaced in order to accommodate smaller hand size.

4.2.4. Sound Diffusion

The question of sound diffusion and balance in performance situations was not addressed until the final stages of the project. Being able to control one's sound level on-stage is important, and may be compared to performances by acoustic musicians who are trained to project to the audience in the performance space [11]. During rehearsals in the studio, each performer was equipped with their own speaker, allowing for individual level control. However, acoustics in performance environments made achieving adequate sound balance and differentiating between the instruments more difficult, due in part to the lack of refined dynamic control and distinct instrument identities (several instruments used the same synthesizer, Logic Pro's *Sculpture*). This complex issue can be addressed in the sound synthesis and mapping stages of DMI design, as well as further experimentation with speaker placement and sound projection.

5. CONCLUSIONS

The CIRMMT/McGill Digital Orchestra Project is a successful example of interdisciplinary collaboration between researchers with differing backgrounds. In addition to designing and building new DMIs, the team's accomplishments include creative output and the establishment of basic performance practice for the instruments. As the Digital Orchestra instruments and repertoire continue to evolve, the authors hope to further refine the gesture-to-sound relationships, notational systems and performance paradigms.

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