Composing for DMIs - Entoa, music for Intonaspacio

Clayton Rosa Mamedes
NICS - CIDDIC, Unicamp
IDMIL - CIRMMT,
McGill University
Campinas, Brazil
Montreal, Canada
claytonmamedes@nics.unicamp.br

Mailis G. Rodrigues
CITAR UCP
IDMIL - CIRMMT,
McGill University
Porto, Portugal
Montreal, Canada
mailisr@gmail.com

Marcelo M. Wanderley
IDMIL - CIRMMT
McGill University
527 Sherbrooke St. West
Montreal, Canada
marcelo.wanderley@mcgill.ca

Jônatas Manzolli
NICS Unicamp
165 Rua da Reitoria
Campinas, Brazil
jonatas@nics.unicamp.br

Denise H. L. Garcia
CIDDIC Unicamp
421 Rua Sérgio B. de Holanda
Campinas, Brazil
d_garcia@iar.unicamp.br

Paulo Ferreira-Lopes
CITAR UCP
Rua Diogo Botelho, 1327
Porto, Portugal
pflopes@porto.ucp.pt

ABSTRACT

Digital Musical Instruments (DMIs) have difficulties establishing themselves after their creation. A huge number of DMIs is presented every year and few of them actually remain in use. Several causes could explain this reality, among them the lack of a proper instrumental technique, inadequacy of the traditional musical notation and the non-existence of a repertoire dedicated to the instrument.

In this paper we present the case study of *Entoa*, the first written music for *Intonaspacio*, a DMI we designed in our research project. We propose a process of composition that considers the design of the instrument as a required step in order to start defining an instrumental technique. We present an overview of the instrument and strategies for mapping data from sensors to sound processing, in order to accomplish an expressive performance.

Keywords

DMI, Music Composition, Gestural Acquisition, Mapping

Introduction

New musical instruments normally emerge from a necessity of new sounds, and new musical paradigms. Over the last few years we have been witnesses of a flourishing area of new musical interfaces, evidenced by the continuous presentation of new musical instruments every year. However, only few of them have an historical continuity, i.e., a few number of these digital musical instruments (DMIs) are still in use. Nevertheless, this is not a common subject in conferences as NIME. If we review the proceedings of the last editions, a scarcely number of the presented papers refer to questions related to the challenges DMIs have to face [12], [3], [20], [13], [14]. We believe that the reasons for the short-life cycle of most of the DMIs are essentially three: the lack of an instrumental technique dedicated to the musical instrument, the necessity of a new form of musical notation more suitable for DMIs, and the non-existence of a repertoire. All of this problems are interconnected.

NIME'14, June 30 – July 03, 2014, Goldsmiths, University of London, UK.

DMIs present an ensemble of characteristics that bring new considerations in music. We will not focus on the separation between the sound control and sound generation system, since this had already been treated extensively by other authors [5],[24],[4]. From an overall review on the literature on this subject, we understand that a DMI is presented, most of the times, as an hybrid object. On one hand, DMIs appear as musical toys, musical gadgets or interfaces on a sound installation, functions that require a straightforward strategy to allow everyone to be able to play them [6], [12]. In several other situations DMIs are related to musical instruments, with a great amount of expressivity, and consequently demanding a learning stage [6], [13]. Although this characteristic does not need to be negative per se, since it opens the music universe to unsuspected performers (music amateurs, public in general), it also introduces some confusion in the definition of the roles of the performers, instrument designers and composers.

The concept of DMI has been, in our view, strongly connected with performative music, where improvisation has a marked position. Chadabe [6] refers that an interactive instrument[1] combines performance and composition. In consequence of these mixed roles (performer - composer) both Chadabe [6] and Toeplitz [23] support the idea that no notation is needed. Toeplitz states that the computer already uses a symbolic language, which makes musical notation pointless. The function of music sharing and preservation would be performed by the computer itself. This presents some problems, especially with obsolete or discontinued software[2]. Thus, musical notation still has a functionality on contemporary practices. We can, however, envisage new ways of notation, more suitable for composing music with DMIs. A gestural notation where the idiomatic gestures [14] [22] of the instrument would be represented, can be a good solution. The existence of a gestural grammar reflects the creation of an instrumental technique that is particular to the instrument and can be shared between performers. It also makes it easy to learn the instrument, and allows the organization of a community of performers and composers.

[1]The idea of interactive instrument for Chadabe relies on the mutual reaction of the instrument to the performers actions and vice-versa. The performer does not have the total control over the instrument. However, not all DMIs fall in this classification, interactive instruments would be a particular case in the universe of the DMIs.

[2]Digital conservation is one of the main issues on digital art disciplines.

The method we propose and exemplify below can be implemented using as a reference the study of instrumentation[1]. In this, the student learns the properties and resources of each instrument, as well as examples of its usage. We propose a collaborative work between composers and instrument designer that will define an instrumentation and patterns of notation for the new DMI.

We designed a DMI - Intonaspacio, in which we observed the most common gestures performed with the instrument, from an experiment with several participants. These will make part of what we believe would be a gestural grammar of Intonaspacio, allowing the construction of gesture based scores. Finally, we collaborated with a composer, who wrote Entoa, the first written piece for Intonaspacio. The final goal is to create a repertoire for Intonaspacio and to establish a gestural grammar emerging from the experience with several composers and performers.

Intonaspacio

Intonaspacio [19] is a digital musical instrument, in which sound ambiance is integrated on the process of sound generation, in real-time. It allows the creation of site-specific sound, adding the room as an extra parameter in music composition. The gestural interface is a sphere with an ensemble of sensors that allow the control of the sound material, Figure 1. The sensors are: an Inertial Measurement Unit (IMU) with a three-axis accelerometer, gyroscope and magnetometer that sense orientation and impact; two piezoelectric sensors with different sensibilities for detecting impact on the structure, an infrared (IR) sensor to measure distance, and finally a wireless mic to capture and record the sound ambiance of the room. The information collected by the sensors is sent to a computer using an Xbee. Once the instrument is completely wireless, the performer could explore space restricted only by the range of the Xbee itself. We decided to use sensors with different sensibilities in order to have different degrees of freedom and thus an instrument with more expressive potentialities. Mapping

Figure 1: Intonaspacio

was divided in two main layers, one corresponding to the extracted features of the instrument, and the other to the sound control of the instrument. This allow us to have a first layer, immutable, which would correspond to the behavior of the instrument, and hand over the second layer - the sound generation, to composers. Although Intonaspacio has a variable voice, the gestural interaction is stable. This helps in the learning process and to engage the performer.

The extracted features were calculated from the information retrieved from the sensors. These are not always directly proportional to the sound control, i.e., the relation between the sensed gesture and the sound reaction is not a linearly one. Instead we use derivative (rate of change of a variable) relations, as well as integration (how much time a performer maintains the same action). It creates complex relations and the performer, after a learning period, is able to control Intonaspacio more accurately.

Entoa: relate sensors to sound

Entoa (2013) is the first musical work for Intonaspacio. Composed especially to the instrument, the work explores its built-in features and aims to create an expressive and intuitive performance that emphasizes the spherical shape of the instrument. The composition process started by the definition of groups of sensors, based on range and measured action (distance, impact, and so on) associated to each sensor. Groups of gestures were cataloged and associated to sound events, in order to establish action-reaction couplings that could be recognized by the audience as intuitive [2] and expressive [15], [11]. Classification of sound events was based on the spectral typologies of sounds and its dynamic morphologies [21].

The sound design in Entoa explores a timber palette of metallic sounds. Sound events are triggered and processed in real-time, based on the interactions between performer and instrument. Shape, size and speed of gesture control sound features as sound intensity, superposition of sound layers, variation of spectral content through sound processing and displacement of sound sources in spatial diffusion.

Notation of Entoa

The notation of Entoa comprises a text-based indicative score, consisting of verbal signs suggesting how the work can be performed. [3].

The score of Entoa provides simple guidelines to gestures and expressive possibilities to the performer (details about velocity, size, duration or overlaying of gestures are purposely left to the responsibility of the performer). This option causes Entoa to become an indeterminate performance. As they are, these instructions allow a large range of interactive possibilities with the instrument. Nevertheless, the overall form of the composition, the articulation of its sections, dynamics and expressive possibilities, are bounded by a set of specific indications set by the composer.

Finite-state machine model as formal structure

To organize the formal development of the music, we implemented a composition structured as a finite state-machine model [9]. In this approach, each state in the music progression corresponds to a new section. Each section has an independent group of procedural rules, which in our case comprises different mapping designs for each section. Transition among states is established based on predefined rules with schematic outlines that smooth these transitions.

The designed mappings provide a rigid structure for data processing and have a limited range of interaction for selected sensors and sound events. This model introduces a creative process grounded on bounded sections that have a specific sound design, mapping and formal function inside the work. Below, we present details on the mapping of all sections.

[3]Examples of this notation are the works of Steve Reich *Pendulum Music* [17] and *Clapping Music* [18], or performance instructions used by some members of Fluxus [7]

The state S of the work increases from 1 to 5, conditioned by a fast sequential playing of piezos $P2$ and $P1$, in a time span measured in milliseconds :

$$S = S_{i+1} \quad if \quad 0 < t_{P2} - t_{P1} < 500ms \tag{1}$$

A three-dimensional model of sound spatialization is implemented in all states, and it is based on the rotation of the instrument and the distance at which the instrument is from the performer. The model uses a linear mapping for rotation data, set after a number of experimental tests. This aims to increase space control and make clear to audience the relation between gestures of rotation and sound diffusion. The performer can control displacement of sound sources by rotating Intonaspacio around its vertical axis within a range of $0 < \theta < 360$ degrees. Rotating around the horizontal axis of the instrument will cause the sound sources to displace vertically within a range of $-90 < \varphi < 90$ degrees. The spatialization model is based on a 3D Vector Based Amplitude Panning. The IR sensor measures the distance between performer and instrument. The sensor tracks distances within a range of $0 < d < 30$ centimeters. The extracted distance is converted to a spatial distance d_s within a range of $0 < d_s < 5$ meters. Different venues would ask for different configuration of speakers in the patch, in order to correct or simulate space in different rooms.

Section 1

Section 1 uses recordings of singing bowls pre-processed with ring modulation. This effect creates a sound environment composed by notes with an inharmonic spectrum and an open attack-decay profile [21]. Dynamically, this section starts with a *pianissimo*, and progressively increases to a *mezzo-forte* before reaching next section. Interaction in this section consists on triggering sounds with both piezoelectric sensors and spatialization control. The dynamics of the triggered sounds are retrieved from the analysis of the acceleration time interval when the sensors are tapped. Our model analyses time interval t in milliseconds between crossing of a noise threshold n and an attack threshold a. Amplitude values e are constant, settled according to a certain sensibility chosen by performers. This model relates velocity of attack a to sound level:

$$a = \frac{e}{t_n - t_a} \tag{2}$$

Since the distance between the sound source and the listener changes the perceived dynamics, we use this spatial cognitive feature to control sound intensity between each triggering. To make this feature credible, all sounds events were slightly compressed, which increased the resonance intensity. Thus, the performer can continuously control presence, direction and intensity of sounds combining rotation and distance of the instrument to his/her body.

Section 2

In the second section, a track of sequenced sound events is reproduced. This track contains sounds with closed attack-decay combinations and continuously graduated dynamic morphologies, as well as sounds with spectral typologies of both harmonic and inharmonic notes [21]. This track is processed in real-time by an harmonizer. Interaction with Intonaspacio controls the parameters of the harmonizer, changing the spectral content of sounds.

In section 2 we use the Roll descriptor to control the amplitude of the sound effect. For each sound channel we have defined a different configuration for the harmonizer, increasing perception of space and preserving musical appeal by response to movement. Direction of rotation for Roll ϕ controls the intensity of harmonizer effect for left h_l and right h_r channels:

$$\begin{array}{l} h_l = |\phi| \quad if \quad \phi < 0 \\ h_r = \phi \quad if \quad \phi > 0 \end{array} \tag{3}$$

Mapping of h_l and h_r values considers that changes in higher frequencies are more noticeable by audience due to masking effects [8]. We progressively accentuate curves when mapping these values to higher frequencies of the harmonizer.

Section 3

Section 3 was conceived as the central apex for the work. The previous section concludes in a *mezzo-piano* or in silence (according to the performer's criteria) giving an expectation of continuity. The conceptual schema of this piece expects a rupture induced by a strong interaction of the performer with the instrument. We expect a dynamic range from *forte* to *fortissimo*. In this section, a track of sequenced sounds constituted by notes with an inharmonic spectrum [21], is continuously played. An amplitude envelope controls the dynamics of the sound according to the information retrieved from the gyroscope, in the x and y axes. When the performer moves the instrument and the angular velocity α surpasses a certain threshold u, it initiates the sound with an amplitude L, otherwise the sound is muted, as follow:

$$L_k = \begin{cases} 0 \quad if \quad \alpha_k < u_\alpha \\ \alpha_k \quad if \quad \alpha_k \geq u_\alpha \end{cases} \tag{4}$$

The envelope has a 10 milliseconds fade in and fade out to smooth the appearance of sound. This is particularly useful when the instrument is moved very fast.

Section 4

Section 4 combines sounds of singing bowls from Section 1 with a track of percussive sounds with node spectral typology and attack-impulse morphology [21]. In this section, we return to the same idea of controlling sound events by tapping on the piezoelectric sensors, while sound diffusion is controlled with Yaw and Pitch angles, for both the continuous sound and the triggered sounds. Pitch also controls a chorus effect, in a similar mapping to the one presented in Equation 3 for Roll. Conceptually, at this moment of the work, we expect a reduction of the sound level and gestural interaction of the performer with Intonaspacio.

Section 5

The last section of the work conducts a large *crescendo* that concludes the work in a *sforzando* followed by a short coda. The singing bowls of the previous section are still present, together with a sound track constituted by sounds of nodal spectrum and gradually continuous morphology. Jab gestures are introduced, that trigger brief inharmonic sounds with low pitch, high amplitude and a sharp closed attack-decay morphology [21]. The sum of the accelerometer values for the three coordinate planes retrieves jab gestures. In this section all sensors are used simultaneously. At this point, the performer had explored, in previous sections, the features of the instrument individually. Section five is when the performer can explore the combination of all the expressive possibilities of Intonaspacio.

Conclusion

DMIs face certain difficulties in order to have historical continuity. Most of the novelties presented every year are not able to arouse the attention of enough musicians or

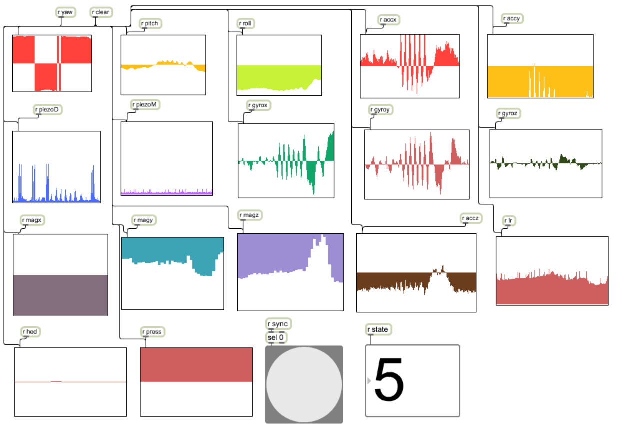

Figure 2: State 5: sensor's activity

composers, which could prevent its disappearance. Several causes could be pointed to explain this condition, including the idiosyncrasy of DMIs [16] [10] or their obsolescence. In this paper, we point three important characteristics that we believe contribute to the preservation of DMIs: the existence of a musical notation, the creation of an instrumental technique for the musical instrument and finally, the creation of a dedicated repertoire. We focus especially in the last one, presenting an example of a music written especially for a DMI - Intonaspacio.

Traditional musical notation are not suitable for most of these new instruments. Also, DMIs are more centered in a performance and improvisation situation than the traditional composition. Most of DMIs don't produce single note entities which make it difficult to adapt to traditional musical notation. Thus, we propose the construction of a gestural grammar of the instrument that would be the basis for the formation of a new musical notation, focused in gestures, and more suitable for DMIs.

We present our collaborative experience around the composition of Entoa as a case study that explains chosen strategies exploring the shape and resources of the instrument, a gestural grammar resulting from composition and performance, as well as mapping configurations that implement our usage of the sensors of Intonaspacio. We propose here a process of composition that includes exploration and documentation, allowing in the future to establish a grammar comprising the idiomatic usage of the instrument.

Acknowledgments

This research is supported by the Foundation for Science and Technology (FCT, Portugal) and by the São Paulo Research Foundation (FAPESP), grants 2011/01553-8 and 2012/21039-0.

1. REFERENCES

[1] S. Adler. *The study of orchestration*. W. W. Norton & Company, 2002.

[2] M. A. Boden. *Mind as Machine: A history of cognitive science*. Oxford University Press, 2006.

[3] J. Butler. Creating pedagogical etudes for interactive instruments. In *Proccedings of the 2008 Conference on New Instruments for Musical Expression*, Genova Italy, 2008.

[4] C. Cadoz. *Interfaces Homme - Machine et création musicale*, chapter Continuum énergétique du geste au son - simulation multisensorielle interactive d'objets physiques. Hermes, 1999.

[5] C. Cadoz and M. M. Wanderley. *Trends in Gestural Control of Music*, chapter Music - Gesture. IRCAM - Centre Pompidou, 2000.

[6] J. Chadabe. The limitations of mapping as a structural descriptive in electronic instruments. In *Proccedings of the 2002 Conference on New Instruments for Musical Expression*, Dublin Ireland, 2002.

[7] K. Friedman. *The Fluxus Reader*. Academy Editions, 1998.

[8] S. A. Gelfand. *Hearing: An Introduction to Psychological and Physiological Acoustics*. Informa Healthcare, 2010.

[9] A. Gill. *Introduction to the theory of finite-state machines*. McGraw-Hill, 1962.

[10] R. Gluck. Live electronic music performance: innovations and opportunities. `http://www.ciufo.org/classes/sonicart_sp09/readings/gluck_liveelectronics.pdf`, Fall 2007.

[11] D. Huron. *Sweet anticipation: music and the psychology of expectation*. MIT Press, 2006.

[12] S. Jordá. New musical interfaces and new music-making paradigms. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, 2001.

[13] S. Jorda. Digital instruments and players: Part i - efficiency and apprenticeship. In *Proccedings of the 2004 Conference on New Instruments for Musical Expression*, Hamamatsu Japan, 2004.

[14] J. Malloch and M. M. Wanderley. The t-stick: from musical interface to musical instrument. In *Proccedings of the 2007 Conference on New Instruments for Musical Expression*, New York USA, 2007.

[15] L. B. Meyer. *Emotion and Meaning in Music*. Chicago University Press, 1956.

[16] N. Orio and M. M. Wanderley. Evaluation of input devices for musical expression: Borrowing tools from hci. *Computer Music Journal*, 26(3):62–76, Fall 2002.

[17] S. Reich. Pendulum music. Musical score, 1968.

[18] S. Reich. Clapping music. Music Score, 1972.

[19] M. G. Rodrigues, M. M. Wanderley, and P. Ferreira-Lopes. Intonaspacio: A digital musical instrument for exploring site-specificities in sound. In *Proceedings of CMMR*, Marseille France, 2013.

[20] N. Schnell and M. Battler. Introducing composed instruments, technical and musicological implications. In *Proccedings of the 2002 Conference on New Instruments for Musical Expression*, Dublin Ireland, 2002.

[21] D. Smalley. *The language of electroacoustic music*, chapter Spectro-morphology and structuring processes, pages 61–93. Macmillan, London, 1986.

[22] D. A. Stewart. Digital musical instruments composition: Limits and constraints. In *Proceedings of the EMS*, Buenos Aires, Argentina, 2009.

[23] K. Toeplitz. L'ordinateur comme instrument de concert. In ADERIM-GMEM, editor, *Actes des neuvièmes Journées d'Informatique Musicale*, pages 199–207, Marseille, 2002.

[24] M. M. Wanderley. Gestural control of music. In *International Workshop Human Supervision and Control in Engineering and Music*, pages 623–644, September 2001.