MOTION-ENABLED LIVE ELECTRONICS

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ABSTRACT

Motion-Enabled Live Electronics (MELE) is a special approach towards live electronic music aiming at increasing the degree of the performers' embodiment in shaping the sound processing. This approach is characterized by the combination of a high-resolution and fully-3D motion tracking system with a tracking data processing system tailored towards articulating the relationship between bodily movement and sound processing. The artistic motivations driving the MELE approach are described, an overview of related work is given and the technical setup used in a workshop exploring the approach is introduced. Brief descriptions of the pieces realized in the workshop and performed in the final concert inform the presentation of the conclusions drawn from the workshop.

1 INTRODUCTION

This paper describes a workshop exploring a particular approach towards live electronic music aiming at increasing the degree of the performers' embodiment in directing or shaping the sound processing. The workshop took place in the context of the *impuls 2009* [1] international ensemble and composers academy for contemporary music held biannually at the University of Music and Performing Arts Graz (KUG). Six composers and six performers from Europe, North America and Japan participated in the one-week workshop entitled *Motion-Enabled Live Electronics* held in the CUBE performance space [1] at the Institute of Electronic Music and Acoustics (IEM). The six pieces prepared for – and further developed during – the workshop were presented in the CUBE in a concert entitled *Enacted Electronics*. This concert took place on February 22nd 2009 and was transmitted via multi-channel Internet streaming to two remote locations in the context of the *CO-ME-DI-A* [2] project, one of which in Graz (MKL at Kunsthaus) and the other one in Paris (IRCAM). In this paper we explain what motivates our approach, we describe the system developed to realize it and we report about the experiences made in the workshop and the concert.

[1] c.f. http://www.impuls.cc/, accessed 2009/04/12
[2] c.f. http://www.comedia.eu.org, accessed 2009/04/08

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2 MOTIVATIONS

Motion-Enabled Live Electronics (MELE) uses state-of-the-art motion tracking [3] of the performers' instruments or body parts (e.g. head, arm, or wrist) to inform the sound processing and projection. There are several motivations for the MELE approach.

In a typical live electronics concert, where the sound of the instruments is picked up with microphones to be processed and then projected via loudspeakers, the performers on stage may either resort to simple interfaces such as pedals and switches to control the processing or the live electronics are controlled by an additional operator off-stage. MELE was developed with the aim of providing performers with autonomous and intuitive control of the live electronics. MELE insures intuitiveness by unobtrusive bodily control (no need for physical interfaces other than tracking markers) and autonomy through independence from additional operators. These will still be needed to ensure optimal sound pickup and projection, but they will be less concerned with actually performing the live electronics. Performing should be in the hands of the performers as much as possible, for allowing them to fully identify with their very role, especially with respect to the live electronics.

In playing a musical instrument, the performer's body typically extends into this instrument – the instrument becoming part of the performer's body schema (in the sense defined in [2]). In order for the performers' bodies to extend into the sound processing and projection as much as they usually do into their instruments, a more bodily access to live electronics is in need. This is difficult to achieve with standard controllers because of the low dimensionality and low spatial or temporal resolution of their control spaces. In using refined motion-based interfaces for live electronics, sound processing and projection may rather be *enacted* than *operated* by the musicians, which is one of the goals of our approach.

[3] c.f. http://www.vicon.com, accessed 2009/04/08

From a composer's point of view, being able to make use of the location and orientation of the performers' instruments or body parts to inform the sound processing opens up completely new perspectives of conceiving the stage space as an interface. For instance, this space may be structured as a parameter space in which the performers navigate by moving about the stage. Or the relative distances and orientations of the musicians may inform the live electronics such as to include socio-spatial and psycho-spatial aspects of performance. One may think of the performers to *inhabit* a composed virtual stage space. Of course, all these aspects assume employing mobile instruments that may be carried around by the performers while playing.

Through detailed motion tracking of the musicians or their instruments, accompanist or ancillary gestures [4] may be harnessed ("instrumentalized") to shape the transformation and spatialisation of the instrumental sound. Besides their effect as "expressive movements", these gestures also color the sound of the instrument as a consequence of the movement, which results into a varying acoustic excitation of the performance space [4]. Therefore, when used for controlling the spatialisation of the processed instrumental sound, the audible effect of these gestures will be recognized as highly familiar by the audience, heightening their empathy with the performer and enhancing their immersion in the performance.

3 RELATED WORK

As described in the section 4, the MELE approach and setup are rather particular. Therefore there is not so much other work directly related to MELE. Of course, various kinds of motion tracking have been used to control sound processing and synthesis (e.g. with the EyesWeb system [5] or with VNS [5] used to create what Winkler calls "motion-sensing music" [6]), but very rarely high-definition systems such as the one employed in MELE have been used in stage performances. This is due to the low availability of such technology and the complexity of using it in live performance. It was one of the objectives of the MELE workshop, to show that such systems can be used successfully in a concert situation. Nevertheless, MELE shares many aspects with work in the field of gestural control of sound synthesis, processing and spatialisation, which has received wide attention in the field of sound and music computing during the last decade (e.g.[7] and [8]). MELE is closely related to tracking-based approaches such as TrakHue [9], where the live electronics are controlled via body motion. Recently a special focus on questions concerning gesture controlled spatialisation can be noticed (e.g. the work of Marshall et al. [10] and Schacher [11]). Although MELE has also been used to control sound spatialisation, its approach is more holistic in the sense that sound processing and spatialisation are considered in common – as being *inseparable aspects of live electronics*. One of the objectives of MELE is to offers a framework to treat both aspects in concert. In most of the work related to MELE, the sound is produced or transformed by the motion of the audience (such as in installation situations, e.g. using a system like VNS) or by dance performers (e.g. [6]). The project that had the biggest influence on MELE is the Embodied Generative Music (EGM) project [6], which also supplied much of the technological infrastructure described next.

[4] "those gestures that are part of a performance, but that are not produced for the purpose of sound generation" [3])

[5] c.f. http://homepage.mac.com/davidrokeby/vns.html, accessed 2009/04/10

Figure 1. A 4-marker tracking target mounted on a clarinet using a Marschgabel fitting (and microphone attached)

4 THE MELE SETUP

This section describes the features of the setup that has been proposed by the workshop organizers to the participants. These features have been communicated to the composers before they developed their pieces for the MELE setup. The preparation of these pieces has been followed closely by the workshop organizers prior to the workshop, so composers arrived at the workshop with almost finished scores or at least clearly defined concepts.

The setup was determined by the studio and performance space in which the workshop and the concert took place. This space is equipped with a 24-channel hemispherical loudspeaker array optimized for Ambisonics spatialisation and a video motion tracking system [7]. The setup constrained the stage space to a circular region in the center with a diameter of about 6 meters. The audience was seated in a circle around the stage. The stage space was fully covered by the tracking system, allowing for relatively large movements of up to three musicians to be tracked. As the loudspeakers

[6] c.f. http://embodiedgenerativemusic.org, accessed 2009/04/10

[7] composed of 15 M2 cameras and a V624 data station by Vicon

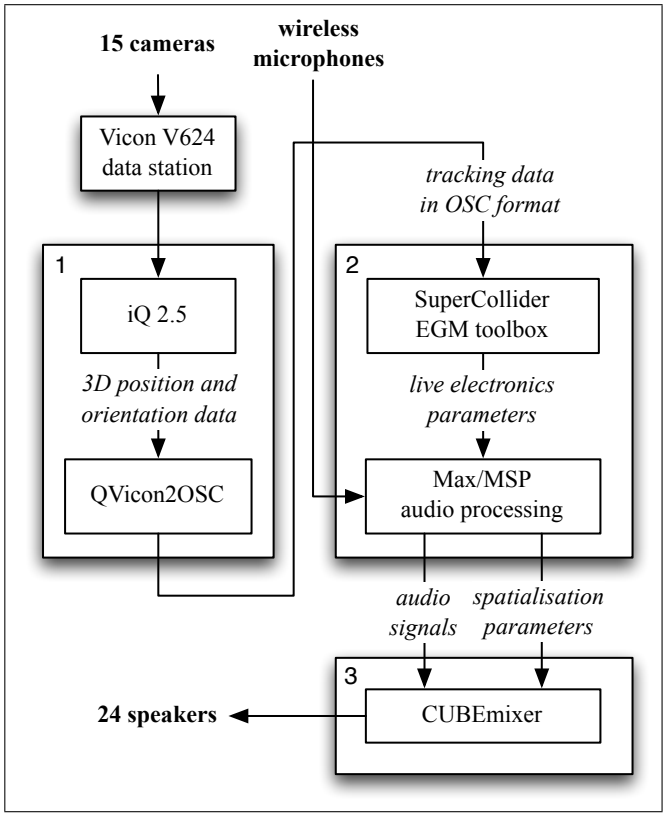

Figure 2. The MELE setup, signal and data flow

were located behind the audience, a very intimate situation arose for performance and sound spatialisation – the musicians and the audience actually sharing the same acoustic and visually unoriented space.

The musicians were equipped with wireless microphones and tracking markers, either mounted on their instruments (figure 1) or worn on their arms (figure 4) or heads (figure 6). The mounting solutions were developed with the musicians prior to the workshop and were also determined by the way the musicians' motions were used in the pieces. An important requirement for the solutions adopted was that they should not interfere in any way with the musicians' normal playing and moving about the stage.

The computer infrastructure of the MELE setup consists of 3 machines, one dedicated to the tracking, a second one to tracking data and audio signal processing and a third one to the spatialisation (figure 2). The tracking system was controlled with the iQ2.5 software by Vicon. The tracking data was translated to OSC with the utility QVicon2OSC [8] and the Ambisonics spatialisation was realized with the Pd application CUBEmixer [12]. The tracking data was processed using a specialized toolkit implemented in SuperCollider (the EGM toolkit) and developed in the context of the EGM project. Sound processing was realized with Max/MSP or

[8] c.f. http://sonenvir.at/downloads/qvicon2osc, accessed 2009/04/10

Figure 3. Video still of Annegret Mayer-Lindenberg (viola), Jason Alder (clarinet), and Dana Jessen (bassoon) playing Jesse Broekman's piece *Langs Rafels*

SuperCollider – depending in the composers preferences. All communication between the mentioned programs was realized via OSC.

The particularity of the MELE setup can be seen in the combination of a high-resolution fully-3D tracking system with a tracking data processing system tailored towards applications articulating the relationship between bodily movement and sound processing – the EGM toolkit. The tracking system ensures a very high spatial (below 1 mm) and temporal (120 Hz) resolution, a low overall latency (about 20 ms from movement to sound), and a large tracking volume (more than 60 m^3). The EGM toolkit provides modules for data conditioning (e.g. geometrical transformations, scaling, filtering, clipping), feature extraction (e.g. speed, acceleration, periodicity analysis, relative distances and orientations), and physical modeling for the specification of the dynamics of virtual instruments (e.g. mass spring systems, potential energy surfaces). These physical models are typically used for generating synthesis and processing control parameters rather than sound.

5 WORKSHOP

Every composer used the MELE tool in his or her own way and developed an individual approach and concept of composing within the setup. In every piece a different idea for linking bodily movement and sound was investigated. In some cases a collective instrument was built that established a performative relationship between musicians and composer while in other pieces a "scene" was set up where spatial relations between the musicians were established. The performers shaped and spatialised their own or each others' processed sounds. Thus the idea of influencing sound through individual physicality was in some compositions expanded to a collective behavior. In some pieces these

choices focused on the physical and musical interplay between the musicians. In other compositions an environment was set up in which the performer interacted with sound sources or sound objects.

Different choices were taken and mixed in the use of improvisation as a compositional tool. Some compositions fixed the performers movements in the score while others left the kind and range of activity open for improvisation with space or sounds. Also different approaches using and integrating the proposed tool itself in the composition could be noticed. While some composers created a scored piece that was then projected into space and complemented with processed sounds, others started from the interaction and sound processing possibilities offered by the setup to develop the whole piece. Yet another option that was explored was to present an electroacoustic composition that was then interpreted with the help of the MELE tool by a musician controlling the spatialisation or the dynamics of the electronic part.

In his trio *Langs Rafels* for clarinet, alto, and bassoon, Jesse Broekman explores hidden layers of instrumental timbre revealed by his sound treatment. The musicians navigate each others' timbre spaces by moving about the stage, their spatial orientation shaping the sound spatialisation. In *Langs Rafels*, the clarinet, the bassoon and the right arm of the alto player are tracked (figure 3).

In Carlo Ciceri's duo *Violata* for alto and flute, the spatialisation of the processed sound is related to the positions of the musicians on stage as they revolve around the centrally placed music stands. The movements of the musicians' right arms induce subtle and organic micro-variations in the spatialisation keeping the projected sound alive (figure 4).

For his piece *Tball* for trumpet, David Pirrò created a virtual object with which the performer plays by participating in a real-time physical simulation. In listening to the sound resulting from the interaction and watching the behavior of the instrumentalist, the object appears in our imagination. In *Tball*, the trumpet's bell is tracked (figure 5).

For his violin and bass clarinet improvisation duo *A Short Walk Through Time*, Stephan Prins built a granulation-based virtual instrument which is played collectively by the performers' head positions and orientations. The composer is performing as well by controlling certain aspects of the instrument with a fader box. In *A Short Walk Through Time*, the two musicians wear tracked caps (figure 6).

In Gerriet K. Sharma's piece *cornerghostaxis #1* the bassoonist is accompanied by a fixed four-channel electroacoustic composition. The spatial behavior of the performer very subtly controls the spatialisation of the piece, thus allowing for an intimate relationship between the unprocessed instrument and the electronic sounds. In *cornerghostaxis #1*, a tracking target is attached to the bassoon (figure 7).

Tuning into paranoia by Shiori Usui is a piece for a trum-

Figure 4. Video still of Annegret Mayer-Lindenberg (viola) and Marie-Noëlle Choquette (flute) playing Carlo Ciceri's piece *Violata*

Figure 5. Video still of Paul Hübner playing David Pirrò's piece *TBall*

Figure 6. Video still of Marieke Berendsen (violin) and Jason Alder (bass clarinet) playing Stefan Prins' piece *A Short Walk Through Time*

Figure 7. Video still of Dana Jessen (bassoon) playing Gerriet K. Sharma's piece *cornerghostaxis #1*

Figure 8. Video still of Jason Alder (bass clarinet) and Paul Hübner (trumpet) playing Shiori Usui's piece *Tuning into paranoia*

pet and a bass clarinet player engaging in a dramatic situation on stage. The expression of their musically enacted state of mind is enhanced by the live electronics processing and its control through their socio-spatial relationship. In *Tuning into paranoia* the second bell of the trumpet and the head of the bass clarinet player are tracked (figure 8).

6 CONCLUSIONS

The role of the performers was central to the whole workshop. They confirmed that they could gain a new and different access to the issues concerning performance with live electronics. As the control of the electronics was "attached" to their bodies and their movement, the effect on the resulting sounds was more direct, without mediation through other external devices that they would have to learn to use or play. Because of the unobtrusiveness of the tracking they could move relatively freely in the space and in some cases forget the markers they were wearing or that were attached to their instruments. These preconditions assured that they could get more conscious about the changes they could provoke in the sound and in the spatialisation and get a more precise control of these. In a conclusive meeting after the final concert, having then a clearer overview of the possibilities of MELE, some of them felt that in some pieces not all the potential implicit in this approach has been explored by the composers and that they would like to explore live electronics much further in such a setup. In other cases the musicians – especially those involved in the pieces that used physical models to drive sound synthesis and projection – underlined that they felt having achieved a clearer understanding of the dynamics of the electronics and how they could influence it. In fact, during the rehearsals of these pieces the musicians surprisingly asked for a more complex thus a more "realistic" interaction with the programmed physical model, that was in the beginning kept simple, in order to achieve a finer control on the sound.

The fact that a large volume was reliably tracked gave the performers the possibility to move relatively unconstrained in the space. For the audience this created the impression that the musicians were playing in a "scene", an environment in which different things happen, controlling diverse aspects of the live electronics. This situation is opposed to similar contexts in which gestures or smaller movements are used to drive the live electronics. If a limited range of action is used by the performers, the impression is created that they are playing an additional instrument, highlighting their interaction with this "device".

As a consequence, the musicians felt themselves and their actions on stage very much in the focus of the audience's attention, which resulted in a different awareness of their performance. After the final concert, besides underlining that they surely will integrate these experiences in future performances, the performers formulated the need for a choreographic support, especially concerning the "mise en scene" aspects. But also the composers had to deal with issues concerning more explicitly the performance situation, which demanded to be composed or choreographed besides the notes that have to be played by the musicians.

A general issue that emerged during the MELE workshop concerned how composers and performers work together on a piece. In the end it became clear to all of the participants, that in the particular situation of this workshop, where the performers were deeply linked also with the electronics part of the pieces and thus to compositional choices and ideas, a collaborative way of working was needed involving equally both musicians and composers. This resulted in most of the cases in a process in which the performers took actively part in the composition by taking decisions and developing ideas. The composers had to relate to aspects of the performance from a compositional point of view, guiding and supporting

the musicians and taking into account their needs and constraints. This way of working together that established itself almost naturally was felt as very inspiring and rewarding by all the participants.

The MELE workshop was an intensive period of experimentation where many new but also already developed ideas were tested and put into work. Another important result is that both composers and performers could gain different insights in their work and especially in the relation between each other. These aspects are not specific to the particular context in which they were worked out – the CUBE or MELE – but refer to general issues concerning performance aspects thus applying to very different contexts.

As we have described in section 5 of this paper, the pieces realized during the workshop were very different from each other, adopting different strategies for the use of the tracking data and ways to link bodily movement to sound production and spatialisation. The spectrum of the solutions ranged from "classical" mappings to new approaches that used physical models as an intermediary level in the interaction of the musicians with the dynamics of the sound production and spatialisation. Particularly these last approaches were very inspiring especially for the performers as they could relate easily to such systems, gaining a very precise and intimate control of the electronics in those pieces.

Given the success of the workshop and the great interest of composers and instrumentalists in our approach, the next MELE workshop will be offered in the context of *impuls 2011* at KUG in Graz. Interested instrumentalists and composers should contact the first author of this paper in time, as only a few participants can be accepted.

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