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Introduction

Since the 1950s composers were inventing and experimenting with their own analogue electronics, making instruments, improvising and performing with them whilst intuitively stumbling upon new discoveries. The medium of performance with live electronics has come a long way from the initial experiments of the 1950s. Today, a setup of live electronic performer can easily combine acoustic instrumental processing with analogue and midi instruments in one digital set-up. The diversification and popularization of the medium could be attributed to the growing production market of midi controllers, digital software as well as wide world web communication and sharing of open source software, know-how and general information. Despite availability of many different live electronic tools, the live electronic instrument is often split in two: a fast processing digital laptop and a slick looking commercial midi controller which promises “intuitive”, almost no-knowledge necessary of the electronic processes beyond the basic button mappings. The easy to use formula has its benefits making electronic music tools easily accessible to many, however does the use of such products in live electronic performances make for captivating, out of the ordinary experiences? Or is there a danger that the automotive “button pressing” performances abstract the understanding both for performer and the audience making the experience incomplete, boring and sometimes inaccessible?

In order to free myself from automotive button triggering in live electronics I decided to research gestural control in performance with live electronics. To come to my own approach in working with sensors, I started with a question: how do I want to diversify my acoustic instrument, flute, so that it becomes possible to control my playing gesturally when playing with live electronics? Since I play flute also in other circumstances than with live electronics, it was important for me

to keep the instrument without significantly altering the mechanism or its body. I knew that I was interested in effective as well as accompanist gesture mappings, effective being those related to playing the instrument like pressing keys with a certain pressure sensor attached to it and accompanist being gestures resulting from controllable or expressive movements which occur during performance, gestures that could also be deliberate and composed[1]. The process of working with gestural instrumental interfaces in live electronics could challenge the role of the musician as more than a performer, it could expand this role. It demands personal research, making and composing with newly invented instruments or controllers as well as interdisciplinary approaches to the use of such extensions - the *mise en scene* for the situation of performance[2].

In *Beginning with Music Continuing Otherwise* issue of RTRSRCH magazine, Kathy Van Eck discusses her compositional methods with live electronics and amplified objects where live electronics for her a priori open new instances for composing or improvising with the body because once the sound becomes transmitted into electricity one can recompose the physical aspect of what is seen and heard[3]. In my research I looked at musicians who compose with gesture as an integral part of a composition or improvisation in live electronics. I also use this approach in my own compositions to allow for greater composed and improvised interdisciplinary possibilities.

Some innovative performances with live electronics evoke an experience where the abstract sound processes become recomposed through gestures by use of gestural controllers or sensor controlled interfaces. These gestures become visible beyond a button/knob operation that is

[1] Miranda R. Eduardo and Marcelo Wanderley. *New Digital Musical Instruments*. p 10.
[2] Eckel G., D.Pirro, G.K Sharma. 'Motion Enabled Live Electronics'. p 5.
[3] Van Eck, Cathy. *Beginning with Music Continuing Otherwise*. pp 9-12.

typical of commercial midi controllers. Many such performances have taken place in STEIM, a studio for electro instrumental music in Amsterdam where the history of the studio directly links to the history of gestural controller instrumental research because of the work of the many notable musicians, engineers and artists. In some instances, direct manipulation of the electronic instrument as in the case of former artistic director of STEIM Michel Waisvisz's Crackle Box (see fig. 1) where the body of the performer becomes a part of the musical electronic circuit itself:

Fig.1: Images of the Old and New Crackle Box (Text and Image Archive for Michel Waisvisz)

The great advantage was that by intuitively touching the electronics one could learn to play this new instrument without having to have schematic knowledge about the circuitry very much like a traditional music instrument. It could be learned by playing by ear and developing experience and manual/mental skills instead of having to dive into a world of logic, functions, interaction schemes, electronic circuit theory and mathematical synthesis methods. One could play an electronic instrument in direct relation to the immediate musical pleasure of performed sound.

(Michel Waisvisz in Interview with Andi Otto. August 27 2007)

At the time when MIDI instruments and controllers were becoming more advanced and removed from gestural control, Michel Waisvisz found a way of taking these processes back by hacking such sophisticated midi synthesizer boxes and controlling the analogue amplifiers and synths with his fingers, sometimes altering the way these electronics reacted because of the sweat collected on his fingers[4]. In turn, Waisvisz's tinkering with controlling sensors inside midi synths boxes led him to the creation of his very own sensor instrument *The Hands (*see figures 2-3).

Fig.2 (left): "1989- 2000, The Hands II" (Carla van Tijn)

Fig. 3 (right): "The Hands" (Text and Image Archive for Michel Waisvisz)

[4] Andi Otto. Personal Interview. April, 2014.

The performances with gestural controllers and sensors today have not come to significantly diversify the standard instrumental practice with live electronics. This paper will discuss the history and evolution towards gestural performances while looking at the composers of the American avant-garde in the 1950s and 1960s as well as the developments in Amsterdam's STEIM centre for electro acoustic instrumental research from early 1980s to present time; I will discuss the technical aspects of sensors and gestural controllers, highlight some artists who are working with similar sensor interfaces as myself, discuss my own practical research while illustrating difficulties and challenges in working with sensors and gestural control-like interfaces involving physicality and embodiment. In my conclusion I will attempt to answer why work with gestural controllers has been marginalized and not fully embraced by musicians in order to make predictions about the future of the medium.

Chapter 1:

Early Electronic Music Experiments with Embodiment of Live Electronics

> *I was at a concert of electronic music in Cologne and I noticed that, even though it was the most recent concert of electronic music, the audience was all falling asleep. No matter how interesting the music was, the audience couldn't stay awake. That was because the music was coming out of loudspeakers. Then, in 1958 - The Town Hall programme of mine - we were rehearsing the William Mix, which is not an uninteresting piece, and the piano tuner came to tune the piano. Everyone's attention went away from the William Mix to the piano tuner because he was live.*
>
> (John Cage. In Interview with Thom Holmes. April 1981)

As one looks back at the earliest experiments with live electronic music in the American avant-garde by such pioneers of the genre as John Cage, David Tudor, Gordon Mumma, Pauline Oliveros, Robert Ashley and Alvin Lucier, one can see that most experiments were reacting in real-time to feedback of manipulated amplified objects and their movements. One can also discern that the composers were searching for a new performance medium outside of the one represented by fixed electroacoustic music or static instrumental performance. This other performance medium at the time was guided by chance in compositional processes and characterized by unpredictability of feedback, it was also the beginning of live electronic music. In some instances the feedback traced in sound the movement of microphone or speaker, and revealed resonant frequencies of the performance space[5]. Such processes were experimented

[5] Collins, Nick and Julio d'Escrivan, ed. *The Cambridge Companion to Electronic Music*, p 43.

with in David Tudor's piece with feedback of 250 fluorescent light bulbs which was premiered in collaboration with Cunningham Dance Company and Robert Rauschenberg in Stockholm Modern Art Museum in 1964[6]. Robert Ashley on the other hand included theatre in his live feedback manipulations as demonstrated in *The Wolfman* (1964) where he manipulated the pitches of very loud feedback by shaping his mouth in front of the microphone. These examples show a fascination with live manipulations of electronic sound by the performer/composer, with or without predictable results while attempting to grasp control mechanisms of such processes. Also one can trace a search for new possibilities in performance with live electronic sound while allowing it to guide the decisions in composition of space and the use of performer's physicality with live electronic processes; inevitably, opening the door to interdisciplinarity and collaboration with other art forms.

From 1957 to 1964 Robert Ashley, in collaboration with composer Gordon Mumma and sculptor Milton Cohen, opened a loft project called "Space Theatre" dedicated to projected images and music. It was built by architect Harold Borkin and could serve as a multimedia performance space. The space consisted of different projection equipment and mirrors that could rotate and project all around the room, Milton wanted to have live electronic music with these theatre performances thus Mumma and Ashley transformed the space into a light projection and electronic music theatre[7]. Two performances a week packed to a full capacity of 40 attendees was a norm for the theatre. All of the performances were accompanied by live electronics and included self-made electronics by Mumma and Ashley. The theatre did not have any public or

[6] Otte, Hans. DAVID TUDOR & JOHN CAGE/Rainforest II / Mureau. Online liner notes to CD. New World Record. Accessed May 15, 2014. <http://www.newworldrecords.org/linernotes/80540.pdf>

[7] Robert Ashley. *Electronic and Experimental Music:Technology, Music, and Culture*. In Interview with Thom
interview with Thom Holmes, March 22, 2001.

institutional funding and sprung up out of necessity for experimentation and attracted such artists as David Tudor and John Cage together with whom they were able to establish the medium of live electronic music in the ranks of American experimental music[8].

Embodying sound physically through feedback is central to the work of Robert Ashley as demonstrated in *The Wolfman* (1964) https://www.youtube.com/watch?v=XKux6PuYkYw. The setup of the piece is very minimal consisting of microphone, amplifier, tape recorder and speakers. The volume of amplification is turned up very high at the point of feedback for the performance space while performer delivers a set of vocal patterns very close to the microphone. The feedback is so high that while the tape plays a kind of modulating sound material that is picked up by the microphone and fed back into the space, the performer can change the filter through which one experiences the feedback of the sound by placing the mouth very close to the microphone and making a set of vowels[9]. This way the audience experiences the room as a resonance of the performer's vocal cavity, which shapes the room and moves the sound around according to the shape of one's mouth. The simple physical and theatrical aspect of sound embodiment in *The Wolfman* produces a very strong effect on the audience especially in the presence of feedback.

In the 1960s, John Cage and David Tudor started to look for ways of making electronic music interesting out of the need to create music for their collaborations with Merce Cunningham Dance company. "It stimulated us very much, and it led to the use of microphones for purpose other than to amplify"[10]. Cage's interest in chance music paralleled his first electronic works for

[8] Holmes, Thom. *Electronic and Experimental Music: technology, music and culture*, 4th ed. p 120.
[9] Holmes p 218.
[10] John Cage. *Electronic and Experimental Music:Technology, Music, and Culture*. In Interview with Thom Holmes, April 1981.

Cunningham Dance Company where the abstract and new aspects of live electronics could complement Cunningham's equally experimental choreography. The reason John Cage got involved with dance was out of the practical need for experimentation as modern dance companies were much more open to his work with chance and live electronics than orchestras and ensembles[11]. *Variations V* (1965) composed for Merce Cunningham Dance company sprang from the idea of electrically triggering sounds through the movement of dancers. Thus using body movements and gestures to trigger live electronics. In the following example you can see an excerpt of *Variations V* which highlights the interdisciplinarity of the work. https://www.youtube.com/watch?v=jQTFZNm3dE4

The performance featured dancers on stage and a group of musicians and engineers with electronic gear on raised platforms near the back of the stage with projected experimental film by Stan Vanderbeek and video images by Nam June Paik[12]. One can see several screens scattered in the performance space in the above mentioned video. Some sounds were triggered by the movements of dancers on stage while others were controlled and mixed by musicians off stage[13]. Sound sources included continuously playing tape machines of at least 6 playing sources of sound composed by Cage, Tudor and Mumma; at least six shortwave receivers; audio oscillators, electronically generated sounds triggered by proximity-sensing antennae; light beams aimed at photocells that could be interrupted to generate sounds; contact microphones attached to objects on stage; homemade electronic machines that could be adjusted on stage[14]. Cage assembled a sophisticated team of musicians, engineers and artists in order to realize *Variations V*. Amongst them Max Mathews from Bell Laboratories who built a

[11] Holmes, p 412.
[12] Holmes, p 413.
[13] Ibid.
[14] Ibid.

96 port input mixer into which all the audio sources were plugged as well as Robert Moog who was familiar with Theremin technologies designed proximity-sensing antennae that were triggered by dancers movements[15]. The proximity-sensing antennae were the first gesture sensing type instrument of the kind used at this time, although the idea of a theremin dates back to 1928.

The idea that sound could be manipulated by performer's physical movements in live electronics was experimented first in the 1950s and 60s in the work of Robert Ashley, Gordon Mumma, John Cage and David Tudor and beautifully illustrated in *Variation V*. As performers and innovators, these composers were actively looking for ways of embodying live electronics physically in live performances as supposed to fixed electro acoustic playback. However, it is not until late 1980s where the question of controlling sound through gestures and embodiment in performance has been fully embraced by many artists active around STEIM studio for electro-acoustic instrument building.

[15] Ibid.

Chapter 2:

The Influence of STEIM on the Development of Gestural Controller Interfaces

The history of gestural control instruments in Amsterdam is essentially the history of STEIM. The centre has had a lot of influence on my research and the work of the artists discussed in the next chapter, also called "the vatican of electro-instrumental music" by Nicolas Collins who was the director of STEIM from 1992-1995 and whose work and research have been marked by several STEIM residencies, collaborations and projects[16]. Until today, STEIM enjoys international status as a centre where musicians and researchers can research and fully experiment with the creation of new electronic technological set-ups and gestural interfaces.

It is impossible to speak of STEIM without speaking about the artists important to its evolution. Already aforementioned Michel Waisvisz who was the artistic and managing director of STEIM (1981 - 2008) and propagator of its main aesthetic that *touch* is the most important aspect in communicating with the new electronic performance art technologies[17] demonstrates this aesthetic by several of his inventions such as *CrackleBox* (1974) (see fig. 1), *CrackleSynth* (1974) (see fig. 4-5), and *Hands* (1984) (Fig. 2-3).

[16] Collins, Nicolas. 'Fundamentalistisch Avond' (STEIM series curated by Michel Waisvisz). Hi-8 Video Cassettes.

[17] From www.steim.org

Fig. 4 (left): ”1976-1989, The Crackle Synthesizer”

Fig. 5 (right): “Electric Music Theatre with bassist Maarten Altena”

(Text and Image Archive for Michel Waisvisz).

In the above illustrated examples, Michel Waisvisz can be seen playing a modified Putney VCS3 synthesizer. He connected the miniature pins of the VCS3' patchbay with touchpads in order to play the synthesizer directly without the keyboard with his bare fingers. Also one can gather that the back lid has been taken away so that he could also touch and play the inner wires using skin-conductivity[18]. He used the instrument also in a theatrical piece with a bassist Maarten Altena (see fig. 5).

The STEIM aesthetic of *touch* was also supported by Joel Ryan who was STEIM’s artistic director from 1985 - 1990. In interview with Joel Ryan, I discovered that Michel Waisvisz’s work was inspired by his own analogue instrument making techniques which he wanted to make digitally by inviting software programmer like Joel Ryan to work at STEIM. With the popularity of Yamaha DX7 which opened the possibilities of using MIDI communication digitally, Waisvisz became interested in adapting his scratching of analogue sensors to computer software. The

[18] From www.crackle.org

familiarity of a keyboard coupled with his sense for touch led to the creation of *The Hands* (Figure 2) instrument[19]. LiSa[20] became an integral part of *The Hands*, and was realized with help from Joel Ryan and Frank Baldé, who converted Waisvisz's memory of a Fairlight (see fig. 6) keyboard sampler available in these days only in major TV studios in Holland. Fairlight had a possibility to hold many samples in one memory block, where one could point anywhere on the keyboard of the sampler in order to come across any desirable sample. This is what LiSa was able to reproduce so well digitally, and in essence this is exactly what one hears when one can see one of Michel's performances with *The Hands:* *https://www.youtube.com/watch?v=pYfRORkuPX8*. In this video we can see Michel is live sampling the audience's clap and further interacting and synthesizing the other sounds also available in his sampler.

Fig. 6: Fairlight sampler instrument (Chesler, Oliver)

[19] Joel Ryan. Personal Interview. June 20, 2014.
[20] LiSa - is a live sampling software ultimately designed for live sonic performance. LiSa's functionality is centered around creating a sound field in the computer, where the performer can record and manipulate multiple sound streams on the fly.

The developments in Michel's incredible gestural/touch instrument *The Hands* became possible to share with other artists coming to work at STEIM such as Australian violinist/composer Jon Rose and video artist Steina Vasulka. Joel Ryan together with Frank Baldé were instrumental in developing STEIM's SensorLab interface which translated analog signals from sensors to MIDI numbers. In this way, Jon Rose was able to grab samples through space by pointing his bow equipped with an ultrasound sensor at them[21]. This suited the theatrical aspect of his performance but also the fact that he was using an ultrasound sensor which functioned as long as the bow was in action and pointing at the receptor, once the bow was lifted the sample would be held frozen in mid-air like the bow[22]. Work at STEIM led Jon Rose to the invention of his own K-bow interface which functions much like the early experiments with ultra-sound sensors and SensorLab[23]: https://vimeo.com/14405086

On the other hand, Steina Vasulka who was artistic director at STEIM from 1996-1997 was interested in controlling video by means of her playing the violin. Before devoting her time to experimental video she was a violinist: "She had a violinist's approach when she was pointing a camera"[24]. With help from Steim's SensorLab she was able to use the pitch to MIDI converter on acoustic violin sound in order to control video images through software such as big EYE and Imagine[25]. It is interesting to note that the work at STEIM led to the development of her own approach for ZETA which is a five-stringed electric violin with a MIDI output. The set-up, at the moment, is that stops on A and E string point to frame locations on the disk. The D and G strings control speed and direction and the C string is a master controller assigned to address

[21] Joel Ryan. Personal Interview. June 20, 2014.
[22] Ibid.
[23] SensorLab - was one of the first small, general purpose, sensor to midi interfaces for the prototyping of musical instruments and interactive control systems.
[24] Joel Ryan. Personal Interview. June 20, 2014.
[25] Ibid.

segments on the disks[26]. As one can see it is a similar idea as with using a LiSa sampler in Waisvisz's *Hands* instrument whose approach undoubtedly influenced Vasulka's more violinistic approach in ZETA.

Nicolas Collins who was artistic director of STEIM from 1992-1995 had several approaches to live performances. He invented a trombone instrument, which acted as a sampler and not so much as a brass instrument after which he switched to sensor finger instrument for working with samples of his own speech. https://www.youtube.com/watch?v=89jbI0ZuaH4#t=494 In this example from 1986 he uses the trombone as a sampler instrument. His approach is very hybrid. He has always remained a fan of the analogue systems because of their tactility and hands-on approach as opposed to the endless powerful logics of the computer systems[27]. He has always remained a tinkerer of electronics as a composer/performer as well as propagator of the music of composer/performers like David Tudor, John Cage and his teacher Alvin Lucier.

From 1981 - 2008 most major innovative projects to do with instrumental and gestural interfaces came through STEIM as a centre for knowledge for building individualised technological set-ups for musicians. This could be largely attributed to strong and sustained artistic and managerial guidance of Michel Waisvisz who was STEIM's general director during those years. Also it could be attributed to the fact that before STEIM was fully funded by the Dutch government and could hire more software and hardware developers to spend time on invention and project development rather than on administrative tasks in order to secure external funding due to the cuts in government funding in 2008[28]. Another reason for the changes in STEIM's operation

[26] From www.vesulka.org
[27] Handmade electronics.
[28] Frank Baldé. Personal Interview. December 9, 2014.

could be attributed to the general evolution of electronic music production, affordability of hardware parts, invention of Arduino[29] and general hacking information available over the internet. Today one could set up one's own studio anywhere in the world in order to make electronic instrumental controllers with Arduino which made it possible to easily connect any sensor to digital software and to one's laptop. The centre as such for experimental electronic instrument making is dispersed and is not found in one place. Also STEIM's general focus today is linked with education on graduate level as well as in workshops and projects for the care industry. Recently STEIM has patented its own product, which is an interactive touch instrument for disabled people[30].

To this day STEIM is continuing the idea that music is a practice and not a language where the musical instrument maker has value in the evolution of live electronics and new instruments. Even if invention and experimentation happens everywhere, STEIM still has the knowledge and experience which guides development in such projects as in the International Matabody project - an international EU project between 67 partners and 16 countries[31]. Through many residencies that take place in STEIM, the importance of musician as the researcher is always stressed[32]. In other words STEIM supports artists with their evolving role as musicians, researchers, inventors, and improvisers.

[29] Arduino - an open-source physical computing platform based on a simple microcontroller board, and a development environment for writing software for the board.
[30] Frank Baldé. Personal Interview. December 9, 2014.
[31] metabody.eu
[32] Joel Ryan. Personal Interview. June 20, 2014.

Chapter 3:

Practical Application of Sensors in the Work of Andi Otto and Jan Klug

In order to grasp the practical application of sensors and gestural interfaces for acoustic instruments I have interviewed two musicians Andi Otto and Jan Klug who are both working in the field of extended acoustic instruments. I asked them similar questions pertaining to their history of involvement with gestural controllers, external influences on their work, how sensors and gestural controllers influence their performance, what do they think of gestural performances and whether mapping of data plays a big part in their gestural set-up preparations. The summary of the interviews is presented below.

Andi Otto - Personal Interview April 13, 2014

Andi Otto's is a German musician and composer working in live electronic music, his work is connected to playing a specially designed gestural controller called FELLO. FELLO is an enhanced interface bow which produces sound physically on cello as well as changes electronic processes like sampling, filtering and effects by way of gestures that affect the overall sound. FELLO is equipped with a wireless Minibee[33] sensor as well as a pressure sensor which are mapped via JunXion[34] software to send data to LiSa for live sampling and Ableton Live for filtering, envelope changes, and equalizers.

[33] MiniBee - a small microcontroller board based on the Arduino, integrated with a connection for an XBee wireless chip.

[34] JunXion - a Mac OSX data routing application that can process 'sensors' from any HID (joysticks, mice, touchscreens), MIDI, OSC, Audio, Arduino and Video device using conditional processing and remapping, with MIDI or OSC events as its output.

The evolution of his gestural controller instrument is closely linked with STEIM when a former artistic director Jan Verna invited Otto to submit a residency application where he could work on his live electronic performance as he came from a studio background and needed to know how to render his electronic studio effects via live electronics more successfully. The first FELLO experiments were performed with a hacked accelerometer from wii nunchuck attached to the bow made by one of STEIM's engineers Byungjun Kwon and used together with a PD[35] patch made of a combination of delays and filters for improvisation purposes. Otto was curious about expanding the possibility of this accelerometer as it was simple at the time, used only one parameter of the axis and was not light enough for playing. Today he uses a more advanced Minibee accelerometer in combination with a pressure sensor which changes parameters of the Indian raga scales mapped through junXion.

The cello experiments with FELLO started happening at the same time as Otto was completing his Master's research on STEIM's history and was therefore able to understand the evolution of SensorLab approach through direct interviews with Michel Waisvisz, and use this curiosity and approach to his work with sensors. He learned about the shift of Waisvisz from digital to analog by hacking midi controllers and ignoring the keyboard, by wiring midi data and directly touching the sensors. Waisvisz was taking radical steps in embodiment of electronics at the time in history when these processes were becoming more and more disembodied and abstract[36]. Otto on the other hand used performance with FELLO interface in his own performance practice which comes from deejaying and studio work, playing in clubs and collaborating with other djs.

[35] PD - Pure Data is an open source visual programming language.
[36] Otto, Andi. Personal Interview. April 13, 2014.

Andi Otto has developed a language in his FELLO performances which is largely based on a vocabulary of gestures which are both physical and symbolic, ambiguous and direct. The bow is an interface which produces physical sound on the cello as well as a trigger that controls envelopes, effects and sample playback: https://vimeo.com/33805035 This video is filmed at the end of Otto's artistic residency in Kyoto, Japan in 2011. You can clearly see him using direct and indirect gestures, gestures which produce sound on the cello and those that are secondary to this process in his performances with FELLO interface bow.

In Andi Otto's performances, the electronic processes concerned could be limitless whereas physical gestures have a limit. The gestures, Otto uses in his performances mean something and often posit themselves as in he has something to say for instance by raising his bow. He often limits the performance to two or three symbolic gestures like up bows and down bows, for tilting and sampling. Since the computer processes can be limitless, one needs to choose well the useful gesture parameters for mapping of effects, filters and playback.

Jan Klug - Personal Interview. November 6, 2014

> When gestures are engaged on interfaces that are facilitating them, when they are expressive and meaningful, they allow the audience to participate in the musical action in a totally different dimension, employing empathy and a feeling of connection that makes musical performance a rich experience. It makes musical processes palpable even though the concrete meaning and parameter implementation does not need to be understood technically and in detail - a sense of connection and meaning might be sufficient.
>
> (Jan Klug, In Personal Interview, November 6, 2014)

Jan Klug is a German born saxophonist who has background in computer science and multimedia programming as well as a Master's degree from Sonology Institute in The Hague. Jan is an active performer/researcher and teacher of Max/MSP in FMI Groningen's MFA department that combines Art and Science. As a musician in Holland he works in live electronics with some gestural control sensors and instruments like Minibee and theremin.

Jan Klug's involvement with live electronics started when he wanted to make control over Max/MSP more intuitive. He was looking to have the kind of intuitive approach to playing with live electronics that he had with guitar pedals back to when he was starting out to experiment with live electronics. Looking at the available degrees of freedom that remained next to the standard theremin operation, he discovered that hand orientation and palm-located button pressing were still available, so for orientation-sensing he focussed on an accelerometer but also experimented with gyroscope and magnetometer. At the STEIM masterclass, the MiniBee device was introduced, its ease and connection-stability convinced him to use it.

The MiniBee controllers are attached to his hands, to measure hand orientation and to provide buttons in the palms of his hands. He found gloves too intrusive because he could not play theremin or saxophone with these so he made little braces of wire to attach the MiniBees at the back of his hand, without disturbing the motor action of his fingers. He doubled the controls that are attached to the MiniBees also on other control devices like iPad and foot controllers to accommodate for different instrumental input requirements, so he does not actively use them all the time. He uses theremin as a sound source, just like saxophones, he also added data-output OSC[37] from the Control Voltage outputs, but decided to use it only in the traditional sense as

[37] OSC - Open Sound Control, is a protocol for networking sound synthesizers, computers, and other multimedia devices for purposes such as musical performance.

opposed to as a controller. Thus he only uses the standard sound output of the Etherwave theremin with applied modification that alters the range and sound quality which goes into the sound processing engine of Max/MSP and other electronic effects.

He considers mapping of the data to be very important in programming of his patches and setups as it is the step that makes the technological attachments invisible to the mind. He configures the incoming sensor values all in his Max/MSP control and transformation engine, so that natural-feeling actions of the limbs produce safe and usable result that benefit intuitive use. Because of his work at STEIM he realized that knowing can also take a different kind of shape without a dozen of flashing lights and computer displays to let one know if one is involved with his own sound, it could be connected with intuition: “I came to see me, the instruments and the processing as parts of a hybrid system, where I could also feel the transformations, as if I was connected to it through the senses” [38]. After his Sonology Masters he was able to engage more directly with the flow of free improvisation, relying more on the gestures of his hands and the feedback of his sound.

Both Jan Klug and Andi Otto perform with gestural controllers as part of their symbolic or physical instruments allowing them to create what Michel Waisvisz describes as “experience and manual skill” where “one plays an electronic instrument in direct relation to the immediate musical pleasure of performed sound”[39]. Thus creating the effect for our perception that a certain physicality takes place and their electronic hybrid instruments are being perceived as a complete gestural instrument.

[38] Jan Klug. Personal Interview. November 6, 2014
[39] Michel Waisvisz in Interview with Andi Otto. August 27, 2007.

Chapter 4:

Sensors and Gestures in General and in my Practice

Today's work with sensors follows a long line of research from analogue sensors and their first midi to digital converters like STEIM's SensorLab[40] to digital OSC[41] communication sensors. Gestural controller interfaces are build out of a variety of sensors and control mechanisms in order to suit the function of the control needed. Several sensors could make up a gestural interface as in the example of Andi Otto's FELLO bow interface where he uses a single Minibee accelerometer with a pressure sensor attached to it and his bow as a sound producing tool and gestural interface. In the past, gestural controllers were invented to mimic acoustic instruments and to overcome their limitations such as various midi Moog keyboards that strived to improve capabilities of velocity measurements of touch, midi flutes and finally instruments that did not exist before like Michel Waisvisz's *Hands* and Tomomi Adachi's *Body Suite*[42]. Today they could be very flexible control devices depending on the need of the performer's hybrid instrumental set-up as most controllers connect to processing machines via OSC and could be wireless.

Gestural study with instruments and the body is also an extended field where several parameters could be clearly defined as in Eduardo Miranda's and Marcelo Wanderely's *New Digital Music Instruments: Control and Interaction Beyond the Keyboard.* In this book, the reader is introduced to static and dynamic, intrinsic, cinematic, functional, descriptive, effective and

[40] SensorLab - was one of the first small, general purpose, sensor to midi interfaces for the prototyping of musical instruments and interactive control systems.

[41] OSC - Open Sound Control, is a protocol for networking sound synthesizers, computers, and other multimedia devices for purposes such as musical performance.

[42] Miranda R. Eduardo and Marcelo Wanderley. New Digital Musical Instruments: Control and Interaction Beyond the Keyboard. Wisconsin: A-R Editions Inc, 2006, p 52.

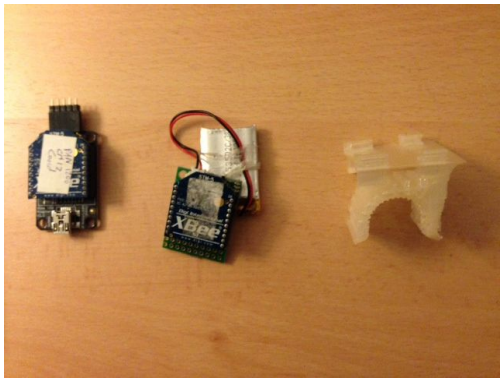
effectuating gestures. Effective and effectuating gestures relate directly to sound producing gestures on an instrument and accompanying or secondary gestures, relate to body movements that take place which do not directly produce sound[43].

In *New Digital Musical Instruments,* one also learns about mapping of gestures. However, since the book was published in 2005, the author is dealing with analogue and midi to digital mapping techniques, which has changed significantly with introduction of OSC communication protocol in digital music. OSC allows for higher resolution of data than MIDI and therefore results in richer mapping possibilities when dealing with sensors. Moreover OSC could be directly introduced in music and computing softwares such as C++[44], Python[45], Max/MSP, SuperCollider[46], and PD as well as shared across different devices and programmes like Reaktor, OSculator, etc. When dealing with analogue sensor data, data was available either through direct variable from sensor or from signal processing of its data. Choosing the mapping parameters of the sensor could be as important as the composition of the piece that one is going to perform. In the words of Jan Klug "...it is the step that makes the technological attachments invisible to the mind" and also more fascinating for the audience in a performance situation[47].

Much like the musicians whom I have interviewed, I also work with Minibee accelerometers to which I can attach sensors. At the moment I use two Minibees, one of which has an addition of a pressure sensor button which I use like a sustain pedal in preset changes. Both of my

[43] Miranda R. Eduardo and Marcelo Wanderley. *New Digital Musical Instruments: Control and Interaction Beyond the Keyboard*. pp 10-11.
[44] C++ - a general purpose programming language
[45] Python - open source, object oriented programming language
[46] SuperCollider - an open source environment and programming language for real time audio synthesis and algorithmic composition
[47] Jan Klug. Personal Interview. November 6, 2014.

Minibees have a possibility of being attached to the flute directly by help of a plastic attachment (see fig. 7 - 8) built at STEIM by hardware designer Nicolo Merendino. Thus I usually attach one Minibee accelerometer to the end of my flute to act as a wireless controller which can change presets, measurements of velocity, direction of movement to control continuous effects like pitch shifting, envelope following, and delay.



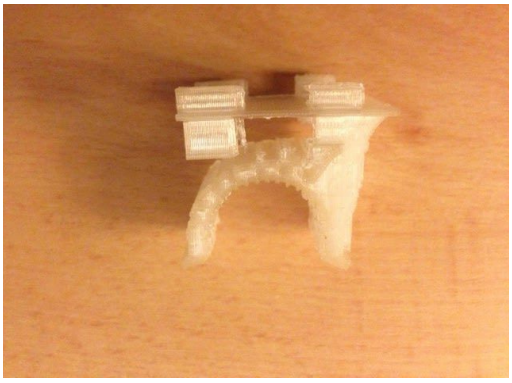


Fig. 7 (left): MiniBee receiver and accelerometer sensor

Fig. 8 (right): Plastic flute attachment for MiniBee sensor (Moroz, S.)

I have the flexibility of using the other Minibee to attache on my body for gestures to do with movement rather than playing my instrument. I have worn it on my ankle before and used it as a trigger for changing presets or triggering samples in a patch much like a foot controller; this gave me freedom to walk and engage in interdisciplinary performances. Also, one could attach additional sensors to the second MiniBee to do with touch, change of light or proximity which could also help in interdisciplinary and multimedia performances.

I perform wirelessly providing me with the liberty of movement and triggering in different situations when collaborating in more theatrical circumstances. My wireless setup consists of

two microphones, Adc2, Barcus Berry microphone connected directly to my flute sending a signal to a DPA microphone, Adc1 (Figure 9), which amplifies and processes my sound in Max/MSP, SuperCollider or Ableton Live softwares. It is important to have a signalling mic as it serves two purposes: tells sound processing to occur, creates an envelop for it only when I am producing sound on the flute and determining a more accurate signal for pitch following if I want to synthesize my sound to another midi type Max object like a synthesizer. Thus it accompanies my sensor set-up as well since it is also wireless and allows for movement in performance.

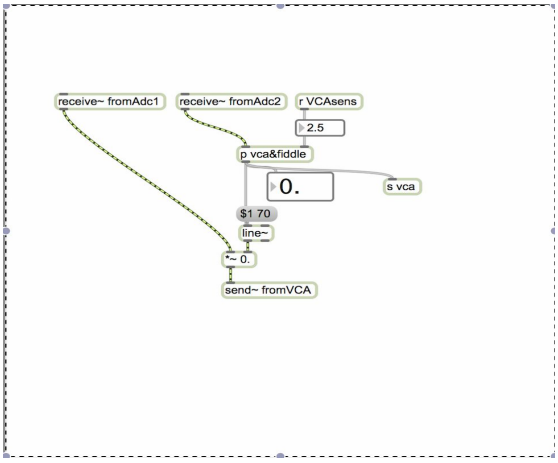


Fig. 9: VCA Max/MSP flute input gating (Moroz, S.)

Like Andi Otto, I also use junXion software sometimes for my Minibee sensor when I want to use it in Ableton Live which does not communicate through OSC protocol. JunXion successfully converts the signal to MIDI communication which can be easily mapped to Ableton Live. Besides converting the OSC signal of the sensor to other protocols it can adjust the resolution of it to a desirable working range by creating an alternative table which then sends values 0 to 127 to Ableton Live or other softwares.

There are times when I use JunXion software to send video tracking information of my body movement to Max/MSP patches as this is another sensing parameter that I would like to have at

my disposal in composition of movement based pieces. In the future I hope to use several theremin sensors for the purpose of proximity and body tracking in space. This approach could also bring my work closer to the early experiments with embodiment of sound by John Cage and David Tudor that I describe in Chapter 1. I have not yet worked with motion capture devices such as Kinect[48] but I can see a significant potential of such sensor parameter for body tracking. However, I realize that the conditions of one's equipment and working methods need to be of the highest quality in order for motion capture to work effectively.

The difficulties and challenges that one could encounter in working with a few sensors could be attributed to the fact that a lot of sensor work demands extra research and practical application that could be completely new to one as a classically trained performer. Even though I study in Live Electronics and have had instruction in comprehending and working with most softwares mentioned in this paper, the learning curve is steeper for some applications than others. For instances some programming languages such as C++ and Python used in Minibee communication are beyond my current capability thus it takes time and advice from engineers in STEIM whenever I want to take the next step in my Minibee adjustments. I am gradually learning and acquiring more programming skills thus I am becoming more comfortable in mapping sensor data to desired parameters which is very important in sensor performance possibilities, however I am still not at the stage where more advanced programming languages like C++ and Python are a part of my capabilities. I admire the work that the pioneers of electronic instruments achieved before me but also understand that at the time where we are in history most work with sensors will demand rigorous programming skills as computing systems are becoming more complex and less accessible in operating systems of our Macintosh

[48] Kinect - motion sensing input device, developed initially for use with web cameras to control Xbox game consoles, its software technology enables motion capture, facial expression and voice recognition.

computers[49]. This too provokes more hands-on work with live electronics such as the popularity of Arduino hardware as a physical microcontroller that could stand alone without a laptop in a performance. However one should not forget the possibility of immediate wireless controllers that are readily available to us via toys like nintendo controllers, smartphones, motion leap, IOS applications like TouchOSC, C74 and Lemur. All depends to what end the performer is looking to apply these devices in live performance.

As Live Electronics and work with sensors and gestural controllers undoubtedly opens doors for more interdisciplinarity it also challenges the performer to take risks as well as necessary training to be able to act with one's own body when performing. This too could be a challenge aesthetically and physically and could demand one's time and attention. I would advise to become active physically if one is to use direct gestural control with the body in performances.

The repertoire for a musician performing with live electronics with one's own gestural set-up is limited and perhaps could not be called repertoire as we are used to in the classical music sense. The repertoire question is similar for the gestural musician as it is in the case of a computer musician. The repertoire for a computer musician could come in many different forms as Juan Parra Concino states in his doctoral dissertation *Towards a Performance in Computer Music* where he points out that the computer performer is involved in four forms of work when addressing repertoire, *reconstruction*, *reinterpretation*, *re-appropriation* of other works or *composition* of one's own work[50]. It is important to note that most musicians working gesturally create their own repertoire or improvise with their set-up when it comes to performances such

[49] Joel Ryan. Personal Interview. June 10, 2014.
[50] Parra, Juan Cancino. *Towards a Performance in Computer Music*. Ghent: Orpheus Institute Series, 2014.

as in the case of Michel Waisvisz, Jon Rose or Nicholas Collins. Thus it is important to remember that one could perform any piece of repertoire from compositions available to us for an acoustic instrument and live electronics and reconstruct or reinterpret it as it would be suited for one's own gestural set-up. For creation of new repertoire, it is encouraged to work with composers who will write for musician's particular set-up. I'm collaborating with composer Marcelo F. Lazcano on a creation of a new work for my particular set-up which I described at the beginning of this chapter. In this work the flutist will be asked to use theatrical gestures and speech as well as movement on stage, which would suite my wireless setup possibilities.

As this is the beginning of my personal research into gestural controllers, I am still searching for the best extensions of my hybrid live electronics set-up which would make my playing more flexible and intuitive in live improvisations and composed movement based works. The overview of the artists and musicians that I came across in this research confirms a lot of predictions about the course that my work should take, which foremost should stem from sensing and mapping body movements to controllable and flexible parameters for optimized live performance possibilities.

Conclusion

Performers' quest for embodiment of live electronic music comes from a long history of research, tinkering and application in live performances as one can see with the experiments of John Cage, David Tudor, Gordon Mumma, Robert Ashley and others. It is something that I find we have lost with commercial controllers available to us and overly complex computer sound synthesis systems that have made performances with live electronics less interesting, thought provoking or accessible as a result. With so much technology available to us, one can get lost in finding a suitable gadget or controller, thus one can also take these processes back by making one's own device. With open source software for Arduino programming being easily available to us via internet sharing, the question of control of any sensor or self-made controller device becomes obsolete, and the only real question stays rooted in how we apply the information available to us.

Thus I can predict that with time gestural control will be used more in live electronic music but also that there will be an increase in commercially produced devices such as smartphones and IPads with applications that will control sensors within such devices as opposed to self-made sensor gestural controllers. As I have mentioned earlier, the computer systems are becoming more and more complex, and only those equipped with rigorous programming skills are able to have access in programming such devices in the ever changing OS X of the macintoshes and the more accessible IOS of the "smart" devices. As in all the areas of advancement in arts and technology, the possibilities in working with sensors will stay limitless but also heavily depended on one's resources, time and skill available to invest in such endeavours. However, it will not be

as inaccessible as it was twenty years ago and anyone will be able to explore performing live electronics with the control of the gestures if one would find a need for it in their music.

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