SOMATIC SOUND IN PERFORMATIVE CONTEXTS

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ABSTRACT
This paper presents a new spherical shaped capacitive sensor device for creating interactive compositions and embodied user experiences inside of a periphonic, 3D sound space. The Somatic Sound project is here presented as a) technological innovative musical instrument, and b) an experiential art installation. One of the main research foci is to explore embodied experiences through moving, interactive and somatic sound. The term somatic is here understood and used as in relating to the body in a physical, holistic and immersive manner.

Author Keywords
Somatic interaction, somaesthetics, periphonic, holophonic, embodied, immersive sound, touch, capacitive sensors.

ACM Classification
H.5.2 [Information Interfaces and Presentation] User Interfaces–Haptic I/O, H.5.5 [Information Interfaces and Presentation] Sound and Music Computing.

1. INTRODUCTION
The project group has performed musicological and artistic research over several iterations of the Somatic Sound installation. The Somatic Sound project is a touch based system to compose real time, interactive user experiences inside a 3-dimensional, near full-sphere sound field where speakers placed at different heights so as to produce periphonic sound; as if it comes from all directions [18]. Further, Somatic Sound is an innovative sound installation where the user can i) corporally control the playback of multichannel sound through touch, and ii) simultaneously experience a three-dimensional audio space as a physical continuum. The project combines the production of music through touch-based, multi-channel 3D sound with the simultaneously placing the performer into the position of a listener. The research investigates how this enables new and innovative interpretations of iconographic works of music such as Feldman's "The King of Denmark" [6].

2. BACKGROUND
Within the framework of the artistic research project 'Radical Interpretation of Iconic Musical Works' financed by the Norwegian Artistic Research Programme and based at The Norwegian Academy of Music in Oslo, the project group has developed innovative ways of interpreting, performing and experiencing famous scores for percussion [7]. The research group has been characterized by inter-

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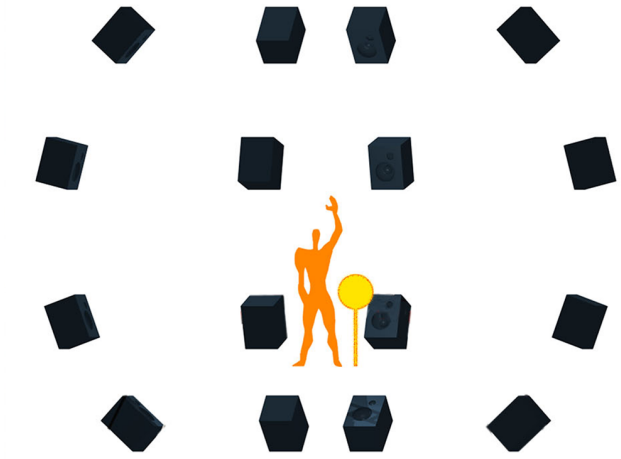

Figure 1. Schematic view of the Somatic Sound installation showing the user inside a spherical set-up of loudspeakers.

and transdisciplinarity across the disciplines of music performance (percussion player), music composition, conceptual design and experience design. As a cross-disciplinary project it has been led by a hands-on approach to doing research in music, design and the arts.

2.1 Reinterpretation of Iconic Works of Music
One of the iconic solo works for percussion that has been re-composed specifically for several medias and performing situations, including video, site-specific art, context related performance and staged concert performance is Morton Feldman's 'The King of Denmark' (1964).

The research project itself is about challenging the almost sacred relation to the score that classical musicians are trained to have. Research focus has been on how the musical content of Feldman's score can be interpreted radically different according to the performance medium and still be in accordance with the inherent raison d'etre of the work.

The radical interpretations project has followed several formats of presentation such as acoustic performance, live amplification, studio production, and sound installations. The Feldman part of the Somatic Sound project represents its own set of investigations with its own set of artistic interventions. The project aims at gaining more knowledge about a wider range of possible interventions.

At the outset of the research project we were guided by two open research questions: i) how do we experience embodied, interactive sounds in an immersive, moving sound space, and ii) how do sounds produced by embodied, part haptic and kinaesthetic interaction affect the users or composers experience?

2.2 Touch based performativity in Feldman's King of Denmark

One of the many peculiarities of Feldman's iconic percussion piece '*King of Denmark*' is as Steven Schick noted, that it is almost an anti-percussion piece [19]. It is to be performed with the softest touch or even lightest stroking of the instruments. This is in itself radically different from the loudness and power we often perceive and expect in percussionists performances. One of our first approaches to the piece was by performing it as close to Feldman's descriptions as possible using physical instruments. User observations of the performative situation quickly revealed that the sounds produced are hardly noticeable for anyone but the performer and those sitting directly beside the instruments.

Figure 2. Instrumental set up and audience placement during Feldman's King of Denmark according to classical score. Performed by Kjell Tore Innervik.

To many Feldman's composition is already a radical way of staging music. One of our research questions was how to then again radically perform and transform the piece? One way was to perform the score on a radically different set-up and instrument. Here the Somatic Sound project represents a solution to how touch and full-sphere, immersive sound systems enable innovative and to a large degree immersive as well as corporal user experiences both to Feldman and possibly many other compositions as well.

3. MAPPING THE FIELD

3.1 Spherical Sound Systems

Several full-sphere, surround sound systems have been built and presented across various fields and contexts over many years [22] [18]. Many of these experiments have had a high impact on shaping new audio formats and listening experiences. However, there are still no standard as how to build complex and periphonic spatial audio systems -such as ambisonics- within the experimental and artistic contexts. The current plethora of approaches, set-ups and systems makes the field too rich to compare and map in details. If a goal is to create immersive, periphonic sound systems, then open, re-configurable solutions are the more likely options as system parameters are dependent upon and have to be tailored according to objectives, architectural qualities and equipment available. The many different ambisonics labs around the world illustrate this. [15]
At the same time this abundance of approaches is inspirational and shows how the field is open for continuous experimentations in areas such as psychoacoustics.

3.2 New spaces for new music

The Somatic Sound project is contextualized and situated within the experimental and artistic domain. It is inspired by the many projects attempting to build new spaces for new music. Edgard Varèse and Iannis Xenakis work on the Philips Pavilion (Brussels 1958) was a major demonstration of the possibilities of spatially distributed, multi-channel sound systems. In his attempt to create the ultimate house of music, Karl Heinz Stockhausen was co-designing the «Spherical Concert Hall», or 'Kugelauditiorium', showed at the 1970 Osaka World Expo. As Stockhausen noted, his reasoning to build such an auditorium for sound was that we have little experience with sound coming from other directions than frontal [11] [14].

Other recent, on-going, relevant and associated projects range from NOTAMs new lab project on periphonic sound [16], to the SPIRAL lab, part of the Spatialisation and Interactive Research lab at University of Huddersfield [12], to the AlloSphere Research project [2], to Natasha Barret's immersive spatial sound installations [3], and media art contexts such as Solve et Coagula's interactive and somatic sound art [21]. In the latter experiment, users are interactively composing immersive sound through their own body-based performance. Such body-based interfaces raise the questions of i) how to play music through bodily movement and not just skilled fingers, and ii) how to build controllers that relate to playback over periphonic loudspeaker set-ups.

3.3 Controllers for sound and mapping of space

Within a periphonic or ambisonic loudspeaker set-up one main question is how to control, trigger and render sounds. In Stockhausen's composition for the Spherical Concert Hall it was possible to achieve the three-dimensional sound distribution live, using a spherical sensor built in the Electronic Studio at the Technical University in Berlin to feed the 50 sound sources [8].

Recent spheroid, multichannel controllers to affect various playback parameters include the Crystal Ball using five infrared optical distance sensors that allow users to control sound and other effects by using their hands or other objects [4]. The AlphaSphere is a spherical device featuring six rows of eight touch- and velocity-sensitive pads that work with any MIDI software [1]. Unlike Stockhausen's sensor, both these controllers are generic and not specifically built for composing music inside periphonic sound systems. Construction of control interfaces inside such complex sound systems is still exploratory and the approach to building such range from a general engineering to the idiosyncratic [23].

4. ONTOLOGICAL AND BODILY EXPERIENCE OF SOMATIC SOUND

The Somatic Sound project uses a phenomenological approach to the field as it investigates the way the world of our experience is constituted for us. Phenomenology according to Heidegger understands intentionality as a form of being-in-the-world, [9] and recognizes the importance of embodied action for shaping perception. This understanding of the body's fundamental importance sets the body right at the centre for both understanding and creating existential, sensory immersive experiences.

The experimental approach of the project centres on the phenomenon of perceptional breakdown –such as reports of unusual perception of sound in the installation- and how this reveals novel

dimensions of how we sense sound in space, sound as space as well as sound as somatic, physical objects [10]. A phenomenology of Somatic Sound as it is applied here, allows us to understand the interplay between subjective, felt embodiment and the layout of the experiential interface design.

Additionally the project investigates sound in relation to the evolving field of Somaesthetics [20]. According to Shusterman, Somaesthetics is an interdisciplinary research project/approach devoted to the critical study and ameliorative cultivation of the experience and use of the living body (or Soma) as a site of sensory appreciation (aesthesis) and creative self-stylization. This central focus on the body as centre of action is a highly important, but often neglected dimension of experience- and interaction design. Within the Human Computer Interface (HCI) tradition, instrumental functionality appears to have the stronger attention than the actual embodied, live and subjective sense of experience. Our focus on this ontologically important aspect was made possible through the innovative user interface: a custom built, field reactive sphere covered in 24-carat gold.

In the middle of the installation space the golden sphere acts as a controller for both the real-time composition as well as the listeners' experience. Around the performer there were up to 30 loudspeakers placed in a hemispherical setup at about two meters from the epicentre. (Figure 1)

Figure 3. Somatic interaction with the golden sphere, functioning as electronic skin.

5. SOMATIC INTERFACE TECHNOLOGY

The somatic sound system is built around a field and touch sensitive golden sphere divided into 48 areas/zones. Each zone is made touch sensitive through capacitive sensing and controlled through a custom built patch in Max/MSP. The sphere is covered in 24-carat gold both of aesthetical and instrumental purposes. Besides the look and feel of gold, the conductive properties of gold are suitable to increase the sensitivity of the capacitive sensors. The hardware was initially built solely with the Arduino Uno platform. Due to the need for high update rates, these were later replaced by single purpose sensors electronics, in particular the NXP MPR121 capacitive touch sensor.

5.1 Near Field Sensor Technology

The sensor globe consists of the aforementioned physically separated thin sheets of gold foil, each connected with a thin wire to an input of an MPR121 capacitive sensor board. There are four of these sensors boards, each with twelve inputs, giving a total of 48 possible zones, each with its own separate measurement. An Arduino Uno placed at the center of the golden sphere reads these measurements periodically from the capacitive sensors at the native resolution, and transmits these to the computer via a serial link without any processing of the measured data. As a result the golden globe functions as a multichannel capacitive sensor.

One interesting effect of this kind of touch sensor is that the globe so reacts to non-contact movements and manipulations such as gestures. It therefore requires little or even no force to activate and compose sounds.

5.2 Spatialized Sound

On the computer side, the sensor data is read by an application implemented in Cycling '74's Max programming environment. The data is processed and filtered by custom Java based objects/externals to remove much of the noise inherent in the capacitive measurement process. Another Java based external creates the individual coordinates of objects comprising the positions of sound sources in a slowly moving «cloud» around the performer. The sound sources are spatialized based on these data, making the sound turn from distant and diffuse to having more presence and proximity. The spatialized sound itself is rendered using Ircam's Spat externals. A plethora of panning methods are available via Spat, but the project usually utilized the Vector Base Amplitude Panning (VBAP) method when loudspeaker array setup time has been limited [17].

5.3 Mapping

Each of the zones of the golden sphere is mapped in software to its own loudspeaker within the hemi-spherical loudspeaker set-up. The mapping is following a directional analogy, e.g. when touching the top sensor on the globe, the sound will come from the top loudspeaker above the performer; when touching the left loudspeaker, sound will come from the left etc. This analogy and directionally direct form of mapping was implemented to give users an immediate sense of connection between body movement and sound. The haptic interaction gratifies the users movements and touch with, to a large degree, intuitively understood corporal directionality.

In the hemispherical setup of the loudspeakers, the bottom zones were combined, rendering 34 active field-sensing zones. Due to the spatial set-up, no loudspeakers could be placed under the user. Therefore fewer loudspeakers were placed on the ground, and several of the lower controllers that could not be mapped according to directionality were instead used to control environmental sounds such as low frequency bass tones emitted from sub-woofers.

6. SETTING UP SOMATIC TOUCH

The touch sensitive Golden Sphere accurately senses touch, strength of touch, position as well as distance between body and sphere. The way touch becomes both the trigger and controller correlates well to the immediacy and the living, internalized dimension of Somaesthetics. Touch is, as such, a lived, embodied experience. It is a 'dialectical sense' constructed through personal experience. The goal of a Somaesthetics is to play an important role in the art of living [20]. Even if the percepts of the body are unreliable, they form the base of our knowledge. Somaesthetically speaking and as an intersubjective experience, using the golden sphere to haptically articulate a sound based experience contributes to building, questioning and affirming bodily knowledge. As such the golden sphere facilitates for a practical Somaesthetics, a specific body practice and use of the body as living soma.

Figure 4. Somatic interaction with the golden sphere, during performance The Norwegian Academy of Music in 2015. Performed by Kjell Tore Innervik.

6.1 System Set-Ups and Iterations

The Somatic Sound system has been iteratively developed and performed on several occasions and with various sound contents (Dramatikkens Hus in Oslo 2012, Oslo School of Architecture 2013, Ichihara Biennial in Japan 2014). The latest version of the system, named *Dead Voices* (ANX, Oslo, Norway 2014) served as our first technical framework in testing Feldman's *King of Denmark* composition somatically performed. Within that last iteration of the set-up, the user is immersed inside a 3D sound cloud made out of 77 different sound files. Each sound file contained a one to three minute long voice based story.

6.2 A Virtual Cloud of Sounds

The sounds hover as a virtual cloud centred on the golden sphere and the user. The virtual, 3D sound cloud is rendered on a custom built application using SPAT/Max. The core set-up and application represents a flexible framework that was later adapted to the sound files recorded during a performance of *King of Denmark*. Like the Dead Voices, the recordings of the percussion-based sounds were mapped into the VR sound space and rendered real through the users touch and near-touch of the sphere. Users of the installation affect and influence the sounds inside the invisible sound cloud by being near to (0 to 20 centimetres) or touching the golden sphere.

By touching, caressing the sphere, sounds are literally caught in the virtual space, pulled down into audible distance to the user, and then float around the user. The golden sphere lets the user become both a composer and somatic listener by haptically bringing the virtual sounds into reality. Users from the audience have reported experiencing the sound universe and content as an emotional experience.

6.3 Physical Sounds Shaping Physical Space

The combination of a multichannel touch interface with a full-sphere, immersive spatial sound system turns sound into a material for direct, somatic and dynamic experiences. The project demonstrates how innovative combinations of digital technologies and use of sound can impact and shape spatial experiences. The installation functions also a sound controller and instrument that both investigates and demonstrates how physical, interactive and three-dimensional sound systems affect our phenomenological perception of the world.

7. EMBODIMENT IN SOMATIC SCORES

Sound machines make you feel more intensely […]. Sonically speaking, the posthuman era is not one of disembodiment but the exact reverse: it's a hyperembodiment. – Eshun [5].

In relation to Eshun's quest for more embodied experience of sound, it still remains as a challenge to build a somatic instrument and interface that not just let the performer compose in real time, but physically transposition him/herself into the very soundspace that is created, thus simultaneously becoming both performer and affected 'audience'.

7.1 Dimensions of Touch

By gestures close to, direct or indirect touch of the touch sensitive, near-field sphere, the user can move and compose the aural experience of the room. The installation space is so physically impacted and modelled through sound. The sound produced can therefore be called phenomenological in the sense that it is a direct, physical and dynamic experience. The users control of the sphere follows several of Hunt and Kirk's description of attributes characteristic of real-time multiparametric control systems such as no fixed order, instant reaction to movement, practice based system that must be learned by user [13]. The capacitive sensors also facilitate for several dimensions and combinations of touch and gestures such as gentle gliding movements, sliding, sudden strikes/approach, lift and removal.

Within the context of HCI the project demonstrates how innovative combinations of technologies can create spatial experiences based on sound. The installation's three-dimensional sound output is composed in real time through the touch of the golden sphere interface. The spherical montage of up to 30 speakers frame the space, effectively wrapping a sound cloud around the user. The periphonic set-up creates an isotropic sound space with uniformity in all orientations. Together with the high resolution of sound sources this allows for precise directions and volumes of the sound, creating and affecting the perception of spatial sound. The sound encompasses all users present into a physical and spatial experience.

7.2 Sensuous Fields

Such interactive and corporeal sound spaces create a sensuous field for somatic experiences. The sound becomes embodied as the HCI interface, letting the user effectively and literally touch Feldman's music.

In relation to the field of Somaesthetics the sound experience can be described as an attempt to affect the soma within each participant. This addresses one of the challenges with instrument-based performances of Feldman's *The King of Denmark* score for an audience. Unless they are placed right beside the instruments they are unlikely to hear anything of the soft touch based, 'anti' percussion piece. During a live performance of the classic score in front of an audience at the National Academy of Music in Oslo in 2015, the sounds were barely audible even from one side to the other of the instrumental arrangement. If setting the conceptual aspects of *The King of Denmark* aside and one presumes an audience is to actually hear the piece, then a more effective way to do so would be by somehow amplifying the sounds. The Somatic Sound project therefore did cut the studio recording of the piece into a number of individual phrases, most head-to-tail, a few overlapping. The average length of these being around eleven seconds, ranging from six seconds to almost forty. These recordings were then mapped onto the golden sphere and played back through a spherical loudspeaker set-up surrounding both the audience and the performer.

8. FINDINGS AND OUTLOOK

Somatic Sound has been performed over several occasions and with several scores. Audience and user observations as well as verbal feedback indicate that the system provides a high degree of

immersive, embodied and interactive sense of sound. For the performer we have found such systems to be an inventive way of interacting with both the score and the audience. For performers and composers, this set-up enables innovative forms of presentation and concert staging. Somatic Sound so represents an important exploration as to how we can design more affective sound experiences.

Adapted to the sound recordings from Feldman's King of Denmark and as performed for a larger audience at the National Academy of Music in Oslo, the Somatic Sound system produced a strong immersive experience of the piece, both for the performer and the audience. The system allowed the percussionist performer to only use his own body and without prolongations as for example sticks and other sound exciters. Triggering sounds through the sensitive capacitive sensors let the performer retain the inherent sensitivity of the original score. Including the audience within the periphonic sound set-up let them take part both in the physical performativity of the player as well as experiencing the sounds more intimately.

Our research into somatic sounds is on-going and still in process of collecting more and better user data. We continue to follow a practice-based approach to our guiding research questions. Emerging, transdisciplinary research questions is for example how somatic sound designs can impact not only users in concert settings, but also contribute to shaping our experience of everyday environments and architectures.

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