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Sensience: Electroacoustic Collaboration in a Reactive, Non-Tactile Ultrasonic Sensing Environment

Abstract

Sensience *is the title of a collaborative work realised with a proprietary ultrasonic sensing system and live tenor saxophone. The collaboration allows the acoustic saxophonist to move freely within an ultrasonic performance space and to trigger a range of samples pre-recorded by the performer. The aesthetic intention, the musical form and technical design of the work are discussed, along with an overview of the work's performance. The work is briefly contextualized with regard to interactive computer music practice.*

BACKGROUND

The first part of the *Sensience* collaboration is an ultrasonic system entitled PLaY+SPaCE. The system uses up to eight ultrasonic sensors to detect positions of people or objects moving within a detection space of up to 100sqm, the technical attributes and design of the system detailed previously in Campbell 2003 and 2005. The system allows an acoustic performer to move within the space unencumbered by physically attached sensing devices and hence the system is non-tactile. The system has previously been used in a wide range of applications including dance, installations, disabilities workshops and multimedia performances.

Prior to this collaboration, a similar work was developed for Sydney-based jazz saxophonist Andrew Robertson, forming the groundwork for the technical approach to *Sensience*. In this work, a live improvisation by Robertson was recorded and numerous samples of various lengths were selected from the recording. The samples were then assigned in the PLaY+SPaCE software environment to specific points within the system's physical sensing space, allowing Robertson to move within the space to trigger and react to samples of his own earlier improvisation. Additionally, Robertson's movement through specific points within the space allowed the performer to add and control effects such as delays and granular techniques to the triggered samples.

The second contributor to the *Sensience* collaboration was Berlin-based saxophonist Ulrich Krieger, an accomplished performer with a high level of skill in extended saxophone techniques and considerable experience in a wide variety of musical styles (Krieger 2006). During an artist residency in Australia in 2006, the collaboration for *Sensience* was established, the saxophonist provided with details of the PLaY+SPaCE system and shown video footage of the former Robertson collaboration. Subsequent meetings were held to establish directions for the new collaboration.

AESTHETICS

An outcome of initial meetings was that a similar technical model to that utilised in the Robertson work would be followed, however the samples would be in line with Krieger's own interests in noise, ambience, and noise on the verge of silence (Krieger 2006). Kreiger's highly developed instrumental technique would enable the sampling of multiphonics and breath noise through the saxophone at very low volume levels, the mergence of pitch into and out of such noise, very low volume pitches, percussive and pitched key clicks and tongue slaps. Additionally, Krieger has an interest in generating timbres from his instrument that are not generally associated with the saxophone: electronic/synthetic sounding timbres that he is able to produce at low volume levels, a technique he labels 'acoustic electronics' (Krieger 2006).

The possibilities of combinations of samples of the above techniques, along with live/acoustic performance were explored, as well as the use of effects and DSP. A decision to present an ambient and quiet work was made, and DSP effects, though of interest to both parties, were to be limited to basic delays and reverb. The work would thus rely on Krieger's triggering of the samples based on his extended saxophone techniques, in combination with his improvisational abilities to acoustically react to those samples through layering and contrast.

INTERACTIVITY/REACTIVITY/FORM

Discussion on interactivity generally has raised numerous questions as to what constitutes a truly interactive system within new media arts. Manovich (2001) dismisses the term "interactivity" as being too broad, relevant to any Human Computer Interface (HCI). Rather, Manovich provides a range of concepts and sub-classifications, for example "variability", "branching-type interactivity", "closed interactivity" and "open interactivity". Within *branching-type* interactivity the user may select items (e.g. buttons or hyperlinks) that enable movement along particular branches or pathways of a website or multi-media presentation. In a *closed interactive* system elements along a branch are predefined and fixed. Conversely, in an *open interactive* system both the elements and structure of the overall work are "modified or generated…in response to the user's interaction with the program" (p.40).

In the area of computer music the discourse has been a focus in monographs eg. Rowe (1992) and Winkler (1998), and in numerous papers, eg. Bongers (1999). Bongers outlines interactivity between the performer and the HCI as complete when a full interactive loop occurs, wherein the system and the user both contribute to human and machine cognition in the realisation of a work. Reactivity (as opposed to interactivity) occurs when the user alone controls the output of the system, without "cognitive" returns or responses from the computer.

Winkler (1998) provides a further definition, a reactive system in his terms labeled as a "Conductor Model" wherein one entity (the conductor) directly controls musical output (the orchestra). A more fully interactive system is in Winkler's "Improvisation Model", equated to a jazz ensemble wherein the individual player's solos "alter and influence the surrounding accompaniment".

The PLAY+SPaCE system allows for various levels of interactivity, however from the outset, the *Sensience* collaboration did not seek to utilise any level of *open interactivity*. Rather, within the limited timeframe the work was created, such possibilities for interactivity were stripped down so that, in the terms of Manovich (2001), a closed interactive system was designed. As the performer has complete control of the output of the system, this design falls under Winkler's (1998) "Conductor Model", a system that is essentially, and in Bonger's (1999) terms, *reactive*.

Reactivity in *Sensience* is achieved through the performer triggering pre-determined samples within the space and reacting to these, for example playing live and sustained saxophone pitches and multiphonics over multiple sustained samples to create richly layered timbres and textures. The work is structured around the improvisational abilities of the performer, variable reactions to the system made possible by simple and constrained randomisation of triggered sample output, as described below. Whilst the system outputs are indeed finite, a combination of deterministic and constrained randomisation of sample triggering results in a range of possible musical environments that are less constrained by pure determinism.

The work is designed to have six individual and linear sections (scenes), each scene containing various sonic possibilities for the user to explore. Unlike even the most basic of reactive or interactive media, the user here has no navigation options to freely move between scenes, nor to step backward. Rather, there is a single navigation function assigned to a single trigger point in the ultrasonic sensing space, this point acting as a "Next" button to move to the following scene. Figure 1 illustrates this basic structure of the work.

Figure 1 – Structure

The strict limitations on interactive possibilities within this structure are relevant to the compositional aesthetic selected for the work. Limited numbers of samples are available in each scene, requiring the performer to acoustically react to, and work with, repetitive sampled elements as per minimalist and ambient musical styles. The limited sonic possibilities resulting from this simple reactive system, and the elementary form utilised in the work, were nevertheless sufficient to provide the performer with materials with which he could engage to such an extent as to form a live performance of c. 20 minutes in duration.

SAMPLING

A single recording session was held, with Krieger providing c. 20 minutes of audio appropriate to the project. From the recording 23 samples were derived and grouped into six categorised sample sets. Six samples were single pitched notes played at very low volume and categorised as "Straights", five samples were single pitched notes dissipating into breath sounds and categorised as "To Noise", two samples were pure breath sounds and categorised as "Noise", five samples were key clicks including both percussive and pitched sounds and categorised "Clicks", and five samples were tongue slaps, categorised as "Slaps".

A disadvantage of the PLaY+SPaCE system is an audible click emitted from each sensor on sending an ultrasonic signal. In the system the sensors are timed to emit sequentially and hence there is a continuous audible clicking. Normally the intrusion of the clicks is masked by sounds/music triggered by users within the space. In *Sensience* however, the exploration of low volume levels resulted in the clicks being intrusive. A workaround was devised wherein the clicks themselves would become integral to the work, the sound of the clicks sampled and assigned to the space for triggering by the performer. The sampled clicks were categorised as "Sensors", the sample assigned to eight consecutive keys within the software sampler used for the work to result in variation via pitch shifting.

In each of the six scenes of the work trigger points in the PLaY+SPaCE sensing space are assigned to varying sample categories and combinations of the sample categories.

SENSING ENVIRONMENT

The PLaY+SPaCE hardware configuration for *Sensience* utilises four ultrasonic sensors, labeled S1 to S4 in the Figure 2 map. Each sensor is assigned to detect eight trigger points, a total of 32 trigger

points available in the overall space. The PLaY+SPaCE sensing space can be up to 100sqm in size, but for this work a size of c. 50sqm is used, leaving room for an audience beyond the lower edge of the grid in Figure 2. The trigger point numbered 1 on Sensor 1 is assigned throughout the work to trigger changes of scene (the "Next" button), indicated by the red arrow.
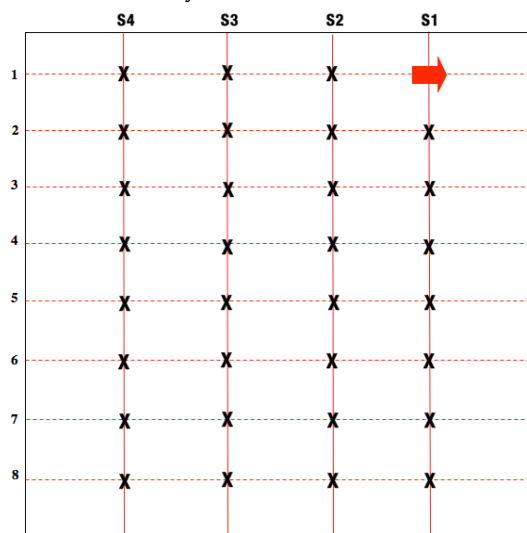

Figure 2 - Sensor Configuration

Figure 3 provides a visual perspective of the space, with Krieger in performance. The carpeted area in the image is the sensing space, the four sensors placed on stands at the edge of the carpet at the height of the performer's waist.

Figure 3 - Performance Space. Photo used with permission.

SOFTWARE ENVIRONMENT

PLaY+SPaCE utilises a proprietary software program for interfacing with the sensor system, as described in Campbell 2005. Each individual work created for the system then uses a patch designed in MAX/MSP to map incoming sensor data, to provide the user with navigation options and to

output audio. Generally third party plug-ins are utilised, including samplers and effects.

Figure 4 shows the main MAX/MSP patch used for *Sensience*. Subpatch objects within the main patch contain programming relevant to each of the six scenes of the work. For third-party items, vst~ objects are used and here show the software sampler used (Steinberg's Halion2) and basic reverb and delay effects added prior to audio output.
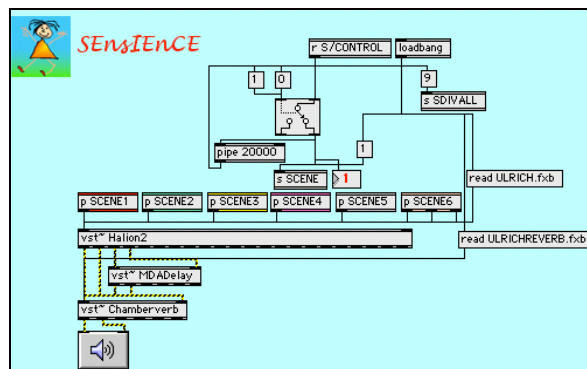

Figure 4 - Main MAX/MSP Patch

SCENE MAPPING

The general mapping of sample categories in each scene is shown in Figure 5, this figure forming the basis of the following overview of a performance of the work.

Figure 5 - Scene Sample Assignment

As an example, scene mappings for the opening scene are discussed in detail. Figure 6 shows the mapping for the scene, wherein the "Clicks" sample category is used, the five "Clicks" samples assigned to ten trigger points in the space. In addition to the key clicks, the "Sensors" sample category is also used in this scene. All 32 trigger points within the space trigger the "Sensors" sample, one of the eight pitch variations (resulting from pitch shifting) randomly selected at each triggering. This results in considerable layering of the sampled sensor clicks over the audible/acoustic clicks of the sensors themselves, the samples triggered as the performer moves throughout the entire sensing space.
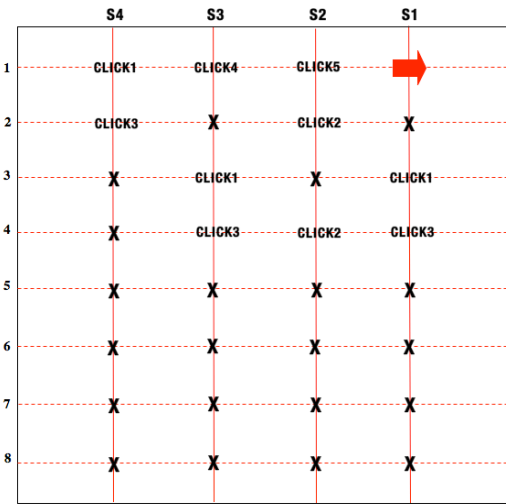
Figure 6 - Scene 1 Mapping

Figure 7 shows part of the MAX/MSP subpatch for Scene 1 and represents the mapping of the "Sensors" sample within the space. Input from all eight trigger points of the four sensors (S1 to S4) is allowed to generate a random number from 1 to 8. This number is then mapped to appropriate MIDI keyboard numbers as assigned in the software sampler.
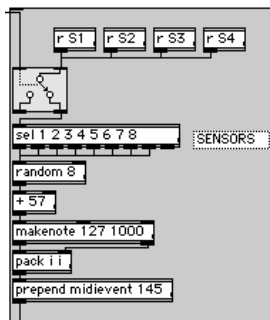

Figure 7 - Scene 1 MAX/MSP Subpatch

Inputs from Sensors 1 to 4 in the remainder of the subpatch (Figure 8) are mapped to trigger key click samples as seen in Figures 5 and 6. For example, trigger points 3 and 4 are selected from the Sensor 1 input to trigger MIDI note numbers 72 and 76 respectively, these in turn assigned to the "CLICK 1" and "CLICK 3" samples in the software sampler.
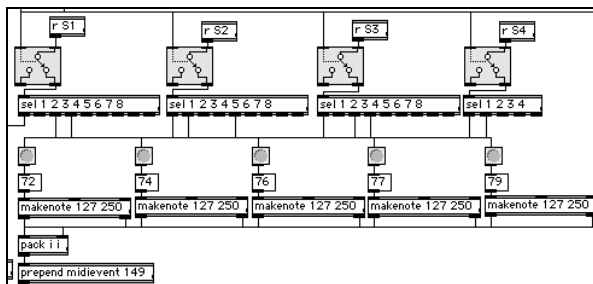

Figure 8 - Scene 1 MAX/MSP Subpatch

The sample assignments in the remaining five scenes each use a similar approach in triggering to that of Scene 1, i.e. the samples in each scene are either set to limited and specific points in the sensing space or are triggered randomly from a range of trigger points. The widespread triggering approach as used for the "Sensors" sample in Scene 1 is utilised again in Scenes 3 and 4. The 32 trigger points used here may be considered as a random triggering 'zone' that encapsulates the entire sensing space.

In Scene 5 of the work, smaller zones are employed, as shown in the mapping in Figure 9. Here two random triggering zones are used for the "Noise" category samples, triggered by movement through points 2 to 8 on Sensors 1 and 4. A subset of the "Clicks" category is used (six of the ten trigger points as used in Scene 1), these treated with a simple delay effect.
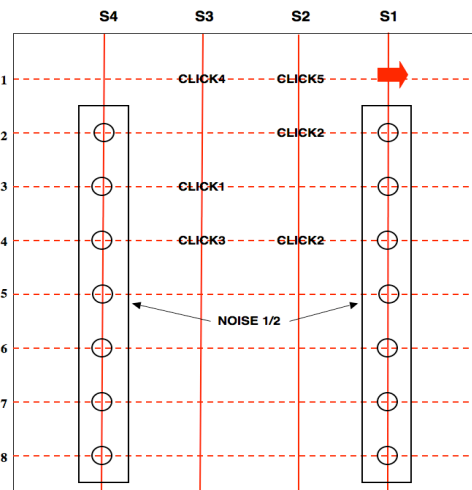

Figure 9 - Scene 5 Mapping

In Scenes 3 and 4, two different samples are triggered within a full-space zone of 32 trigger points. the mapping of two different samples to a trigger point resulting in a polyphony, or layering, of single-note "Straight" samples. Within the scene, four different dyads are randomly triggered, these shown in Figure 10.

Figure 10 – Scene 3 Polyphony

Considerable variation occurs within Scene 3 as lengths of individual samples differ (ranging from 15 to 24 seconds), and a pitch cannot be retriggered until it has ended. Figure 11 illustrates with the first dyad, the upper pitch able to be retriggered prior to the end of the lower pitch. Within the scene this

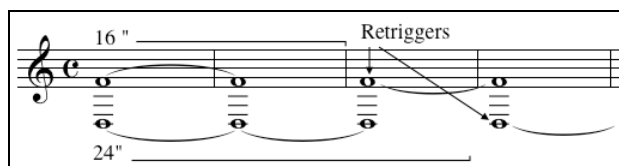results in a continuous layering of the six samples in the "Straights" category.

Figure 11 – Scene 3 Sample Layering

In Scene 4 a similar mapping is used, though here the samples are from the "To Noise" category resulting in continual layering of both pitch and breath noise.

Scene 6 of the work combines the "Straights" samples mapped as per Scene 3, i.e. over the entire sensing space. As shown in Figure 12, the "Sensors" sample is mapped as per the "Noise" sample on Sensor 1 in Scene 5, and the "Slaps" samples are assigned to a random triggering zone.
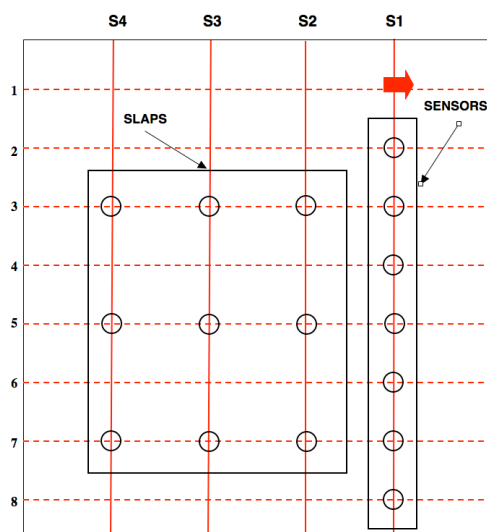

Figure 12 – Scene 6 Mapping

A final feature in the design of the work is an overlap of samples between sections. Rather than have an abrupt shift from one section to the next following a trigger to change scenes, a short period occurs in which trigger points in the space are allowed to trigger samples from both the old and the new scenes. In the opening two scenes this period is ten seconds, due to these scenes being quite sparse sonically, and in the remaining scenes the period is reduced to five seconds. Though these time periods are relatively short, they enable an effective transition between scenes by introducing new samples in conjunction with those previously heard.

PERFORMANCE

The preceding discussion has focused on the 'electro' portion of the *Sensience* electroacoustic collaboration, however this provides little detail regarding the musical outcomes achieved through Krieger's acoustic reactions to his triggering within the space. The following overview shows the manner in which the performer utilised the combination of his instrument and the triggered samples to achieve an ambient and quiet work of varying textures and contrasts.

The performance took place in October 2006, with Krieger having several rehearsals in which he adopted strategies for his performance before giving careful consideration to a slow choreography that he would utilise to further enhance the ambience of the work.

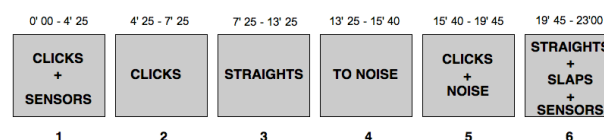Figure 13 provides the structure, sample categories and timings of the six sections.

Figure 13 - Sections/Timings

The work begins with the integral clicking of the PLaY+SPaCE sensors, the system started prior to the performer entering the space. Krieger enters and immediately begins the layering of the "Sensors" sample, occasionally adding percussive acoustic sounds including fingernails on the bell and barely audible keyclicks, thus imitating the sampled and acoustic sensor sounds.

The space is slowly explored, the occasional triggering of the "Clicks" samples imitated and augmented acoustically. Over the course of the scene, Krieger moves slowly from a left-hand entry point to the right hand Sensor 1, exploring the "Clicks" samples in his progress. The trigger to Scene 2 is activated after 4'25" of this slow exploration.

Scene 2, with its focus on the "Clicks" samples allows Krieger to introduce similarly textured tongue-slaps, centred around Ab1. Following this introduction, the performer briefly focuses on repeatedly triggering the Click 4 sample on Sensor 3. This sample has a combination of pitched (Bb 1) sounds and a rapid percussive series, approximated in Figure 14.

Figure 14 - Click 4 Sample

Through the repeated triggering of the sample the performer establishes a rhythmic episode, simultaneously developing a tonal interplay between the sample's Bb and his acoustic Ab.

A similarly brief interplay occurs on the Click 1 sample on Sensor 4 before the performer introduces a pitched and sustained D3, moving back to Sensor 3 to trigger "Clicks" samples and reacting to these with acoustic clicks. The same process is followed as the performer moves to Sensor 2, now introducing a sustained Db1. A brief focus on this pitch sees the performer move to Sensor 1 to end the scene.

Krieger treats Scene 3 as a central section in the work, extending the scene out over a six-minute period. Here the layered samples provide a continuous shifting drone over which the performer layers further pitches and multiphonics and melds his output into the sample layers utilising his "acoustic electronics" technique. Krieger's control and ability to play at very low dynamic levels allows him to imperceptibly add his acoustic layers to the sample layers, the listener often unable to distinguish between the acoustic or the electronic sound source. In this performance this audience experience is further enhanced by the sampled stereo output being spread throughout the room via a 7.1 surround speaker system.

Scene 4 structurally acts as a bridge, linking the "Straights" samples of Scene 3 to the "Noise" samples of Scene 5. Here Krieger simply continues the layering of the previous scene, augmenting his single pitch and multiphonic layerings with breath noise.

In Scene 5 Krieger structures his performance around the sample mapping, dividing the scene into five parts. The first and third parts are focused on noise with the performer's movements centred on the trigger points of Sensors 1 and 4 (see Figure 9). The second and fourth parts respectively utilise the "Clicks" samples assigned to Sensors 2 and 3. In the fifth part Krieger locates the area that is not assigned any trigger points (space between Sensors 1 and 4) where he is not detected by Sensors 2 or 3, and uses the ensuing silence (with the exception of the sensor clicks) to focus on slap-tonguing, this an introduction to the same timbre used in Scene 6.

With the "Clicks" samples of Scene 5, the PLaY+SPaCE system is set in a mode that allows trigger points to be locked into the system's timing. In this mode the performer may remain stationary at a trigger point and the system will recognise the performer's position at each ultrasonic pass, once every 512ms. This mode is utilised in the scene on Sensors 2 and 4, allowing continual retriggering of the "Clicks" samples assigned to these sensors. Krieger utilises the rhythmic repetition of the samples here to set up a chattering rhythmic background, over which he applies acoustic single note

and multiphonic trills and tremolos, further key clicks and rapid *sotto voce* passages.

The final scene of the work is recapitulatory in nature, and following the increased rhythmic activity of Scene 5, the performer uses the slow moving and sustained layers from the "Straights" samples to ease the work to its conclusion. Acoustically, Krieger recapitulates on the numerous timbres he has exploited throughout the work, both contrasting and blending with the layered "Straights" and the "Sensor" samples. Interspersed with his blends and contrasts, the performer reacts to the triggered slaps. Relative to the delayed "Clicks" samples of Scene 5, the "Slaps" samples are also treated with delay, the performer often imitating the samples with his own acoustic slaps and imitating the delay through repetition and decrescendo.

In the final moments of the work Krieger moves to the sensor interface, located behind Sensor 1, and powering it down, stops the audible clicks of the system to conclude the work.

CONCLUSION

With the exception of basic demonstration pieces, *Sensience* represents one of the most elementary works yet designed for the PLaY+SPaCE system. The work's linear and rigid form, its focus on reactivity as opposed to open interactivity and its lack of any inherent sound generation or synthesis relegate the design of the work to this position. Yet all of these apparent deficiencies cannot be considered as shortcomings, each having been adopted (or rejected) in accord with the desired aesthetics and sonic outcomes required of the work.

As Manning (2004) points out, "evaluation of electroacoustic works should be based in the first instance on the perceived results and not in terms of the technical means by which they have been achieved". In this light, the level of reactivity or interactivity of a work becomes irrelevant: the computer music practitioner needs develop a technical repertoire suited to a range of music/performance settings, a repertoire that is utilised with a full knowledge of the capabilities and limitations of the computer music system used. Thence, selection of an interactively open or closed (reactive) design for a work may be driven by the aesthetic requirements of the work and its user.

As described above, aesthetic considerations, along with a limited timeframe for composition, were key factors in the development of the *Sensience* collaboration. Whilst a range of more complex levels of interaction may certainly have been explored, the choice of a simple reactive system provided multiple sonic environments suited to the performer's desire to systematically explore in real-time his own pre-recorded samples in conjunction with his live playing.

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