AN INTERACTIVE SURFACE REALISATION OF HENRI POUSSEUR'S 'SCAMBI'

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ABSTRACT

We have constructed an interactive touch surface exhibit to re-appropriate a historic electroacoustc composition for the digital age. The electroacoustic work in question is Henri Pousseur's seminal composition 'Scambi', originally created in 1957 at the RAI Studios, Milan. The status of Scambi as a key example of an electroacoustic 'open' form makes it ideal for re-appropriation as an interactive public exhibit, while an existing musicological analysis of Pousseur's compositional instructions for Scambi provide insight for the user interface design and translation of written textual composition process into interactive software. The project is on-going, and this paper presents our current work-in progress. We address the musicological, practical and aesthetic implications of this work, discuss informal observation of users engaging with our tabletop system, and comment on the nature of touchscreen interfaces for musical interaction. This work is therefore relevant to the electroacoustic community, fields of human computer interaction, and those developing new interfaces for musical expression. This work contributes to the European Commission 'DREAM' project.

1. INTRODUCTION

DREAM is a European Commission funded cross institutional and multidisciplinary project exploring the Digital Reworking and re-appropriation of ElectroAcoustic Music. The overarching goal of DREAM is a permanent exhibition housed in the Milan Museum of Musical Instruments, to celebrate and document the highly influential Studio di Fonologia Musicale (RAI, Milan, Italy). One of our contributions to the DREAM project is a interactive tabletop implementation of 'Scambi', an electroacoustic work created by Henri Pousseur in 1957 at The Studio di Fonologia Musicale della RAI Milano (see figure 1). This exhibit aims to demonstrate to visitors, through active engagement, the process of creating an electroacoustic composition, and demonstrate to visitors some of the ways in which music technology and compositional practice has changed since the 1950s. In addition to the technical contribution our work makes to the DREAM project, it is also within our remit to assess the feasibility and implications of re-appropriating historic, analog electroacousic composition for public exhibition using modern technologies.

Figure 1. People creating a realisation of Scambi on the interactive surface.

1.1 Scambi and the 'Open' form

Scambi, created in 1957, is an electroacoustic work which exemplifies the notion of an 'open' form. An open form is a work left to some degree underspecified by the author, so as to create a situation in which multiple distinct instantiations can be realised by other people. Although it can be argued that scored music is always 'open' to a certain degree (for instance dynamics are often imprecisely described) [1], composers in post-war Europe explored many and varied forms of openness in musical composition [1, 2]. A discussion of the philosophical and musicological intricacies of open form in art or music is clearly beyond the scope of this paper, and we suggest [3] as a starting point for the curious reader. The rest of this section provides a more concrete discussion of Pousseur's Scambi.

The sonic materials of Scambi are a collection of 32 sound segments, each approximately 36 or 42 seconds in length. Pousseur sculpted these pieces of audio by running white noise through processes such as amplitude filtering, reverberation and tape-speed modulation. Originally these sections were stored on lengths of magnetic tape.

Pousseur identified four parameters within his sonic materials; *Relative Pitch*, *Speed*, *Homogeneity* and *Continuity*, and these were used to describe the starting and ending conditions for each sound segment. By joining together sound segments with matching start and end conditions, multiple sonic compositions could be assembled, with the connecting rule (matching start and end conditions) ensuring seamless joins between segments. Pascal Decroupet's musicological analysis of Scambi [4, 5] uses a notation system of 1s and 0s to describe the start and end of each audio segment; relative pitch (low 0 to high 1), the statistical speed (slow 0 to fast 1), the homogeneity of sound material (dry 0 to reverberated 1) and continuity (inclusion of pauses 0 to continuous sound 1). In Decroupet's system, a segment starting 1111 would begin high, fast, reverberated and continuous, while a sound ending 0100 would be low, fast, dry and include pauses.

Although Pousseur was interested in the idea of total continuity between sections [6] he also noted that the connecting rules are 'but a guide to the making of a unified whole, it being left open to assemble a meaningful event without their help'[6]. Composers are not obliged to use all sections, there are no constraints on the length of the composition, and polyphonic structures are permitted, whereby multiple segments are played simultaneously. Clearly with this small set of guidelines and sonic materials, a vast array of potential configurations are made available to composers. Alongside Pousseur, composers Luciano Berio and Marc Wilkinson created realisations of Scambi at the RAI studio, using magnetic tape and analog equipment. Recently a number of composers have created realisations using digital audio software as part of the UK Arts and Humanities Research Council funded 'Scambi Project' [3]. Both of these approach require a certain degree of technical expertise. Our work here aims to further simplify the realisation of Scambi, and in fact takes as inspiration Pousseur's imagining (in 1959) of an environment in which people can create realisations of Scambi in a social context [6]. More detailed notes on the realisation of Scambi are found in [5].

2. RELATED WORK

2.1 Analog Emulation

The music software industry has marketed the concept of virtual-analogue technologies to emulate classic pieces of music technology. Software such as Propellerhead's 'ReBirth' and 'Reason' present users with interfaces that visually resemble sought-after synthesisers and audio effects. As well as attempting to provide a faithful reproduction of the sounds created by these devices, these applications (and many others like them) use virtual buttons, LED displays and on-screen dials to visually resemble and recreate the user interaction experience of their physical counterparts. These forms of physical controls and user feedback were a necessity for the original physical hardware devices. Within the software domain choices about the interaction design are more open to negotiation as the sound production is not constrained by the physical characteristics of an electronic circuit, while the interaction metaphor [7] is constrained only by the imagination of the designers, and the specification of the machine the software is intended to run on.

This discussion is included to highlight the importance of considering interface design and metaphor when emulating or attempting to recreate a physical or tactile musical interface in an on-screen software environment. A literal, visually faithful recreation of the user interface may be more immediately recognisable, yet may not take full advantage of the affordances or capabilities of the new medium. We believe this debate is as relevant for the re-appropriation of electroacoustic work as it is for the design of analog emulation technologies, and we return to this discussion in section 4.

2.2 Interactive Surfaces for Music and Exhibition

Touch surfaces for musical interaction, performance and composition are a rapid field of expansion, with touch-screen mobile telephones and tablet computers becoming commonplace tools for musicians [8]. At a larger physical scale, the *reacTable* [9] has captured a great deal of public attention. The reacTable allows musicians to collaboratively patch together sound generators and processors by manipulating and arranging small physical objects on a rear-projected tabletop interface. These physical objects represent different sound generators and processors; with position, rotation, and proximity to one-another mapped to various synthesis parameters. Similar physical object based interfaces for music-making include *BlockJam* [10] and *Audiopad* [11], while [12] presents a multi-touch music environment based entirely on direct touch instead of tangible objects. Regardless of whether these systems use direct touch or tangible object based interaction, a key feature of surface interfaces is the provision for multiple points of interaction by *one or more people simultaneously*. Additionally such large-scale interfaces can be used within musical performances as a spectacle that bridges the gap between a performer's physical gestures and the music being created.

Aside from the interactive surface interfaces based on the paradigms of computer music software (on-screen oscillators, musical keyboards, sliders and so on), surfaces are ideal for placement in public contexts [13] where accessibility and immediacy are central concerns, and furthermore it has been noted that members of the public do not usually associate interactive surfaces with conventional forms of computer interaction [14]. Examples of interactive surfaces designed for playful engagement in public exhibitions include Fencott's interactive cellular automata [15] and Iwai's 'Composition on the Table' [16], both of which leverage the potential of interactive surfaces to support direct intuitive engagement with sonic and visual materials in a manner which is distinct from conventional music-making techniques or tools.

2.3 Preservation of Elecroacoustic Music

Electroacoustic works are often tied intrinsically to the technologies employed in their realisation. The preservation of electroacoustic works is therefore a problematic issue for musicologists, historians and composers alike. [17] observes that due to obsolescence, many compositions and performances are impossible to repeat without major reconstructive work to rebuild systems and port code to new platforms, for instance Arfib's implementation of Music V synthesis algorithms [20] for gestural control. However for the majority of composers, written, audio and visual documentation are the only methods of preserving their work for future generations. There are already many projects dedicated to the task of documentation, for instance [18] [19]. However for an open form to *remain open*, documentation alone may not be satisfactory. Rather, it is crucial that the means of producing new instantiations is preserved. It is testament to Pousseur's own written documentation, the extensive research surrounding his methods, and the conservation of his original audio materials that our work is made possible.

3. IMPLEMENTATION

This section discusses our implementation of the interactive surface Scambi interface. We first give a brief overview of the physical table interface constructed for the project, which serves as a prototype for software development purposes and will be used in several public exhibitions in the UK. We then move on to discuss the software design decisions and the influence of existing musicological research on Scambi. Video and additional documentation is available on the first author's website [21].

3.1 Hardware

We constructed a computer vision based multi-touch table. In this approach, a camera views the underside of the touch surface, and computer vision techniques are used to identify the location of fingers and objects on the surface. A predefined 'Fiducial marker' needs to be attached to the underside of any object which is to be tracked. In our system tangible objects were constructed by glueing the fiducial markers to acrylic tiles (see figure 3).

Our touch surface is a 5mm clear acrylic sheet. A short throw data projector is used to back-project onto the touch surface, with a sheet of 1mm matt translucent plastic affixed to the underside of the acrylic as a projection surface. For finger and object tracking the touch surface is illuminated with six infrared (IR) emitter arrays; a technique often referred to as Direct Illumination (DI). Each IR array comprise of up to 32 Osram SFH485P infrared emitters (see figure 2). A Firewire Unibrain Firei camera with a wide angle lens and daylight blocking filter is mounted next to the projector to view the touch surface.

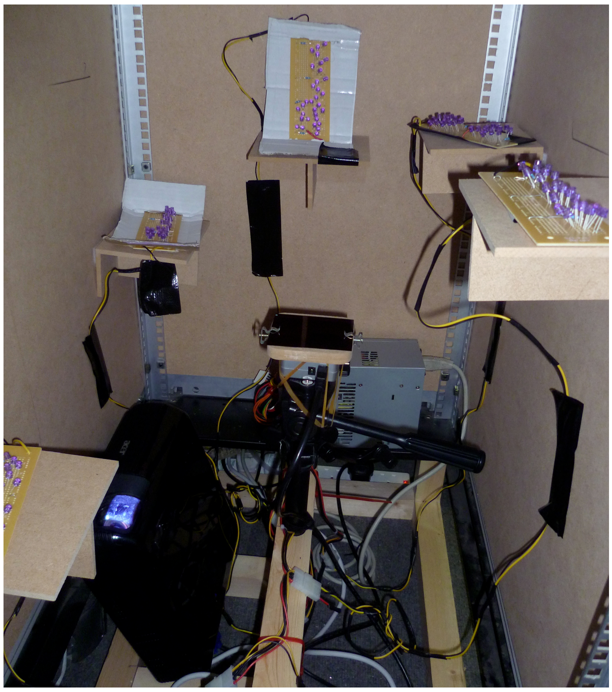

Figure 2. Internal components, including camera with daylight filter, data projector (bottom left) and IR emiters.

The matt finish of the projection surface also helps eliminates 'hot-spots' of reflected infrared light being detected by the camera. Computer vision and fiducial tracking is handled with reacTIVision [22]. This application transmits position information about fiducial markers and direct finger touch using the TUIO Open Sound Control protocol to the Scambi Sequencer application (see 3.2). The whole system runs on an Apple G5 Power Mac.

Several publications document the construction of interactive surfaces [23, 24], so rather than re-iterate these details we move straight to the implementation of the Scambi Sequencer software. Further reflections, lessons and documentation about our construction process are given on the first author's website [21].

3.2 Scambi Surface Sequencer

The Scambi Sequencer allows multiple participants to create realisations of Scambi by arranging tangible objects on the interactive table surface. The Scambi sequencer was written in C++ OpenFrameworks [25] using the ofxTUIO addon library [26] to receive TUIO messages from reacTIVision.

As described in 1.1, Scambi comprises of 32 different audio segments which can be arranged to form many different compositions. In the Scambi Sequencer, sections are represented as on-screen waveforms (see figure 3), and associated to a fiducial marker. Placing and removing fiducial markers on the table surface enables the dynamic creation and deletion of Scambi sections within the composition. Sections can be arranged spatially on the table, although their coordinate position is not mapped to a parameter. Duplicate sections are permitted, and as many can be added to a composition as will fit on the table surface.

Figure 3. The Scambi interactive surface.

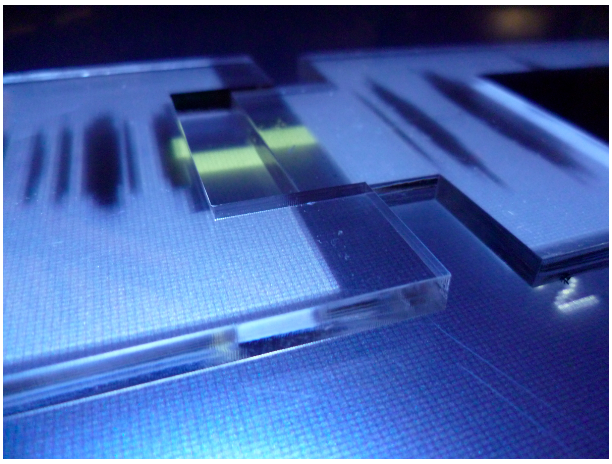

Figure 4. Tesselating acrylic tiles.

It is important to stress that working with the sound segments in this way is entirely different from the approach facilitated by the RAI studios. For instance, the visual waveform representation of the audio was not available to composers, who would have instead relied upon their listening skills to become familiar the sounds. Also, while our design allows for multiple instances of the same sound segment by adding two markers to the table, composers in the 1950s would need to manually duplicate lengths of analogue tape to achieve the same effect.

The musicological notation developed to represent the start and end conditions (unintentionally) resembles the binary number system. Taking advantage of this, the start and ending conditions for each sound segment were copied from [5] and stored as unsigned integer values (e.g., a section starting '0100' was represented as integer value 4). Equality testing and bit-masking operations could then be used as convenient mechanisms to determine the degree of match between sound segments.

Given Pousseur's liberal attitude towards adherence of his matching system, we felt it appropriate to indicate, rather than enforce the connecting rules within our software interface. This gives participants the opportunity to fully explore different combinations of sounds within the Scambi composition, while still drawing attention to Pousseur's original intentions. We use a jigsaw or puzzle metaphor to visually imply the start and ending conditions of each Scambi section. The jigsaw shapes are laser cut into the acrylic tiles, and are echoed in the graphical projections on the table. Sections matching on all four of Pousseur's parameters (pitch, speed, homogeneity and continuity) visually and physically tesselate (see figure 4). Sections placed within a pre-defined proximity to one another on the table surface are automatically joined via connecting lines. Matching sections are connected by a single thick green line, while sections that are not fully matched are joined with a faint red line. These design decisions were made for several reasons. Firstly, we wanted to guide users towards Pousseur's ideal of complete continuity between sections, while in no way restricting people from exploring more discontinuous configurations. Secondly, we wanted to imply the activity of joining sections through the physical affordances of the physical tiles and their projected graphical representations.

Playback of sound segments is started or stopped by touching the projected waveform. Visually, playing runs from the left to right and the current position is indicated a vertical bar. When a segment finishes playing it automatically triggers the playback of any segments connected to its right-hand edge. Sound sections can be added and removed at any point in the interaction, and there is no limit to the number of sounds concurrently playing.

3.3 Real-time Manipulation

The Scambi sequencer allows users to manipulate the audio playback using additional fiducial objects. The stereo position and volume can be altered using the Pan and Volume objects. These objects maps their rotation value to all Scambi sections within a pre-defined proximity. The playback speed and pitch of Scambi sections can be controlled using the Pitch object (see figure 5). Up to a half-speed decrease is permitted by the object, in line with Pousseur's suggestion that the original material can be lowered by an octave without losing interest [6]. With these controls, we remained sensitive to the historic and technological context of the original Scambi, by mimicking the operations available to composers working in the RAI Studios. For instance the pitch control object mimics the behaviour of tape-speed manipulation by altering both speed and pitch.

To avoid discontinuous jumps between extreme values the manipulation objects use a circular mapping scheme. In the case of the Pan, both 0 and 180 degree positions represent the stereo centre, while 90 degrees indicates hard right panning and 270 degrees is hard left. (see figure 6).

4. OBSERVATIONS OF USE

During development we invited people to use the surface interface and give feedback on their experiences of it. Many of these people were undergraduate Sonic Arts and Fine Arts students from Middlesex University. As observers, we took written notes and conducted informal conversations.

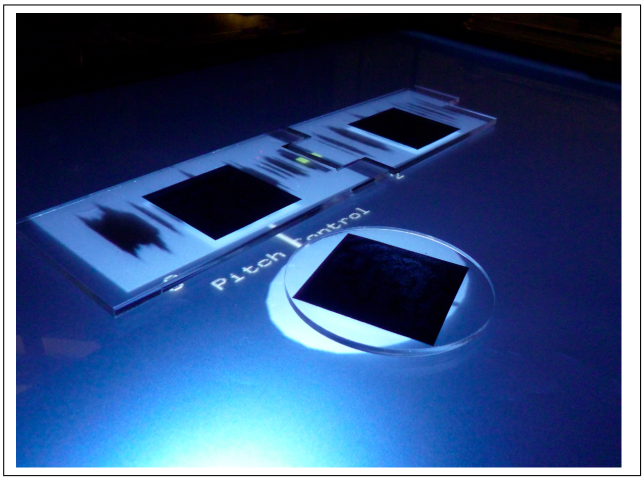

Figure 5. Real-time pitch manipulation.

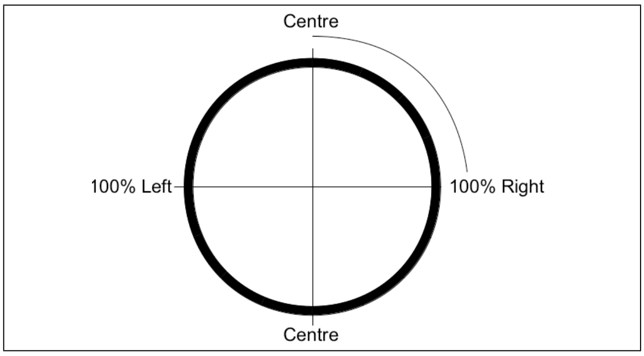

Figure 6. Circular mapping for rotational Pan object.

We answered any questions they had during the course of the interaction and explained the purpose of the project, but gave minimal instructions for how to use the table, as we were interested in witnessing participant's initial encounters with the exhibit, and observing their intuitions about the interface functionality. Reactions were generally very positive, although our attention was drawn to a number of problematic issues, which relate specifically to our interface design, yet may be applicable more generally to interaction with tabletop and surface interfaces.

Our interface uses a mixture of direct touch (fingers touching the surface) and interaction via tangible objects with fiducial markers. Although touch screen interfaces are becoming more common (mobile phones, kiosks, etc), often, our participants did not immediately realise the surface supported both forms of interaction. In our implementation finger tracking is much less reliable than fiducial tracking, although this might be addressed with additional IR lighting. Where touch was unresponsive, participants would often try pressing harder on the screen, although this has little effect, while in overly sensitive areas, touch points were often detected when fingers were 'hovering' over the surface, rather than in contact with the screen. As the direct illumination approach to touch sensing (see section 3) does not require contact with the screen this issue is difficult to eliminate entirely.

Initially, participants appeared more focused on the properties of the surface interface than the Scambi composition itself. They often experimented with adding sounds to the surface and moving objects around. Some participants were already aware of Scambi, and usually progressed to creating compositions or asking about the process of matching sound segments together. Those who were not familiar with Scambi required more information about the composition process before they understood the purpose of the exhibit. Clearly for a stand-alone exhibit, additional information would be useful to aid visitors in appreciating the work. This information could be provided in written form, or could be included in the Scambi Sequencer itself, as a structured 'training' mode that guides participants through the process of adding sounds, combining them and manipulating them.

A potential pitfall of re-contextualising historic electroacoustic using modern technology is that the new technologies may overshadow or distract from the original work. In our case, some participants using an early version of the system were confused by the fiducial symbols, and misunderstood the relationship between sound sections, on-screen waveforms and the printed markers. Some participants assumed the fiducials were created by Pousseur to represented the the Scambi sounds, while others thought the fiducial symbols stored the audio in some way. This confusion highlights an important factor to consider when designing systems using marker based object tracking. The symbols are visually striking and it is easy to see how they could be interpreted as a significant or salient aspect of the work, however they are but a component of the sensing apparatus, and irrelevant from a user's perspective. In our case this confusion was resolved by simply concealing the markers as much as possible, although we make this point more broadly to stress the sensitivity one must have when re-appropriating historic works using new technologies, especially where the infrastructure of the presentation platform can become confused with the aesthetic experience of the work itself.

5. CONCLUSIONS

This paper has described the development of an interactive surface exhibit which revisits Henri Pousseur's electroacoustic open form 'Scambi'. The open nature of Scambi and the flexibility implied by Pousseur's documentation of the work make it ideal for re-appropriation as an exhibit, while an abundance of work concerning the construction of interactive surfaces allowed us to focus on interaction design concerns, which were informed by existing musicological research on Scambi. We have reflected on observations of users interacting with the exhibit, and highlighted consequential design issues for both touch-screen interaction and the re-appropriation of of historic electroacoustic works more generally. Our Scambi sequencer was presented at a public exhibition in early May 2011 at Middlesex University, alongside live performances and fixed-format realisations of Scambi and other open forms by Henri Pousseur.

6. ACKNOWLEDGEMENTS

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