Composition Research Folio

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Abstract

This folio consists of four electroacoustic works: *A.L & Rossler*, *Chucker*, *Cycles* and *Concretion Study: remix*. The following commentary is provided as an introduction to these pieces and the processes involved in their making. Instrument design is addressed as a part of my own practice, with an exploration of issues raised by musical activity with automata in the fields of computer music and live electronic performance.

Contents

Introduction and *Concretion Study: remix*

Musical work with computers often calls for a degree of technical discussion and explanation. The pieces in this folio have been assembled using custom-made tools in Pure Data and Max, and a partly technical commentary follows. I would also like to address my relationship with these tools as an area of personal research interest. The development of real-time performance software is often referred to as *electronic instrument design* and I will begin here.

I would describe my practice as somewhat improvisatory. Firstly, in the sense that I use these tools for improvised playing. It is also the vehicle by which many of the materials and compositional ideas in this folio have been born, expanded and explored. My tools are designed to encourage this kind of 'play'.

Throughout the year I have played as part of a trio called *Elvis Trevor*, who share a history and mutual interest in electroacoustic improvisation. Our activity has informed my software-based work and likewise, the tools have informed our playing. Programming, then, enters a dialogical relationship with the other aspects of our practice. A 'real-world' parallel could be made with Harry Partch's instruments, which were built by the composer with a visual aesthetic and specific tuning systems in mind. The gestures and/or patterns in Partch's writing have, at the same time, been identified by one author as “idiomatic to the physiognomy of a particular instrument” (Blackburn, 2006, p.3).

This two-way relationship could be considered analogous to the evolution of musical tools throughout history. I am particularly interested however, in the rate of this interaction in my own work process. An ongoing assessment of the constraints of a particular software configuration, and subsequent re-configuration has become fundamental when assembling the pieces in this folio. The modular nature of PD and Max enables a fluidity here. This speed of this interaction has the potential to increase as more custom tools are created and implemented as what are termed *abstractions*.

Performing with real-time signal processing chains means working with visual and aural feedback. I have tried to enhance the interactivity of my own software-based instruments through interfacing, but the 'patcher window' has also become a potentially playful environment. Configuration of the software has also been somewhat improvised in this sense, in response to audio-visual feedback. I have recently started to experiment with patch construction during group performance as a means of exploring this potential.

From these premises I would say that the work documented here has been towards refining my own tools for performance in terms of their playability. This has influenced work on the pieces presented in the folio and vice-versa. It has also been to integrate patch construction with sound-making activity in my work.

Motivation has stemmed from a level of dissatisfaction with my previous approaches to the computer, especially in a live context. I often thought of its use as an extension of my electric guitar playing, or a processor of acoustic input material when working with other musicians. This dissatisfaction was partly due to a realisation that I might be able broaden the playable scope of the interface, beyond the manipulation of global parameters, mix levels, effect routing and so on. Earlier configurations tended to encourage slow, smooth transitions and gestures with which I had become overly comfortable.

Concretion study: remix could be considered a document of this approach. It was, however, assembled in the studio and is essentially a 'remix' of a recording of the aforementioned trio, consisting of myself (guitar and electronics), Adam Campbell (electronics) and Lawrence Pitt (drums).

After a recording session in November we decided that each member would attempt their own remix, which might reflect our individual aesthetic preferences and motivations when working alone. They could also supplement some of the recordings in an online release. Source materials were allowed to include other audio collected whilst playing together and in related groups. My version employs some of the processing tools and strategies mentioned: a skeletal structure was pinned down in a first layer, by extreme stretching of cymbal heavy drum material with synced phase-vocoder and granulation. The re-synthesis playback speed and a 'frame blur' parameter were modulated manually to allow space for emptier, frozen moments and dynamic swells around cymbal activity. A good 'pacing' seemed key to accentuate this contrast. Further spectral processing was applied at this stage and other materials introduced in a secondary layer, but a reliance on the original drum track for structure and a slow textural evolution is very evident in the final mix.

An evaluation of this piece has helped clarify that I had become quite dependent on such strategies. Since then, a personal goal has been to inject a heightened sense of gestural interactivity, whilst treating the computer as a sounding instrument in its own right.

Instrumentalism and Software

Miller Puckette once said that “the computer is better used as an instrument” (1991, p.3). It would be difficult to disagree in the context of this commentary, but might also be useful to consider ways in which it could be used otherwise. Puckette was essentially arguing against “attempts to instil 'musical intelligence' in the computer” (ibid.). This position pits the 'instrumental' against automation, the latter renouncing human control. To complicate matters at the other end of this scale, one encounters a wide variety of accounts for instrumentality in today's electronic music criticism and theory.

An article in *Organised Sound* caught my attention whilst researching this topic. The text is titled *Theses on Liveness* by John Croft and my curiosity can summed up in the statement that: “Instrumentality is resistant to redefinition”. It is an *“*impossible conception of instrumentality that other forms of electronic performance, which lie somewhere between the fixed and the instrumental, are excluded” (2007, p. 66).

I should stress that the author actually includes most musics that use electricity in those 'other forms of electronic performance'. He seems to be specifically addressing the composition of works for acoustic instruments with live electronics, arguing for a causal and sonic continuum between the two. The notion of instrumentality here is based on an acoustic instrumentalism. Why then is the author alluding to an 'impossible' concept? It seems somewhat bleak that so many other forms of electronic performance should be deemed to lie 'between the fixed and the instrumental'.

Indeed *Instrument* seems to be a loaded word and a broader definition would be useful. A recent collaboration between three authors (Cance, Genevois and Dubois, 2009) has examined its use in both French and English, from a perspective of Cognitive Linguistics and Psychology. Differing definitions from two French dictionaries are offered and examined in this text.

Le Petit Robert (PR) draws an opposition between instrument and tool, emphasised by "the tool as a prolongation of the body to accomplish a gesture, and the instrument as a prolongation of the body to get a better perception". *Le Tresor de a Langue Francaise* (TLF) on the other other hand insists on the "notion of creation and specifies domains in which the instrument is involved, namely technique as well as science and art. Moreover, TLF gives a specific definition of musical instrument as an object producing sounds with a focus on expressivity and users (composer and performer) of these objects" (pp. 3-4).

At a first glance the *Petit Robert* definition might lend itself better to the familiar acoustic instrument model, depending how literally we consider the instrument as a prolongation of the body. *Le Tresor de a Langue Francaise* might seem to offer a more inclusive definition for software-based work.

Interestingly the *New Oxford American Dictionary* definition comes close to neither translation, defining instrument as a "specific tool used for specific purposes in (scientific or artistic) and delicate work" and the musical instrument as "an object or device for producing musical sounds". The authors note that there is no "explicit mention of agency" as in the TLF definition (ibid.).

The active position, of the 'expressive' user-agent in the TLF translation, seems especially pertinent when working with automata. An over-reliance on automation might limit instrumental expressivity and execution of will in 'play'. My previous dissatisfaction with the aforementioned tools might be explained as a subservience to certain automated processes. I would still like to exploit automata for what they offer and here the machine must “be granted autonomy for inhuman speeds” (Collins, 2003, p.73). The balance between automation and direct physical control has proved fundamental in these respects.

My tools have been designed to heighten perception and enable a greater understanding of the relationship between control and sounding result. This is the role of the physical interface, feedback and 'meaningful' mappings.

Activity and production are distinct notions in these definitions, both pertinent to software-based work, especially when considering that music software is so easily purchased, consumed and collected. This position could be expanded from Bo Dahlbom who has written extensively on issues surrounding Information Technology, calling for a distinction “between using technology to produce something and using technology to consume. It is not a choice between people and technology, but between different sorts of technology” (2003a, p.108). “Should we not develop better tools for activities rather than automata for experiences?” (Dahlbom, 2003b).

It would be fair then to say that the physical 'rapport' between a musician and their tools is a very important factor when approaching this topic. It is however only one relationship, one type of rapport to consider. Much of the research in the field of live electronic performance deals with a physical interfacing modelled on, or as an expansion of the acoustic-instrument paradigm, assuming this is key to expressivity and 'musicianship'. Whilst useful and surely a fruitful avenue for creative outlet, assuming this position might lead to me overlook other meaningful (and potentially expressive) relationships.

David Tudor's work with DIY electronics has been of inspiration to my research. The sounding objects in the environment of Rainforest IV were described by Tudor himself as "instruments, sculpturally constructed from resonant physical materials" (cited in Perloff, 2004).

Other accounts for experimental practices such as the 'electronic process' of David Behrman's *Runthrough* (1970) and the 'instrument as total configuration' (Nymann, 1992, pp.8-9) are certainly useful here in that they explore the conditions of any configuration or formal system as an instrument which may be performed upon. Andy Keep's discussion of 'sound-shaping' as “the practical activity of instrumentalizing” (2009, p.121) is especially insightful. He proposes three levels of performer interaction: *facilitate, influence* and *impose*. I have found these categories a useful reference in understanding my own playing practice.

Christian Marclay and Philip Jeck's turntablism, and the 'mis-use' of electronic devices by noise artists such as John Wiese and Yellow Swans would be more recent examples of personal interest, that account for a broader instrumentality in practice. Keep has called this play with the unexpected use of objects a 'creative abuse' (2009, pp.116-117). Notions of unorthodox technique in music making are perhaps best understood in relation to social space and genre. One orthodoxy of computer and software use however, might be that of simulation. This would be exemplified by the vast amount of music software applications that are presented as if they were hardware. Whilst explainable in that the music industry has greatly shifted from hardware to software use, this could also be seen as a more general cultural attitude towards, or expectation of, digital technologies.

Non-standard Synthesis Versus Simulation

"Computers produce and manipulate numbers and other symbolic data very quickly. This could be considered the idiom of the computer and used as a basis for musical work with the computer" (Berg 1979, cited in Döbereiner 2009 p.2).

Luc Döbereiner has highlighted that the majority of documented synthesis methods, those coined 'standard synthesis', begin with analysis and therefore simulation (2009, pp.2-3). As a one-time intern with the Analysis/Synthesis research team at IRCAM, I'm all too aware of this coupling; so accustomed to it that I had overlooked the prescriptive implications it might have brought to the field of computer music. This kind of simulation is, after all, only one potential use of the computer for musical activity in light of Paul Berg's statement.

Döbereiner outlines an aesthetic context for 'non-standard' approaches, which are said to be rooted in the belief that electronic and digital means allow "the composition of timbre, instead of with timbre” (Brün 1970, cited in Döbereiner, 2009, p.1). For the author these methods give rise to the possibility of an 'axiomatic disorientation'. That is they challenge the premise that an understanding of sounding material stems from the analysis of acoustic phenomena and are in this way are an experimental “non-technical ensemble of technological objects” (2011, p.36).

Of these non-standard methods, the Graphic Sound Synthesis of Xenakis' *UPIC* system is of specific interest to my research. *UPIC* was dedicated to the “interactive composition of musical scores” (Xenakis, 1990, p.329), with which the user would draw frequency-time arcs that are converted to sound. The pedagogical dimension of *UPIC* has been of interest, in that its interface enables an effective understanding of an otherwise abstract sounding result. The visual language of *UPIC* could be said to aid the perception of non-standard synthetic sound.

This would be a primary aim in instrumentalising the computer *sui generis* (Döbereiner, 2011). Visual methods might also allow for the communication of action to an audience if presented. Analogies to sculpture are often made in the language approaching electroacoustic music, and this perhaps an interesting one to expand in interfacing strategies, visual or otherwise.

Döbereiner's would be a useful perspective from which to contextualise an approach to the computer as a sounding instrument in its own right. In programming new real-time performance tools, I have avoided the premise of an ideal acoustic or outboard model. This is not to undermine physical interfacing, but to fully apply a mechanical logic would be to essentially render the computer impotent. Instead of denouncing the inhuman nature of the computer idiom in performance (its calculating speed), I have first embraced this as a liberating quality. It thus becomes increasingly difficult to map 'meaningful' user control to digitally complex behaviours. The task at hand then, is to explore new descriptive languages, and methods for understanding these relationships.

The rest of this paper will outline a more technical description of my approach to this process with reference to the remaining pieces. Enabling factors have been the sonification of dynamic models, more familiar probability-based algorithms, a visual representation of sound parameters and a reactive/interactive graphical interface.

Cycles*, *Chucker* and *A.L & Rossler

These three pieces are composed entirely of synthetic material. The starting point for each synthesis being the sonification of dynamic physical models in Pure Data using Cyrile Henry's *pmpd* object library (2004). More recent experiments have been in Max with Jitter's own native (jit.phys) modelling library.

I should stress that this process is distinct from physical-modelling synthesis which “starts from mathematical models of the physical acoustics of instrumental sound production” (Roads, 1995, p. 265). The mass-spring-damper system (at the heart of pmpd in the mass and link objects, but not its only capability), has been more commonly implemented in computer music and software to model strings and vibrating surfaces.

Sonification is “the technique of rendering sound in response to data and interactions” (Hermann, Hunt and Neuhoff, 2011). It would be the technique by which to map relationships between abstract sound material and user interaction. This approach has helped develop a personal language with which to compose and assemble this sound world. It has enabled me to visualise timbre without reference to formal technique. Many of the descriptors one finds in discussion of computer music, such as 'swarming' or 'density', are physical qualities or behaviours which may be modelled. Sonification strategies might encourage this kind of language and help realise these ideas.

For a more technical breakdown it is useful to distinguish between control-algorithm design (of the model) and synthesis or sound design. I will address each area separately for the sake of clarity.

Algorithm Design Considerations

My initial experiments with the pmpd objects were with spatialisation in mind, searching for a method of automation which might offer a degree of interactivity and flexibility from just a few global parameter controls. An example of such an application would be a mass-spring chain in which mono sound sources are panned according to the particle co-ordinates in virtual space. Excitation from the user results in more complex movement which may be quite easily mapped to any spatialisation patch. It is at this early phase of discovery I started to see a greater potential in data provision to a variety of other sound parameters.

An apparent use for such models would be to simulate natural behaviours, “allowing a natural comportment for digital synthesis” (Henry, 2004, p.12). Whilst this has not been a concern of my research, the familiarity of dynamic behaviour seems to make for intuitive interfacing. That is, the models provide easily comprehensible data when visualised. This means that specific gestures may be learned and practised with relative ease.

As modulations or generatively automated behaviours are introduced, the ability to *influence* the state of a simulation with foresight, but not a precise knowledge of the results of an interaction has proven useful in adding an accidental or improvisational dimension to the process. This is not to say that the computed simulation isn't entirely deterministic, it is simply introduced through a snowballing effect of information.

I have found this somewhat similar to working with 'real-world' feedback. As a guitarist I have long had a fascination with its musical potential and playability. In software the most obvious parallel would be signal rate feedback chains, but scheduler-rate physical models have presented the opportunity to influence control data in a similar causal relationship. These aspects might add a potential for danger and accident in the playing scenario.

The models are excited by interaction with a visual interface window. Clicking on a rendered shape applies force to the 'mass' that it represents. I have also worked on configurations in which the masses are attracted to a moveable point in the window, simulating gravitation. More recently, methods have been explored to select individual 'mass' or body shapes, in order to access and edit their physical properties. The laptop mousepad has proved most useful for this kind of interaction. I hope to customise my own tablet interface for future performance work.

It might also observed that these kinds of algorithms are rather efficient. That is, very little input data produces a much greater complexity of output. This is of course extremely practical in the domain of live laptop work, when sophisticated hardware interfacing is often awkward and/or expensive. Whilst useful for synthetic gesture creation these properties have also informed work on a larger compositional time scale. Through chain reacting effects with comparative operators or external modulation of a few variables, it is possible to elaborate exponentially complex activity which evolves over time.

Non-deterministic or stochastic methods have proved useful in this way. The possibility of the machine 'doing its own thing' has been treated with caution for fear of renouncing instrumental control, but could be *facilitated, influenced* or exploited when necessary. This is where a combination of global (physical property) controls and direct excitement possibilities prove useful in providing a balance between influence and automation.

What is essentially desired and hopefully expandable from these ideas is a broadening of the scope of a my previous algorithmic approach. I may design configurations with internally modulated activity, with the ability to shape and influence them directly in performance-time. As well as providing an interface for excitation, the visual interface allows access to certain micro-level parameters in response to the material produced.

From a practical perspective the designs had to be easily adaptable, allowing for various sonification trials. For this reason I switched to Max. *Poly~* has then been used for dynamic particle creation, with a rather cumbersome graphical interface in which all dynamic properties could be accessed. This was later replaced or fed by a select few global parameters for more specific applications.

The algorithms also needed to be portable or easily mapped to a variety of possible synthesis patches. Output data was therefore fed into jitter matrices for easy access and manipulation.

Implementation in the Folio

Cycles

Up to 40 masses were positioned randomly on a two-dimensional plane, each with a gravitational field attracting the others and a surface interaction for damping on collision. The mass positions were tested for contact and if each was found to be touching at least one other the model was reset, starting the process over. A global gravitation value has been manipulated over time to influence the pacing of each of these gestures, and to allow pausing for other processing. Re-spawning could also be triggered manually, and a single gravitation point introduced using the trackpad to influence movement.

Chucker

Two separate models were used to feed distinct layers of the synthesis. The first was a rather alien bouncing ball in a three dimensional room with rigid walls and a strong force of gravity. Collision detection was used by testing the position of the ball relative to each wall. The ball could be thrown manually on a random, upwards trajectory with key commands or the mouse. The unnatural behaviour of this simulation would cause the bouncing motion to 'stick' with a certain combination of forces in an almost metronomic fashion.

The second model incorporated 12 or so highly attracted masses in 2D, with deflective surface interaction causing seemingly sporadic behaviour.

A.L & Rossler

The most complex piece to describe in that multiple levels of reprocessing were involved before assembling the presented recording. The majority of the sound material has been sourced from an earlier recording, made with a particle system that was influenced by a Markov chain and other operators over the course of 20 minutes or so. The density of this model was also manipulated manually, and some of the sparser moments can be heard in their original form, for lengthier periods. Simpler models were also used to supply more diverse sound material.

The 'master' model which provided a structural framework for the piece, consisted of a single mass with various interactions and wall-collision detection. The speed of the simulation was manipulated and paused to further influence the resulting gestures.

Mapping, Synthesis and Sound Design

The effectiveness of these control tools can only be demonstrated once mapped to sound parameters. Through the visual interface each simulated object is treated as a sounding object and vice-versa, ensuring a close relationship with manual control.

This has been another area of experimentation and play, and it would be difficult to outline concrete conditions for a successful mapping. I have, however, been inclined towards syntheses which reflect the models' activity strongly, therefore assisting perception and an understanding of the computed process. I have come to think of this as *close* mapping.

It has been useful to look at other work in the field of sonification to further grasp the nature of these relationships. A study has recently been initiated (Dubus and Bresin, 2011), surveying a total of 54 articles addressing mapping techniques of physical quantities for auditory display in a wide variety of applications. The research adopts the following sound parameter categories: *Pitch-related, Timbral, Temporal, Loudness-related, Spatialization, Onsets,* and *Saliency.* The physical quantities which these may be mapped to are categorised as relating to either, *kinematics, matter, kinetics, proportions* or *time-frequency.*

Perhaps not surprisingly, the most frequent pairing in the survey was position to spatialisation. The vast majority (86%) of all cases used pitch-related mappings, 20 of these also from 'kinematic' data relating to movement. Whilst I have been concerned with interfacing timbre and space as primary variables, the use of other categories may assist and complement this work.

The authors note that many popular couplings such as position-spatialisation seem to follow the "logic of ecological perception" (p.4). Others mappings in this category include, size to pitch, and velocity to tempo. A size-pitch correlation has been useful for as a visual reference to pitch/frequency-related synthesis parameters. Velocity-tempo might often be implied in real time, if movement is already mapped. With many of these type of mappings parameters overlap, seemingly strengthening the control-sound relationship.

Position to spatialisation has opened up other possibilities for my own work based on spatial perception. Distance to amplitude was introduced, from a user/listener perspective or virtual 'microphone' point. I have also experimented with doppler effects and reverberation based on spatial data. Even if not necessarily translated to speaker space, all have proved useful in visualising depth and timbal evolution in the synthesis. Introducing this kind of perspective or listening point has helped work with space in an ambisonic environment.

'Ecologically' informed mappings have been explored, but I have found equal success with those which do not follow suit. Real-time feedback from the computer means that a wide variety of configurations can be understood from a player-perspective.

Sound materials have been recorded and edited in Logic for the presentation of the folio pieces. In *Cycles* and *Chucker* this has involved the splicing of recorded files and the use of fades to refine and enhance aspects of the original 'performances'. The editing process was more central to the creation of *A.L & Rossler*, in selecting materials for subsequent sampling and re-sequencing. Final mixes were made in Logic using volume automation, compression, equalisation and reverb. Surround mixes of *A.L & Rossler* were created by routing the Logic tracks back to spatialisation patches in Max.

Examples in the Folio

Cycles

Each mass was assigned a 'voice' in an oscillator bank. The velocities mapped to the amplitudes of these oscillators, linking speed to the envelope of each partial. Coordinates on the x-plane are mapped to stereo pan positions. A tuning rule was devised with both additive and multiplicative factors (for frequency) to compose the inharmonic spectrum. Misshapen sines (closer to a triangle) and square waves were used. (See appendix 2a for an overview)

Chucker

The vertical position of the bouncing model has been mapped to the playback position of a granular synthesis patch, contorting the sound file in question beyond recognition. This file was also created with physical model control algorithms but I will not elaborate for the extent of this processing.

Collision with the 'floor' trigged the playback of a short percussive segment of the same sound file to complement the 'bouncing effect'. Contact with other walls triggered playback of randomly selected samples via MIDI. In hindsight, I'm rather fond of the a-synchronicity that has resulted from the makeshift manner in which these mappings were patched, and sample playback positions chosen.
(See appendix 2b)

The second layer, containing more low-frequency information consists of heavily modulated grain streams. Their amplitudes are shaped by the second model's velocities.

The whole layer has then been compressed with a slow release time, each time the ball was thrown into the 'room'.

A.L & Rossler

This piece incorporates a greater variety of the syntheses produced so far with the control algorithms. From the aforementioned particle system patch, velocities were again mapped to the amplitudes of an oscillator bank. An exponential function was manipulated in this mapping to allow amplitude shaping that varied from extreme and percussive, to a very slight modulation.

Mappings not evident in the other pieces may also be heard. Height has been used to modulate the pitch of oscillators, a forces threshold used to trigger sample playback, mass position mapped to the length of a feeding-back delay loop and more.

All of this material was edited into shorter moments and then resequenced to multitrack using random MIDI note triggers from the collision detection in the final model. The result was, at times, a dense cacophony of sound from which elements were removed, or neatened with fades. Further reprocessing was then introduced, pinned to these foundations.

Reflection/Criticism

I would hope that this commentary gives a clear account of my approach to computing as a part of practice, rather than a techno-centric approach to music-making. The works have been addressed in order of their conception or initial recording and this might suggest a procedural logic that is overly simplistic. I do feel however, that *A.L & Rossler* most successfully satisfies some my own criteria stated in this paper.

A goal has been to enhance the playability my tools and the work documented here has been towards this. In taking this research further I will need to look elsewhere, for new strategies and ways to achieve the complexity of *A.L & Rossler* without a need for sampling.

The work has helped form a relationship with abstract sound material and broaden my musical vocabulary in this respect. This was fresh terrain and I am keen to continue on this route. The use of space in *A.S & Rossler* is not realised as fully as hoped and this will be addressed in future work. I have also suggested that the playing interface might be projected to an audience in concert. The implications of this act need further consideration and will be explored in performance.

Appendix 1: DVD and Sound File Information

All sound files can be found on the accompanying DVD. A Max patch is included to demonstrate some of the MIDI and mouse interactions discussed in this paper.

A.L & Rossler

Sample Rate	Information	Files
44100	3 Channel, Ambisonic b-format (first order, 2D) 4 Channel, Quadraphonic (decoded speaker feeds) ch1=LFront, ch2=RFront, ch3=RRear ch4=LRear	AL+Rossler.bformat.aif AL+Rossler.quad.aif

NB. Play and/or decode at a sample rate of 44100. Some material is dependent on the Nyquist frequency in playback. Automatic correction (such as that offered by Max's sfplay~) has been found to produce different (and unwanted) aliasing effects at higher sampling rates.

Chucker

48000	2 Channel, Stereo Mix	Chucker.aif

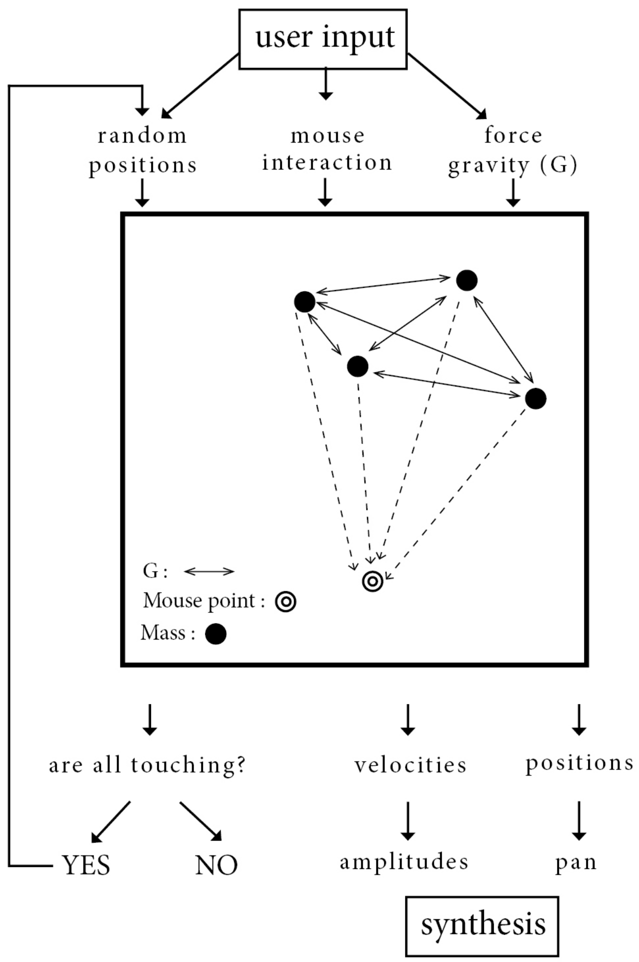
Concretion Study: remix

48000	3 Channel, Ambisonic b-format (first order, 2D) 4 Channel, Quadraphonic (decoded speaker feeds) ch1=LFront, ch2=RFront, ch3=RRear ch4=LRear	Concretion.bformat.aif Concretion.quad.aif

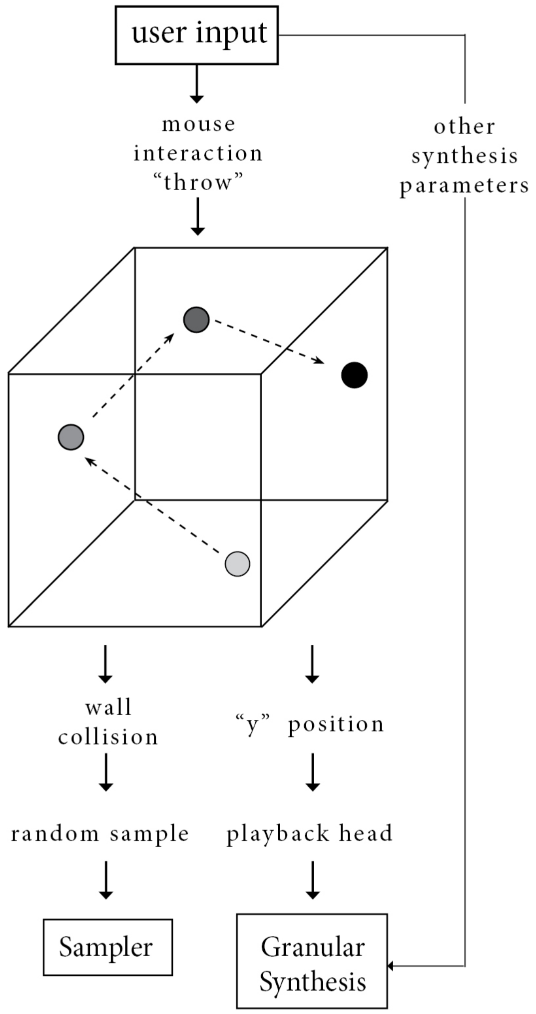
Cycles

48000	2 Channel, Stereo Mix	Cycles.aif

Appendix 2a: Cycles



Appendix 2b: Chucker



Bibliography

Bailey, D., 1992. *Improvisation: its nature and practice in music.* London: The British Library

Blackburn, B., 2006. *Corporeality and Musical Gesture.* [pdf] Available at: <http://www.bradfordblackburn.com/Partch.html> [Accessed 08/12]

Cance, C., Genevois, H., Dubois, D., 2009. *What is Instrumentality in New Digital Musical Devices? A Contribution from Cognitive Linguistics & Psychology.* [pdf] Paris. Available at: <http://arxiv.org/abs/0911.1288> [Accessed 08/12]

Collins, N., 2003. Generative Music and Laptop Performance, *Contemporary Music Review*, 22(4), pp. 67-79

Croft, J., 2007. Theses on liveness, *Organised Sound*, 12(1), pp. 59–66.

Dahlbom, B., 2003. *Producers or Consumers: Two Ways of Looking at Technology.* [online] The IT-University of Göteborg. Available at: <http://www.viktoria.se/dahlbom/get/getDocument.php3?style=../config/style.css&id=157> [Accessed 08/12]

Dahlbom, B., 2003. From Users to Consumers*, Scandinavian Journal of Information Systems,* 15, pp. 105-108.

Döbereiner, L., 2011. Models of Constructed Sound: Nonstandard Synthesis as an Aesthetic Perspective, *Computer Music Journal* 35(3), pp. 28–39.

Döbereiner, L., 2009. Compositionally Motivated Sound Synthesis, In: *Proceedings of "next_generation 3.0".* Available at: <doebereiner.org/texts> [Accessed 08/12]

Dubus, G and Bresin, R., 2011. *Sonification of Physical Quantities Throughout History: A Meta-Study of Previous Mapping Strategies* In: *The 17th International Conference on Auditory Display, Budapest (ICAD-2011), June 2011*

Henry, C., 2004. *pmpd Physical Modelling for pd.* [pdf] Available at: <http://drpichon.free.fr/pmpd/download/>

Hermann, T., Hunt A., Neuhoff, J. G., 2011. Introduction. In: Hermann, T., Hunt, A., Neuhoff, J. G., eds. 2011. *The Sonification Handbook*. Berlin: Logos Publishing House. Ch.1.

Keep, A., 2009. Instrumentalizing: Approaches to Improvising with Sounding Objects in Experimental Music. In: J. Saunders, ed. 2009. *The Ashgate Research Companion to Experimental Music.* Surrey: Ashgate. Ch.5.

Nyman, M., 1999. *Experimental Music: Cage and Beyond.* 2nd ed. Cambridge: Cambridge University Press

Perloff, N., 2001. The Art of David Tudor. Available at: <http://www.getty.edu/research/tools/guides_bibliographies/david_tudor/index.html> [Accessed 08/12]

Puckette, M., 1991. Something digital, *Computer Music Journal* 15(4), pp. 65–69.

Roads, C., 1995. *The Computer Music Tutorial*. Cambridge, Massachusetts: MIT Press

The Outsider: The Story of Harry Partch, 2002. [TV] BBC Four. Available at: <http://ubu.com/film/partch_outsider.html>

Xenakis, I., 1990. *Formalized Music.* Revised ed. Hillsdale, New York: Pendragon Press