These debates in both the sonic and software arts in- probe considerations of how practice at the interface, a generative sound art, might approach this vision. This paper offers a simple, practical illustration. Section 1.1 outlines Whitelaw’s system story. The exposition of this critical device is an attempt to open up the formal, aesthetic con- cerns of the generative art community to a broader cul- tural context, so bridging Cramer’s formalist-cultural divide. Section 1.2 examines current issues in generative art practice. It is suggested that some of the problems cur- rently identified in the field may be a symptom of import- ing models, methods and their attendant perspectives from the engineering sciences and that the field could benefit from more exploratory, experimental approaches to design and implementation of generative systems. Inspiration for an alternative is drawn from Luciano Floridi’s observa- tions of the impact of digital technologies in the broader information society. Section 2 introduces a simple class of generative system inspired by Floridi’s concept of onto- logical friction. This is presented as an alternative to the standard practice of algorithmic composition. Rather than simply encoding the numerical outputs of a formally im- bedded algorithm, the generative process is constituted in the sound in which it is also manifest. In section 3, it is proposed that the poietic and creative nature of computer music, and generative sound art in particular, has unique potential as a discourse for coming to terms with the chal- lenge of contemporary society.

1.1. System stories and critical generativity

The potential for software art, in general, to represent and interrogate the cultural complexities of contemporary so- ciety has been suggested in the past (e.g. [17]). In adopt- ing formal, complex systems as a basic generative tool, software art has the potential to convey not only an image of cultural situations, but more powerfully, to present a systemic abstraction, or model. “Abstract generative art”, suggests Whitelaw “performs cosmogony: it brings forth a whole artificial world, saying here is my world and here is how it works.” [21], p.5. In collapsing the concept nota- tion and execution, such works are in quite a unique posi- tion to illustrate, explore and critique “how it works”. In Kim-Cohen’s poietic and cultural terms, we appear to be tooled up and ready to talk about.

Whitelaw observes, however, that this potential remains largely unfulfilled. Surveying a number of visual artworks he suggests that where complex systems are deployed, the predominant interest is in their formal, generative poten- tial, an inward-looking, utilitarian and non-reflexive con- cern with the formal properties of the emergent structure. He sug- gests that what is needed is a critical approach to genera- tive art, in order to open up these formal systems to dis- cussion and critique, drawing out relations between their internal workings and the outside world. Whereas previ- ous discourse focused on the materials and process (e.g. [4]), Whitelaw argues that a culturally-relevant critique must necessarily refer to relevant systems themselves, rather than their sensory outputs.

Drawing from the way in which Artificial Life simu- lations have been critiqued in the humanities (e.g. [12]), [13]) and the sciences (e.g. [21], p.5. In collapsing the concept nota- tion and the specification of fitness functions able to drive boundless innovation to stem in part from two perennial problems: the design of musically meaningful parameters and the numerical outputs are then mapped to particu- lar sonic parameters. The design of musically meaning- ful mappings from numerical output to relevant param- eters is sometimes natural but often far from intuitive. The challenge is framed as that of establishing meaningful correspondences between the underlying principles of the model and the appearance and behaviour of the artwork and is raising its head again with the new generation of ardent swarm enthusiasts [2]. To call for new approaches to generative design is not to admonish the use of existing algorithms for specific compositional tasks, but to encour- age a more experimental approach in order to expand the repertoire and scope of the practice.

Dorin et al recognise the pedagogical value of these ‘ready-made’ systems (particle systems, cellular automata, physical simulations etc.) but express concern that the systems “operate as ‘black boxes’ whose internal oper- ative sources of these communities coupled with the por- ability of code, means that algorithms, encapsulated in li- braries, are shared amongst practitioners more readily than ever before. We no longer have to implement algorithms from scratch. On the one hand this expedites develop- ment, obvious conventions, reducing la- borious debugging of personal implementations of text- book algorithms and so affording more time to focus on the more ‘creative’ side of development - how these algo- rithms are mapped to specific visual or sonic parameters, for example. The flip side is that in not going through the process of reinventing the wheel, programmers have no need to get to grips with the workings of the wheel. This arguably reduces the scope for creative tinkering and with it, the chances of inventing new methods.

Similar cries for new directions are heard within the Evolutionary Arts (EA) community. Galanter writes that “A great deal of initial promise and enthusiasm, evo- lutionary art seems to have hit a premature and disappoint- ing plateau.” [10], p.216. The field, suggests Galanter, is raising its head again with the new generation of ardent swarm enthusiasts [2]. To call for new approaches to generative design is not to admonish the use of existing algorithms for specific compositional tasks, but to encour- age a more experimental approach in order to expand the repertoire and scope of the practice.

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GENERATIVE SOUND ART AS POETIC POETRY FOR AN INFORMATION SOCIETY

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ABSTRACT

Recent conversation in both the sonic and generative art communities envision a practice which engages with both formal and cultural or conceptual concerns. At the same time there is a sense amongst practitioners in the generative arts community that there is room to develop the methods of the practice. This paper sketched a simple, practical approach to generative sound art which draws from philosophical observations of the emerging information society and implements a sound-based generative scheme as a simple, literal illustration of a practice which looks outward to society and inward at the materials of its practice. It is suggested that a digital sound art of this nature has potential as a discourse for contemporary society, a poietic playground for coming to terms with the implications and challenges of the information age.

1. INTRODUCTION

Seth Kim-Cohen’s recent vision of a conceptual sonic art which engages “both the non-cochlear and the cochlear, and the constituting trace of each in the other.” 15, p.xxi. resonates loudly with an ongoing debate in the generative arts. Ten years ago, Florian Cramer surveyed the landscape of software arts practice and drew a rather gloomy conclusion: “The generative arts community has the potential to convey not only an understanding of genetic representations which afford boundless innovation to stem in part from two perennial problems: the design of musically meaningful algorithmic software-based systems ‘operate as ‘black boxes’ whose internal workings and the outside world. Whereas previ-

These debates in both the sonic and software arts in- spires considerations of how practice at the intersect, a generative art community to a broader cultural context, so bridging Cramer’s formalist-cultural divide. Section 1.2 examines current issues in generative art practice. It is suggested that some of the problems cur- rently identified in the field may be a symptom of import- ing models, methods and their attendant perspectives from the engineering sciences and that the field could benefit from more exploratory, experimental approaches to design and implementation of generative systems. Inspiration for an alternative is drawn from Luciano Floridi’s observa- tions of the impact of digital technologies in the broader information society. Section 2 introduces a simple class of generative system inspired by Floridi’s concept of ontological friction. This is presented as possible alternative to the standard practice of algorithmic composition. Rather than simply mod- eling the appearance and behaviour of the artwork, the software arts practice and drawing a rather gloomy conclusion: “The generative arts community has the potential to convey not only an understanding of genetic representations which afford boundless innovation to stem in part from two perennial problems: the design of musically meaningful algorithmic software-based systems ‘operate as ‘black boxes’ whose internal workings and the outside world. Whereas previ-

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1This phrase is taken inclusively, to refer to software art, generative art and algorithmic composition, i.e. all algorithmic software-based practices which are concerned with making software which makes some- thing.

This being the case, the authors note, can be seen as an echo of Fenton’s warming that art should not become “the handmaiden of science”. Fenton was responding to Jack Burnham’s enthusiasm for technological, process-based, autonomous art in the 1960s, work that shares many at- tributes with contemporary generative art.

The exposition of this critical system story is the bridge he builds in attempting to open up the formal, aesthetic con- cerns of the generative art community to a broader cultural context, so bridging Cramer’s formalist-cultural divide. Section 1.2 examines current issues in generative art practice. It is suggested that some of the problems cur- rently identified in the field may be a symptom of import- ing models, methods and their attendant perspectives from the engineering sciences and that the field could benefit from more exploratory, experimental approaches to design and implementation of generative systems. Inspiration for an alternative is drawn from Luciano Floridi’s observa- tions of the impact of digital technologies in the broader information society. Section 2 introduces a simple class of generative system inspired by Floridi’s concept of ontological friction. This is presented as possible alternative to the standard practice of algorithmic composition. Rather than simply mod- eling the appearance and behaviour of the artwork, the software arts practice and drawing a rather gloomy conclusion: “The generative arts community has the potential to convey not only an understanding of genetic representations which afford boundless innovation to stem in part from two perennial problems: the design of musically meaningful algorithmic software-based systems ‘operate as ‘black boxes’ whose internal workings and the outside world. Whereas previ-

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of form or behaviour is preconceived and the genetic operators designed in order to reach that goal. Whilst the EA community looks to the boundless creativity of nature for inspiration, natural evolution is not teleological. The analogy can be drawn between the processors and their objects in the infosphere and the algorithmic processes and the ‘materials’ (digital audio and graphic representations etc.) in which they are encoded in the digital generative arts. All are digital in nature, but whilst the ontologies of the former align, in common practice, there is a fundamental rift between the latter, evidenced by the perennial head-scratching over the design of aesthetically meaningful mapping and representation schemes. The analogue of ontological friction in this context is the disjunction between the use of formal algorithms and the sonic materials they are intended to organise. The prospect that decreasing ontological friction could increase generative potential is interesting.

The principle of self-observing systems is open ended. A self-determined sample player schematic for current output buffer look for onset if onset occurs, with probability \( P \) extract partials \( F_1 \) \( \ldots \) extract partials \( F_n \) play buffer at rate \( R \), \( n \) new else play buffer at rate \( R \)

\[
R_{new} = \frac{1}{F_1 \times R}
\]

Where \( F_0 \) is the frequency of the 1st partial, \( R \) is a constant and \( R \) can assume negative values. \( P = \frac{f}{f_0} \)

Figure 2 Pseudo code and rate update equation

2. SELF-OBSERVING SYSTEMS

Self-observing Systems is an ongoing project which explores generative sound art methods. The concern in the current study is the construction of a simple generative mechanism which exhibits an ontological alignment comparable to that between ‘processor’ and ‘processed’ as seen in Infosphere at large, a system which relates a story about the world, through the material of the sound. This is approached by implementing a simple system in which the generative process is constructed in the sound.

2.1. A self-determined sample player

The illustrative model is based on a sample player. This familiar unit generator, which is the digital homologue of various physical music players, represents the ‘processors’ in Floridi’s analysis and carictures the impact of the de-physicalisation of devices more broadly. The sample player is furnished with a listening module. Rather than playing in a linear fashion, its playback rate (and direction) are determined by features of the audio it plays.

2.1.1. Implementation

The system was built in java and comprises a variable rate sample player, listener module and short audio file as shown schematically in Fig.1. The sample is played at rate, \( R \). When an onset is detected, absolute playback rate is updated as a function of the most dominant frequency in the current audio buffer and its direction reversed. Noise is added by means of a probabilistic update regime. The probability is inversely proportional to the current rate. This balances the effects of playback rate: at the speed of sound, significant audio features will be further apart in time (and less prominent). See Fig.2 for details.

The listener module is an onset detector comprising the following analysis chain: short frame: Wigner, fast fourier transform, peak detector and spectral difference measure. The peak detector follows the algorithm described in [6]. In this implementation the audio file is not overwritten.

A resynthesis module is included for ‘decoration’ (it plays no functional role in the process), highlighting the moments of change. When an onset is detected, an oscillator bank is triggered, creating a complex chord. The frequency, duration and amplitude of each of N oscillators is set according to the frequency and strength of the corresponding first N partials in the current buffer. In this implementation, \( N = 10 \).

In Baldričís there is a basic and comic exposition of the gestures contained in the original recording. This gestural exposition would be effective in a live interactive setting. Spwang provides a short excerpt from initial experiments with improvisation realised ‘live’. In a performance setting, the self-directed exploration of material has the potential for a lively trading of gestures between instrumentalists and digital performative and digital components of a performance system, an aesthetic design principle which guides many electro-acoustic improvisation systems (e.g. [19]).

2.3. Other self-observing systems

The principle of self-observing systems is open ended. A further hypothetical example is outlined below.
of form or behaviour is preconceived and the genetic operators designed in order to reach that goal. Whilst the EA community looks to the boundless creativity of nature for inspiration, natural evolution is not teleological. Evolutionary pressure is neither fixed nor determined from the ground up in which the process and its sensory characteristics are to develop methods

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The illustrative mechanism is based on a sample player. This familiar unit generator, which is the digital homologue of various physical music players, represents the ‘processors’ in Floridi’s analysis and caricatures the impact of the de-physicalisation of devices more broadly. The sample player is furnished with a listening module. Rather than playing in a linear fashion, its playback rate (and direction) are determined by features of the audio it plays.

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The system was built in java[8] and comprises a variable rate sample player, listener module and short audio file as shown schematically in Fig.1. The sample is played at rate, R. When an onset is detected, absolute playback rate is updated as a function of the most dominant frequency in the current audio buffer and its direction reversed. Noise is added by means of a probabilistic update regime. The probability is inversely proportional to the current rate. This balances the effects of playback rate: at rate, R, significant audio features will be further apart in time (and less prominent). See Fig.2 for details.

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2.2. Sonic examples

The system is intentionally playful and lively and this is reflected in the output. A range of samples containing varying degrees of harmonic and gestural complexity were explored. The examples given here include a draping tap, Sprida, a field recording of blackbird song, Balikbidi, and a live example with pizzicato ‘cello, Spwang. What we hear is an engaging and active exploration of the given sonic material with an apparent intentionality that belies the simplicity of the generative process. In Sprida, the harmonic simplicity of the original drip develops a coherent harmonic progression as each drip triggers a change in rate according to its harmonic content, altering the pitch of the subsequent drips. Over time, the long term structure (albeit musically trivial) unfolds according to the spectral content of individual sound events.

In Balikbidi there is a basic (and comic) exposition of the gestures contained in the original recording. This gestural exposition would be effective in a live interactive setting. Spwang provides a short excerpt from initial experiments with improvised ‘cello. In a performance setting, the self-directed exploration of material has the potential for a lively trading of gestures between instrument performers and digital instruments as a performance system, an aesthetic design principle which guides many electro-acoustic improvisation systems (e.g. [19]).

2.3. Other self-observing systems

The principle of self-observing systems is open ended. A further hypothetical example is outlined below.

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**The basic design principle adopted here is therefore one of circular causality. This is nothing new. The approach lies at the heart of the cybernetic enterprise [20]. Its generative and interactive potential was explored in early electronic systems (consider e.g. Gordon Mumma’s ‘Cyberonic’ Horn piece, Hornpipe (1967) and it has experienced some what of a revival in recent years, following Drake Scopio’s Audible Ecology: Interface series [5]).**

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[1] Dadman (we are not immune to the centre of the universe.) Darwin, (we are not distinct from the rest of the animal kingdom) and Freudian (we are very far from being purely rational minds entirely transparent to ourselves).

Self-directed feedback circuits illustrate how a similar generative process can be constituted across all levels of a digital audio system, extending beyond the confines of a formal algorithm and digital representation of sound through the DAC, speakers, room, mic and back again. It explores ways of auto-maintaining and directing the Larenz effect to create complex, adaptive resonances.

In an analogue system, characteristics of feedback artefacts are determined by the frequency response of the audio system (mic and speakers) and the distance between them. The latter can be modelled digitally using delay lines. In a simple system, the effective gain can be managed by implementing a proportional control algorithm (such as a watt governor) which monitors the amplitude in its input buffers and adjusts the delay time (at audio rates). The gain on each channel can be similarly adjusted. Initial experiments suggest that even this simple mechanism can sustain frequencies other than those promoted by the frequency response of the audio system, creating subtle shifts which are sensitive to tiny changes in the ambient environment. Further variation can be imagined by implementing frequency-dependent delay lines and setting, or evolving, the delay times according to the impulse response of the physical environment. Frequency response of audio system and spectro-temporal characteristics of the surrounding acoustic environment. Recent research in automated methods of avoiding feedback (outlined in [18]) point to several potentially interesting avenues for exploration.

3. DISCUSSION

The self-observing systems offer a simple illustration of a generative sound art scheme which implements a sonic version of Floridi’s ontological alignment. In the design of the generative schema, sound (or its digital representation) is integral to the generative process such that the two are mutually constituted. What we listen to is not the sonification of some numerical process at runtime, but the two are mutually constituted. What we listen to is not the sonification of some numerical process at runtime, but rather than immobility or perceivability, becomes the criterion for existence, even if the interaction is only virtual.

The global infosphere is a distributed world in which different points of view can be maintained, each distributed self having a self-identity and self-awareness.

For the computer musician who has spent the last half century designing intelligent, interactive, modular performance systems toward a networked digital practice, this is nothing new. Artistically, the implications of such developments could even be summarised as an increase in creative opportunity. To the general public, however, this may lead as a science fiction scenario. For society at large such changes bring about significant ethical challenges, not least an urgent need to reconcile the technological and natural worlds.

The public need for new ways to come to terms with the existential and ethical impact of an increasingly technologised society can be seen in the emergence of new forms of hybridised discourse. New Scientist, for example, have just launched a digital publication, Arc, which merges literature (science-fiction) and science (futurology) to explore the impact that technology is having on our lives. “Fiction gives us the chance to explore and be eccentric” says Simon Ings, a novelist, science writer and editor of Arc. “If one thing is for sure, the future is not going to be agreed by committee. The future is going to be eccentric. And the best way of predicting the future is to make it up.” [16] New branches of social science are also emerging which adopt the formal modelling and simulation practices similar to those used in generative art practice [11].

The simulation sciences provide ways of understanding the world through modelling. Science-faction provides a speculative literary discourse for toying with possible futures, but, as Manovich and others have suggested, the generative arts have the potential to speculate to varying degrees from models of possible futures. The development of a generative sound art practice has a unique potential as both a poetic (imaginative, symbolic, figurative) and poetic (from the Greek, ποιητικό, meaning productive, formative) discourse, one which can engage the ears, intellect and imagination in equal measure.

4. CONCLUSION

Now, more than ever, we need new forms of discourse which enable us to come to terms with the complexities of contemporary society. Computer music, and more specifically, generative sound art, represents a possible discourse through which we can model our world reflectively, tinier with these models critical and present these stories in the material of sound itself: to talk about the world through sound.

5. REFERENCES


Self-directed feedback circuits illustrates how a simi-
lar generative process can be constituted across all
levels of a digital audio system, extending beyond the con-
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the two. Under this approach, we circumvent the need
to define either mappings to, or representations of, a final
sonic manifestation. This is offered in response to calls
from the generative art community, that as the field ma-
tures, it should move beyond the implementation of algo-
rithmic solutions from the sciences, it aims to illustrate how
we can explore changes in the broader cultural world, by
representing systemic principles of the changing infosphere
in the materials, both formal and sensory, of a generative
practice.

3.1 Generative sound art as a poetic playground
for an information society

The self-observing systems outlined above are also in-
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5. REFERENCES

posium on Artificial Intelligence and Creativity in Arts and Science, 2003, pp. 41–49.
line]. Available: http://www.netzliteratur.net/
cramer/concepts_notations_software_art.html
[5] A. Di Scipio, “Sound is the interface: From inter-
active to ecosystemic signal processing,” Organised
06), Montreal, Canada, September 18-20 2006.
M. Whitelaw, “A framework for understanding gen-
[8] L. Floridi, “Digital revolution as a fourth rev-
mesmedia/pdf/bbc_1.pdf
lives,” The Information Society: An International
and the Aesthetics of Dynamism,” in Generative Art
[11] K. Gilbert, N. abd Troitzsch, Simulation for the So-
ciety: An International Journal Volume,
tifical Life in a Digital World. University of Cali-
comment to Florian cramer,” in read.me Software Art
[15] S. Kim-Cohen, In the Blink of an Ear: Toward a Non-
Cochlear Sonic Art. Continuum International Publish-
ing Group, 2009.
combines science-fiction and futurology,” The In-
dependent, March 2012.
line]. Available: http://www.manovich.net/DOCS/
abstraction_complexity.doc
[18] E. Perez-Gonzalez and J. Reiss, “An automatic max-
imum gain normalization technique with applica-
tions to audio mixing,” in 124th AES Convention,
Amsterdam, Netherlands, 2008.
oping systems for improvisation based on listening,” in
Proc. of the 2010 International Computer Music
Conference, New York, June 1-5 2010.
[20] H. Von Foerster, M. Mead, and H. L. Teuber, Cyber-
netics: Circular Causal and Feedback Mechanisms
in Biological and Social Systems. New York: Josiah
Macy, Jr. Foundation, 1953.
A critical approach to generative art,” in Read-
technology: Toward a networked digital practice, this
[22] M. Yee-King, “An autonomous timbre matching im-
prover,” in Proceedings of the 2011 International