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Author(s): Bjarni Gunnarsson

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1. Introduction

This article presents ideas relating to the creation of computer music using emergent systems based on rules and local interactions. Three practical examples will be presented with a special focus on the integration potentials the adapted systems afford. The discussion includes a reflection on algorithms, interaction, and the behaviour of sound processes. It questions the scope and potential boundaries of computational systems through the space relating compositional practice with the development of generative environments. It outlines the process of developing such systems, but also the act of using them within a dynamic musical context. The goal here is to merge the thinking of sound, systems and sonic development for creative applications and compositional approaches.

Working with emergent systems in computer music highlights the different levels computational behaviour operates within. Processes based on self-organisation and complexity present a promising direction for musical approaches that question levels, scales and the overlap between structure and sound. However, the relationship between algorithmic behaviours and musical results is not necessarily straightforward to establish. Incorporating strategies in music that have evolved without any clear reference to sound can introduce issues regarding the nature and purpose of such mappings. In many cases, algorithmic systems are studied and discussed separately from the outcomes they deliver. General properties are highlighted but not the details of how they relate to possible musical outcomes. Such segregation can involve difficulties with regard to how the different domains are set to connect or communicate. While the domain difference is challenging, it also presents opportunities to rethink ways of organising sound processes and introduce novel applications for generative algorithms. In what follows, an attempt is made to take advantage of these problems for original musical approaches.

2. Mapping and Behaviour

The approaches presented here involve a process-based approach to sound. Sonorities characterised by development, change, and behaviour. Sound material that evolves through possibility spaces and continuous transition. Working with such materials involves interacting with a dynamic flux that spreads across multiple levels and layers of organisation. The appeal of using behavioural dimensions for those applications is noticeable when developing the controls and parameters that drive their development over time. Rather than specifying precise values for parameters such as frequency or duration, behaviour-driven processes are frequently measured through higher-level controls such as density and regularity. Such meta-parameters correlate well with those used in complexity-related algorithms such as Alife or Agent-based systems (Beyls, Bernardes and Caetano 2015). However, these systems have also mostly developed on their own, evolving based on criteria that have little to do with music and sound. A possible reason for using such ideas within musical contexts could be to extend existing sound processes with features that otherwise they would not have. To introduce behaviours and ways of becoming that could facilitate the development of sound material towards solutions that would otherwise not be possible to realise. Considering the contact point of the different domains through the axis of behavioural dimensions enables possibilities for combining and understanding them as occupying the same operational space.

2.1 INTERPRETATION

Emergent algorithms often model natural processes and physical systems. Incorporating these within computer music involves considering what dimensions to model and whether or not their 'natural' aspects should be featured or suppressed. How to approach the mapping involves addressing differences but also choices. As noted by McCormack *"Mirroring nature involves interpretation and ordering by the artist. As simulacra or simulation, a computer process is not the same as what it seeks to mirror. "* (Mccormack 2013). Modelling differences can introduce tensions within the translated phenomena. They also raise concerns about what is being adapted and why that is being done. Martin Supper remarks that one reason for using natural processes in composition might be to use them *“as a way of generating natural forms naturally—forms which are taken to justify themselves by their naturalness alone.”* (Supper 2001). However, interpretations of natural processes do not mean they somehow require a literal representation. Rather, characteristics of how natural processes develop, change or transform can be fruitful to explore in a musical context. According to Alice Eldrige and Oliver Bown *“the algorithmic musician is seen weaving together equations from complex systems, biology, social behaviour, and so on, to create new artistic works that employ nature in their behaviour, rather than merely representing nature.”* (Aldrige and Bown 2018). Why specifically these disciplines are selected and how their behaviour is actually reflected in new artistic works is not fully clarified. However, their performative qualities are clearly emphasised in favour of literal representations. Frequently, the goal with creative mappings of natural processes is indeed not to display nature or represent extramusical behaviours. Rather introduce behaviours that extend the context they operate within and the conditions they are evoked by.

Reflecting on his musical practice through composing with algorithms, Paul Doornbush emphasises the idea of translation between domains where *“at some stage there must be a translation from the domain of data, mathematics, functions or concepts, to musical or sonic parameters – from the conceptual domain to the sonic domain.”* (Doornbusch 2008). He stresses the domain difference by explicitly stating it (from the ‘conceptual’ to the ‘sonic’). He also formulates the directionality of the relations clearly, where concepts translated to sound have little or no influence back on the concepts. Many reports exist that discuss the *“mapping* *problem"* (Polansky 2002). It is often assumed that mapping translations are simply ad hoc or domain-specific by nature. Artistic bricolage filled with details not suitable for a general discussion regarding complex behaviour and musical algorithms. However, some have also mentioned the lack of discussion on the *"nature of such "manipulations" and the underlying principles which act to constrain them"* (Harley 1994). Or that one should be looking towards other fields since *"a considerable challenge remains—and this is as much a challenge of HCI as of algorithm design—to find effective and usable ways to exploit these principles in compositional practice."* (Aldridge and Bown 2018).

2.2 CREATION PRINCIPLES

Given the fact that mapping goals are usually artistic, it seems that creating them belongs to an artistic activity. Working with behaviours and process-based sound highlight this, as the focus is not so much on implementing a value-by-value mapping, but rather to establish a framework for relating evolving behaviours. Approaching the domain differences through a common ground allows these areas to interact, for example having sound material influence a controlling algorithm. Perhaps most importantly, providing interaction between the domains introduces a meaningful exchange instead of a simple translation.

Discussing operating levels and compositional processes, Horacio Vaggione has noted how *"music-making remains an activity revealing its own "creation principle"*. (Vaggione 2001). Activities and events contributing to a certain musical outcome are somehow always a part of it. Compositional processes involve choices that form part of the complex systems that constitute computer music. Instead of being directly guided by extramusical models, generative algorithms can be thought of as organisational forces injected into compositional situations. The richness of connecting the contradicting forces behind adopted models and musical ones can be something to explore rather than avoid.

3. Context and Scale

Computer music processes emerge within a given medium and the enclosing conditions it consists of. Similarly, generative processes come about within the boundaries imposed by a given computational context where *“the context is the world-state data and arguments that the algorithm has access to”* (Wooller et al. 2005). The dynamic relationship between digital environments and generative algorithms allows for an exchange, or mediation between these two that could be described as *“not a flow between two preexistent entities; rather, it is a process that re-presents or reconstitutes entities [...] it is a generative process, setting the conditions for the becoming of entities.”* (Barker 2012). Enabling the conditions for such exchanges can be seen as an important part of artistic approaches involving algorithms.

3.1 EVOLVING MEDIUM

Computational systems change through the interaction of their parts but also with respect to their own state and potential transformations. The practical approaches presented here follow a similar path where a context (or medium) is designed to evolve through the interactions of the processes it contains. This results in an environment where processes *”are seen as collections of collaborating agencies [...] coupled through interaction such that they are mutually influencing.”* (Brown and Gifford 2013). Establishing such a medium is equally important as crafting the processes it contains.

3.2 LOCAL TENSIONS

Difficulties can be encountered when building operational spaces where detailed sound-synthesis procedures interact with abstract computational processes such as cellular automata or alife algorithms. This can be notably complicated if the two domains are not working on the same scale or structural level. Forcing the levels to match, for example by directly mapping a complex system to sound samples, might not fully take advantage of the natural scope the different domains belong to. When enabling their relationships, the different structural levels, including lower-level details but also higher-level developments must preferably be worked out simultaneously. How they complement and connect over time can be crucial for establishing emergent behaviour and a tight relationship between material and form.

Tensions surface between perceived local sound and the coexisting direction of higher-level structures. Addressing such tensions highlights the importance of working with algorithms spreading over different time-scales. Meaningful interactions between control structures and sonic details afford richness and highlight the specificity of the medium. Focusing on having this relation expressive is a vital element when connecting complex systems with algorithms for process-based sound.

4. Interactivity or Interference

The projects presented here below question the possible modes of interaction of sound, generative systems and manual inputs. Instead of allowing for direct control of a complex system, the idea is to rather consider interaction as part of the system itself. For example, to modify the context an emergent process exists within, react based on system observation or directly interfere with an ongoing flow. Interacting with behaviour also highlights concerns regarding the influences of manual input. In a musical setting, it enables different possibilities of change and control. Actions that do not have instant impact modify the usual feedback-loop of musical interaction. These situations question how a *“fluidity of experience is possible and under what conditions can it be maintained”* (Brown 2012). Interaction with slowly evolving systems reframes the important dynamics of the micro and macro that are so fundamental to electronic and computer music.

4.1 EMERGENCE AND CONTROL

Adopting behaviour from systems characterised by complex changes over time is not trivial. As noted by Oliver Bown *“Although the Game of Life and these various creative models are very interesting from the point of view of studying emergence,* *and give us complex behavior emerging naturally out of a simple algorithm, they come at a cost: we cannot control them easily, even less so than simpler rule-based or parametric systems. Without methods to automatically explore the worlds of possibilities they offer, they may be of limited use for creative practitioners"* and furthermore *"We have some understanding of the creative potential of self-organizing processes but little understanding of how we can control them. After all, this is something of a contradiction in terms. Finding ways to combine emergence and control remains a major challenge for the practical application of complex systems."* (Bown 2019). Should control strategies modify the properties that generate emergence or rather address how the outcomes are processed? Can those viewpoints perhaps be combined and implemented on the same level? Controlling emergence poses difficulties while attempting to do so enables original situations for engaging with systems and self-organisation.

Establishing interaction can be understood as a dynamic process. Something that changes over time instead of remaining constant. Of use here is Andrew Goodman's use of the term *"interfacing"* for discussing interfaces and dynamic interaction where *"the interface might now be thought of more as a process of interfacing, as an unfolding or contingent process within a larger nexus of relation, as an in-action moment of intensity of disruption, contrast and invention rather than a privileged or static position within an art event."* (Goodman 2018). Goodman's interests are towards interactive artworks but at the same time strongly conform to the ways of 'thinking temporally' as presented here. The setup of interactive processes through the dynamics of interfacing enables interaction to occur at any moment within a given timeframe of interaction. This can mean for example to attach (and detach) various algorithms of interaction during this period of time. To augment behaviours through the ways one responds to them during moments of interaction.

Evolving interactivity enables different points of contact within a system consisting of many parts. It recalls the notion of networks and their aesthetics as *“a mode of articulation between ways of doing and making, their corresponding forms of visibility, and possible ways of thinking about their relationships”,* (Kalonaris et al. 2021). Dynamic interactivity reflects a creative process based on exploration. It emphasises a two-way, responsive relationship where feedback and exchange are enacted between a system and its interacting agent. Through such exchange, the purpose of the system is not simply to act on a composer's intention but also to contribute to its inception.

4.2 INTERRUPTING FLOWS

An important possibility for interacting with generative systems is by going against their normal flow. By interrupting or disturbing their regular behaviour. The interactivity approaches presented allow for processes to be interrupted, halted, blocked or disturbed in various ways. This approach to interaction creates immediate audible effects but also introduces tension in the relationship between system flow and manual control. Algorithms can be subject to direct intervention that radically alters their aims and direction. Interaction based on intervention pushes something off track while also allowing for reaction or adaptation. Through such communication, a duality of the direct and the unfolding emerges.

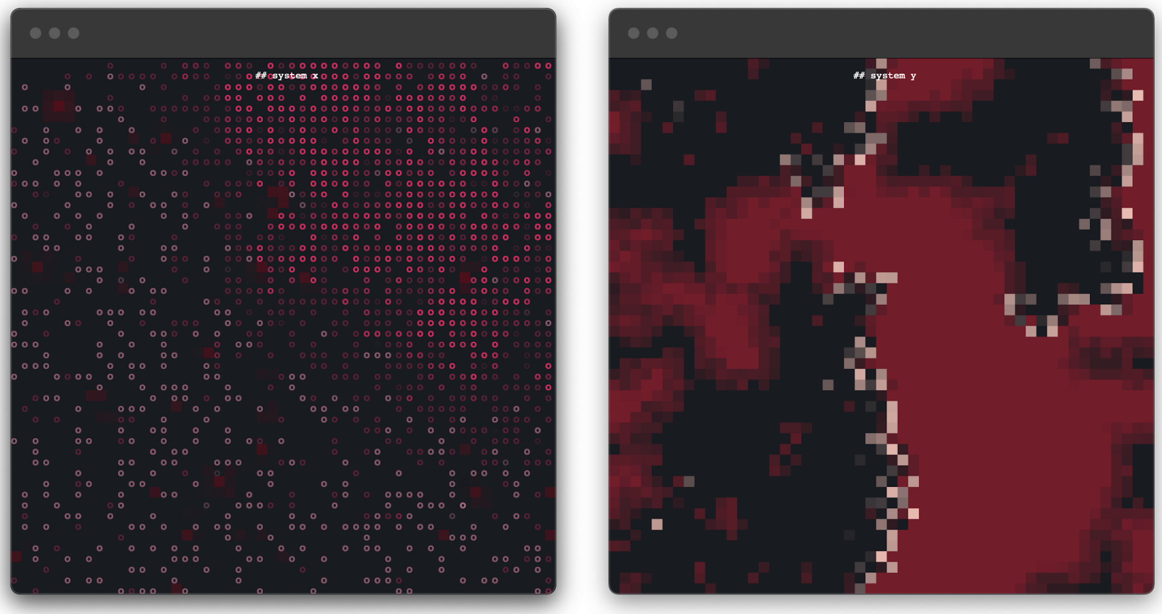
Interference with the ongoing can help to shape interaction where rapid but radical disruptions couple with slower, evolving changes. The balance between the two offers different situations of responses and possible outcomes highlighting how *“interrupts offer a dynamic way of balancing autonomy and command through the interaction with generative processes”* (Gunnarsson 2018). Interfering with a flow of events undeniably provides a strong contrast to parametric control or pre-defined mappings. Blocking behaviours bring forward an attitude of taking over, of engaging with something that unfolds or choosing to ignore it.

5. Brutes and Bullies

Created as an experiment for mapping agent-based interaction to sound synthesis *'Brutes and Bullies'* (https://github.com/bjarnig/Brutes-and-Bullies) is a software system created using the SuperCollider language and the Terra.js Javascript library. The Terra.js library allows for setting up local interactions with the goal of *“creating and analyzing biological simulations.”* (https://rileyjshaw.com/terra). It provides extensive customization and configuration possibilities. Terra.js runs in a web browser where the visual outcomes of the simulations are displayed.

5.1 ARCHITECTURE AND RULES

The architecture of *'Brutes and Bullies'* involves a bridge between a web browser and the SuperCollider language using a NodeJS wrapper that runs through a terminal. Information flows in 2-ways where SuperCollider can start, stop and modify running simulations while also receiving information for interpretation before generating sound. The simulation works by setting up ‘creatures’ that engage in local interaction through simple rules. The creatures contain information about energy, age, reproducibility, and sustainability, but also thresholds and rules that change over time and how they change when put in contact with others. The creatures are entirely customizable, allowing for the addition of new properties and different behaviours. Configuring the simulation means adding different creature types and composing different scenes for their interaction to take place within. In the current phase, no method has been added to influence an ongoing simulation, only to start (or restart) it based on a set of creatures and rules.



Two simulations running in a browser with 'Brutes and Bullies'

Running the simulations becomes the carrier of the creative approach. The simulations enforce a way of thinking that revolves around balancing behaviours. An attitude that considers musical output as something that emerges from an interaction with an autonomous system. The simulation acts as a generative, rule-based system producing output that is subject to different kinds of observation algorithms. The idea is that evolving processes are set in motion where the creator/composer becomes an observer of its various developments. The output can not always be controlled in detail but is instead interpreted and further processed.

Many reports exist of mapping cellular automata and similar systems for musical applications, see for example (Burraston and Edmonds 2005). In *'Brutes and Bullies'* the system supports various approaches and also a direct access to every creature in case of custom mapping. The simulation data that is used by the author is based on dimensions that reflect a specific view of the whole simulation. This can be for example the total, average, or maximum age of all the creatures combined at a specific point in time. Building upon the act of observation is what drives many of the possible applications of *'Brutes and Bullies'*. The observer attaches sound-producing algorithms to the simulations by choosing an available data-dimension and attaching an interpreting process to it. The idea is that the resulting music becomes an interpretation of the behaviour observed in the simulation. That interaction emerges through the observation of a rule-based system by attaching operations instead of controlling interactions.

Besides attaching and detaching different interpretation processes, two other important modes of control are supported. Configuring the context (initial states) and interfering (or blocking) the generated behaviours. For all three of the interaction modes, both manual commands can be used as well as audio-driven operations. This way of working introduces an operational space within which highly detailed synthesis instructions algorithms interact and clash with blind generators of computational behaviours such as biological simulations. The relationship of influence goes in both directions and across different time-scales.

5.2 BLOCKING BEHAVIOURS

'Blocking Behaviours' is the first piece realised using the system and concerns the real-time interpretation of two simulations using dynamic grid behaviour. The duality is intended to provide a reference and dialogue between two simulations that are then further interpreted through the attached processes. The interpretation involves a mapping between different modes of representation in order to simplify and combine. In *'Blocking Behaviours'* the idea is to explore the boundary of generative behaviour, control and direct access to computer sound synthesis. The work questions the concepts of generative activity, control, and sound synthesis through an ongoing reconfiguration and feedback loop. It presents simulations that are 'interpreted' by sound processes in SuperCollider that in turn shape the simulation, creating a feedback network.

In *'Blocking Behaviours'* the simulations run in two different browser windows while the interaction takes place through a live-coding environment. The performer can choose to attach existing processes, interpret the data directly or control the simulation by specifying initial states or interfering with any ongoing activity. The software also supports specifying rules and setting conditions for certain events to take place. For example, when the simulation reaches a deadlock where new states do not deviate from previous ones, it can be restarted, or set to follow a different set of initial states. In practice, perhaps the most interesting way of using the system is to take advantage of the 2-way communication. For example, starting a simulation with an attached sound process that will restart another simulation with another sound process given a certain condition and so the chain continues. Circular processes can be developed, for example through the use of large delay times to shift between time-scales. Behaviour that influences sound which changes the behaviour again and again.

https://vimeo.com/789996552

'Blocking Behaviours' is still a work in progress but a demonstration video is included here below as well as a recording from a recent live session.

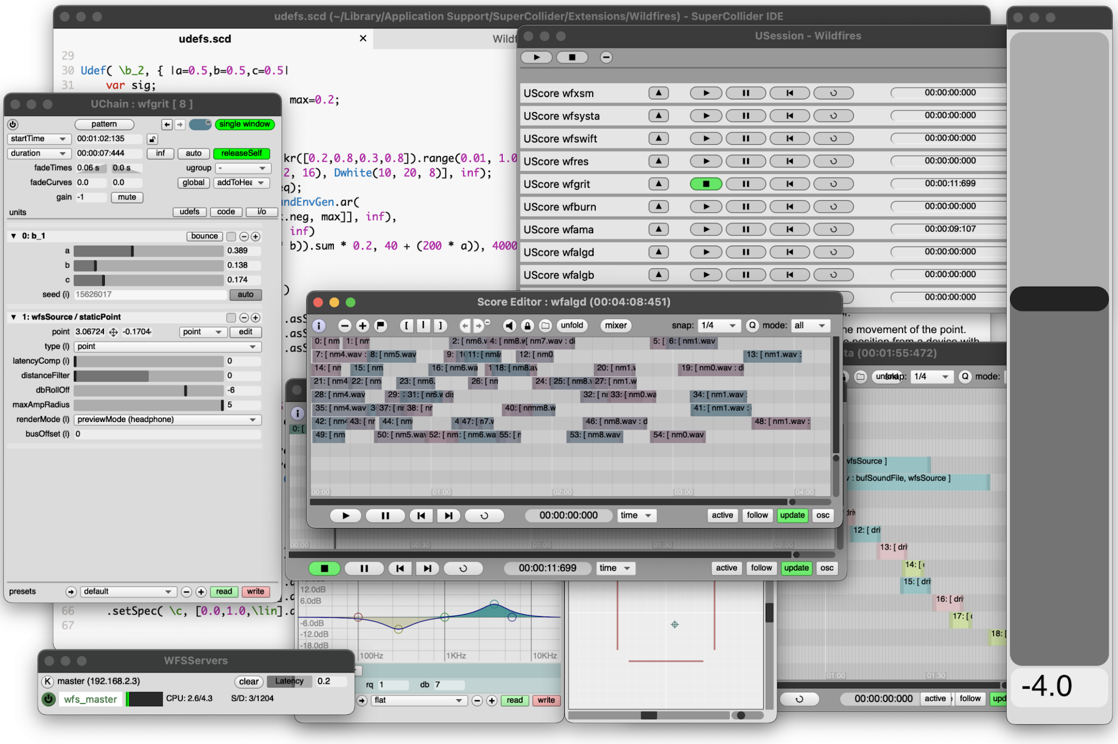
6.Wildfires

Implemented as a compositional solution for Wave Field Synthesis, *'Wildfires'* (https://github.com/bjarnig/wildfires) is a SuperCollider library for generating scores for the WFS Collider software system. It is also the title of a live-electronics composition created by the author using the system and performed on the 192-speaker system from *"The Game of Life Foundation"* (https://gameoflife.nl).

6.1 WFS

Wave Field Synthesis (WFS) is a sound diffusion technology for detailed rendering of spatial audio. With WFS, precise points and movements are synthesised through a large number of individually driven loudspeakers. The rendering system is designed for creating virtual sound environments and offers various possibilities for spatial sound composition. The technology uses loudspeaker arrays to reproduce sound environment but does not rely on a central *“sweet spot”* that often causes limitations for other spatialisation methods (Rabenstein, Spors, and Steffen 2006)

WFS Collider is the software used to interface with Wave Field Synthesis system of the Game Of Life Foundation. The system allows for creating sound sources that have a defined location and/or movement in space. The spatial movements can be driven by a trajectory or function but also stay constant or manipulated live (Sauer and Snoei 2017). While the software’s main component is a timeline-based interface, it has a very open and modular architecture that allows for real-time synthesis, sound processing and the creation of control data. Everything takes entirely place within the SuperCollider environment making it rather straightforward to extend the software or write scripts that interact with it.



WFSCollider with 'Wildfires' session view and Udef editor

6.2 SPREADING AND DISTRIBUTION

Based on ideas of rapidly spreading activity and distributed entities, *'Wildfires'* is a piece composed by the author for Wave Field Synthesis using WFS Collider and a customly created SuperCollider library bearing the same title. The piece questions virtual relationships between artificial sound sources, real-time synthesis processes and how sources can contribute to interaction and distributed influence. The initial idea was to route sound from an external computer (16 channels) live into the WFS Collider system that would then execute the WFS spatialisation to the 192 loudspeakers. That would mean that each of the inputs becomes a sound source where the spatialisation could be a generated or pre-programmed trajectory or even controlled entirely live. Although that is certainly technically possible with the WFS Collider system, it turned out to be difficult to successfully implement in practice. The main difficulties were due to the separation of sound and spatial trajectory across two computers and two systems. Routing audio into an already moving source feels strange and demands quite cumbersome synchronisation strategies. Also, establishing a rapid flow of events, each containing dynamic spatial movement is difficult to achieve in real-time. Instead, a different approach was taken, to generate scores (timelines) to facilitate the main goals of the piece.

The Game of life WFS system setup in Institute of Sonology's New Music Lab, on the sixth floor of Amare, Den Haag.

The idea behind Wildfires was to have WFS sources (events) connect and self-organise through different contact points created by defined conditions. Connected entities could then cause escalation and a sequence of events that would be activated by something external, something underlying, similar to a rapidly spreading fire or a virus. Implementing the distributed sonorities seemed interesting within a spatially detailed speaker-setup such as the WFS environment. In fact, the material would consist not so much of moving a single source, but rather through a path of connected sources that would form a perceived movement.

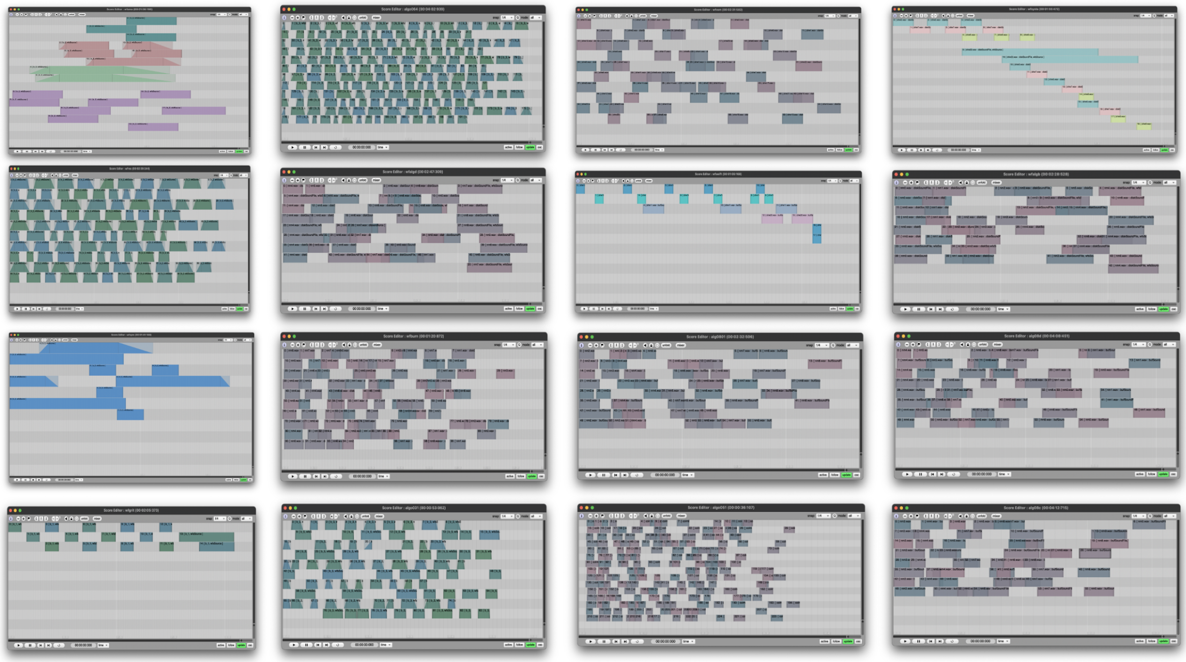
A small SuperCollider library (https://github.com/bjarnig/wildfires) was created in order to generate the scores. It consists of the following components:

WFSAgent	Sound source consisting of start time, duration, track, sound (sample or synthesis) and spatial movement
WFSSynth	Encapsulation for the custom Udefs that are part of the library. Each of those has three parameters (a,b,c) that are normalised to a range from 0 to 1 for a more fluid control
WFSSample	Encapsulates a sound file from disk that can be used by the WFSAgent
WFSTrando	Trajectory for a spatial movement that is generated based on speed and start and end points
WFSTpoint	Static point without movement
WFSCommunity	Collection of agents that constitute the score

The final piece consists of 22 generated scores that are activated during the performance. Each score is a rendering of a construction algorithm that either creates agents based on a set of rules or through self-organisation principles. The scores are fixed once created but the order they are played in is not defined beforehand. The WFS Collider also provides a 'session view' that allows playing several scores at once, to overlap them, stop them etc. During the performance, the Udefs with three control parameters were also used to enable real-time synthesis for all the 192 speakers in addition to the algorithmically generated scores.

6.3 SCORES

Using the agent, the sources and the spatial movements within a community, different algorithms can be activated to generate the scores. Most of the classes simply encapsulate and write the WFS objects but allow accessing them with standard SuperCollider objects. Besides the agent-based objects, the library contains a few custom Udefs that can be used by the agents or without.



16 of the 22 scores that form 'Wildfires'

The scores that constitute *'Wildfires'* contain synthetic sound sources but also pre-composed sound files. The choices of these condition the construction algorithm and the possible choices that can be made. They form a 'fixed context' where the action order is top-down only, there are no means for the sounds to relate back to their organisation principles and this was found out to be a limiting factor, especially when performing the piece. *'Wildfires'* was premiered live during the WFS festival at the Institute of Sonology on June 4th 2022.

https://soundcloud.com/bjarni/wildfires-live-wfs-excerpt

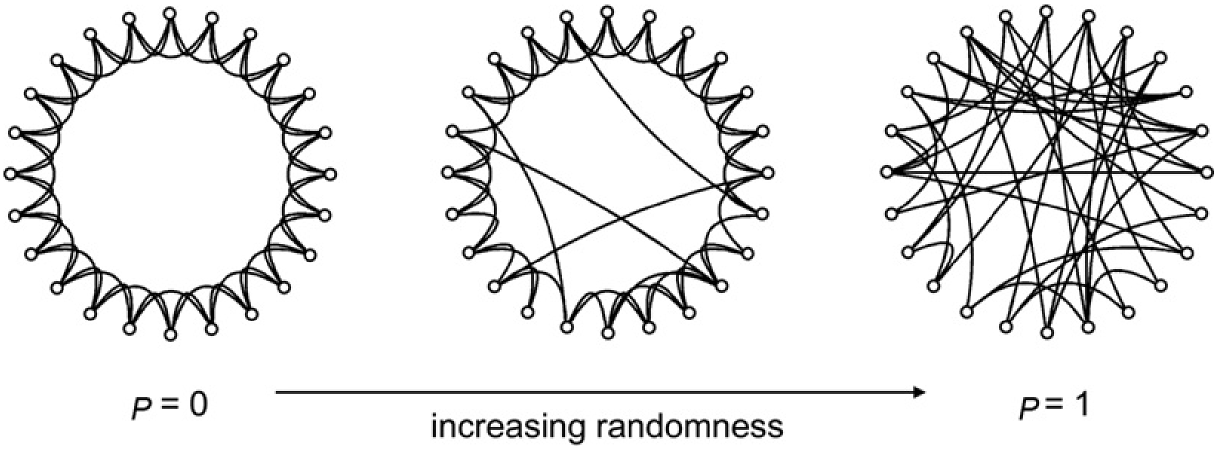
Recording of 'Wildfires' from the WFS festival concert on the 4th of June 2022

7. Random Graphs

'Costest' (2022) is a generative computer music piece that uses algorithmic control for the selection of sound materials, mainly short, articulated impulse sequences and interacting low-frequency textures. The piece consists of 68 blocks that are combined according to a selection algorithm. The material was prepared beforehand and in contrast to many of the author's work, the idea was to maintain a clear distinction between the sound creation and the sequencing procedures. The sections would exist as nodes in a network, they would be fully completed before any of them was ordered in time and independently of each other. In addition, the material was developed with the network behaviour in mind from the start. How the material would function in a random graph was what initially inspired the construction of the piece.

7.1 SELECTION PROCESS

In *‘Costest’*, the selection process was realised using an algorithm inspired by The Watts – Strogatz model, a random graph generation with small-world properties (Strogatz and Watts 1998). The original algorithm attempts to balance the shortcomings of ring graphs and random graphs. The problem with a regular ring network is that while it often has a high clustering coefficient (many close neighbours) it has a consistently high average path length (it takes long to reach most nodes). Random graphs on the other hand often feature short path lengths but a low clustering coefficient. The Watts – Strogatz model attempts to balance the best of both by starting from a highly clustered ring network but then introduces random edges using a probability factor for all the nodes in the ring. The goal is to obtain networks that have both a high cluster coefficient but also a rather short average path length. The sections of *‘Costest’* were treated similarly. They have been ordered as linked nodes, each having 2 edges to their neighbours. Once the initial order is established, random edges are created (swapped) based on a probability factor. The only difference to the original model is the handling of the number of edges and probability factor where both can be varying over the network instead of remaining constant. The implementation is still in progress but the initial approach can be found here:
(https://github.com/bjarnig/RandomGraphs)



Transition from a ring to random via a small world network (Chatterjee 2015)

The piece unfolds through the activation of the connected blocks where the speed and nature of the switching are put to the foreground. The duration of each block is important but even more the difference from one to the next, something largely due to the scheduling behaviour. The activation of the network can run through all of the nodes in the network but also operate in an interactive manner, for example by changing the node pointers, probabilities and speed on-the-fly. Another (still experimental) approach is to control parameters (for example node duration) through analysis (for example amplitude) of the outcoming audio in order to establish a relationship from the sound and back to the structuring process. Finally, methods are supported here to interrupt or disturb the flow of the network, a more drastic way to handle manual influence while it runs.

7.2 CAUSALITY PRINCIPLES

Similarly to the other works discussed here above, the idea with this piece is to establish a causality principle behind the flow of events that is somehow hidden while still very dominant for how things take shape in time. The duality and choice of material articulate the scheduling principles further, where the rapid impulse-sequences occupy the ‘close’ and the low textures the ‘far’. Still, both clearly seem to behave according to the same root causes. The sound material also sometimes seems to interact, although the only factor relating the sonorities is their activation process from the network. The causality relationship between the two types is what creates richness and drives the music forward. The directness of the sharp sounds and the process-like development of the textures result in a duality that aims for balance throughout the piece.

‘Costest’ introduces a shifting attitude that suggests the ’caused by’ characteristic so important for the music discussed here. The scheduling process leaves traces of activity, where every algorithmic shift has a slightly different impact according to when it has been made and where in the network it happened. These shifting points can be considered as musical material in themselves to be further developed or used to activate other processes. Every algorithmic selection represents a point in the graph of potential paths that then is further iterated. In its final form, the graph has been repeatedly executed with different settings for the nodes and probabilities in order to evolve, refine and enforce the final form of the piece. The focus on ordering and change characterises the work that then again perhaps lacks in terms of the relationships between the material and the structuring processes.

https://soundcloud.com/bjarni/costest

Recording of 'Costest'

8. Conclusion

Emergent behaviours can be used as generators of new forms in musical applications that interpret them. Three practical approaches have been presented here where extramusical behaviours have contributed to the creation of sound compositions that interpret them in different ways. In all of the projects, the idea was to introduce concepts that would somehow operate 'behind' the music, forming a 'hidden logic' that would bind together material, form and musical architecture.

The three projects contain a clear separation between sound and structure. The sound consists of process-based material, microsound that behaves and is then framed within a structure by causality principles that are also characterised by behaviour, although on a different level. The structuring processes have been introduced once the material they operate on already existed and are chosen based on their potential for composition.

The pieces and the software systems presented here are still experimental and being developed. Many improvements have been noted where implementation and further experimentation is needed. Most of these concern a more detailed and refined relationship between material and form. However, the tension between structure and sound is perhaps also what fundamentally unites these approaches and the resulting music. The separation is what gives them value. The source and destination conflict but positively and with plenty of potentials. The creative approaches concern working out the relationship between the sound and structure, to separate them but then to combine, to balance their behaviours.

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