INTERNATIONAL JOURNAL OF CREATIVE MEDIA RESEARCH

Vol.11, April 2025

Lorenz Factor: improvising algorithmic music

Dr Adam Parkinson & Justin Randell, *London South Bank University*

Abstract

The authors reflect upon Lorenz Factor, a musical performance developed for the Everyday is Spatial conference at the University of Gloucestershire in June 2022. The piece involves tracking the movements of the audience in order to spatialise the sound and provide streams of data that the performers use to control synthesisers or generate patterns. Further methods drawn from algorithmic composition and data sonification are deployed to give the musicians elements to respond to and perform with.

The authors consider the nature of immersion in musical performances, proposing an approach to immersion that draws upon disciplines including gaming and theatre, and is less technology-driven than some current trends. Considering the use of space, the nature of the instrument and the role of the audience in Lorenz Factor leads to a discussion of Simon Water's "performance ecosystem" and Christopher Small's "musicking", which provide an expanded conceptualisation of musical instruments, performance and audience participation.

Video: https://vimeo.com/770681696

Binaural Audio Mix: https://soundcloud.com/thedanelaw/justin-randell-adam-parkinson-lorenz-factor-binaural/s-rd20CThBnug

Dolby Atmos mix: https://drive.google.com/drive/folders/1SgBtObk4pWpkTHV5owRRZsCtzbtgag_9?usp=sharing

Introduction

Lorenz Factor is a live electronic performance that leaves certain elements outside of the control of the performers. It draws on methods from algorithmic composition and data sonification, coupled with tracking the audience via a camera feed. This creates streams of

data that the performers use to control synthesisers, generate and transform musical patterns, trigger sounds and more.

At the beginning of a performance, we inform the audience they are being tracked and invite them to move around the space, perhaps exploring how they can shape and spatialise the performance. Reflecting on the performance leads us to discuss the factors that can contribute to sonic immersion, and consider two expanded ideas of musical performances: Simon Water's "performance ecosystem" (Waters, 2011) and Christopher Small's "musicking" (Small, 1998).

The Performance

The piece was premiered during an evening concert at the *Everyday is Spatial* conference at the University of Gloucester in June 2022. This performance was spatialised through an 18.2 channel *d&b audiotechnik Soundscape* system installed in a 20m x15m x 4m "black box" studio. We introduced the piece by letting the audience know that their movements could influence the sound. Some members of the audience remained seated listening to the music, whilst others tried walking, dancing and waving at the stage to influence the sound.

Included here is a video with a 5 minute excerpt of the piece along with an audio only recording of the entire performance. The audio in both instances is rendered binaurally, using Dolby Atmos to recreate the speaker layout of the concert and give a sense of the spatialisation over headphones. Some of the audience interaction can be seen in the video, with audience members moving and dancing in front of the stage.

Previous Work

Our performance draws on techniques from algorithmic composition and sonification, using these in a real time improvisatory context. The term algorithmic composition describes compositional practices which use rules, formal processes and probabilistic systems. Not everything in the algorithmic musician's toolbox is strictly an algorithm - Lorenz attractors being a case in point - but the term is useful nonetheless for describing this range of methods.

Algorithmic music is sometimes assumed to be a recent phenomenon, but there is a long history of rule-based and semi-automatic compositions, including the musical dice games

of Mozart and early polyphonic singing, which can be said to be "algorithmic" to some degree. More recently, Steve Reich and Brian Eno used tape loops to create music that evolves outside the composer's control. Composers including Lejaren Hiller and Iannis Xenakis wrote pieces using probabilistic models and capitalising upon the new mathematical processing possibilities provided by computers. A diverse range of what can broadly be termed algorithmic composition techniques are found in the works of twentieth century composers including John Cage, and Gottfried Michael Koenig (Essl, 2007).

We are particularly interested in practitioners who use algorithmic systems in real-time musical performance. This includes George Lewis and his work *Voyager*, a computer that improvises with human performers (Lewis, 2000), and Laurie Spiegel's *Music Mouse*, an "intelligent instrument" with embedded algorithms that can be heard on *The Expanding Universe* (Spiegel, 1980 and 1986). Techniques from algorithmic composition are used in live improvisations by "live coding" musicians such as Alex McLean, Shelly Knotts and Renick Bell.This practice involves typing and executing lines of code during performance, with performers using algorithms to support improvisation. Closely connected to this is the "algorave" (a portmanteau of algorithm and rave) scene wherein live coding musicians improvise electronic dance music (see for instance Collins and McLean, 2014 or Blackwell et al, 2022). We are also inspired by contemporary electronic musicians who perform and improvise with algorithms, such as Autechre and Mark Fell. Fell's recent *Intersymmetric* works with Rian Treanor also explore audience participation and distributed instruments [1].

The Instrument

The instrument for *Lorenz Factor* is messy and often changes, and it's not always clear where it begins or ends. It's an assemblage of laptop computers, synthesisers, a camera, and MIDI controllers. On one computer, Adam uses Max software - a visual programming language popular amongst computer musicians - to generate and transform musical patterns on the fly which his synth (an Elektron Digitone) then turns into sound. Justin spatialises this on the second computer and uses a modular synth for further sound processing

Justin's computer is also tracking the audience's movements with the camera, using computer vision motion analysis techniques. Movements in the audience can cause sounds to move through the space. The audience can also control the timbres of sounds or affect

rhythms and melodies, depending on how we choose to use the data they generate. Of course, the audience can act in any number of ways, including standing completely still, dancing, or purposefully interacting with the piece, changing and moving sounds.

Along with the audience and performers, mathematical models and processes are also shaping and driving the piece. The first of these is aLorenz attractor, a mathematical model describing a chaotic system. It was discovered by Edward Lorenz whilst trying to model the chaotic behaviour of weather patterns. It produces patterns which are similar to a sinusoidal low frequency shape, and we find something musical about the Lorenz attractor, and the combination of repetition and unpredictable evolution that it generates. It's used here to modulate timbres and rhythms, and move sounds throughout the performance space.

Another musical algorithm we use generates "Euclidean rhythms". These are rhythms derived from Euclid's ancient sorting algorithm which Toussaint (2005) demonstrated could be used to generate a whole range of musical rhythms, from techno to Cumbia. In software such as Max, Euclidean rhythm generators can be stacked and layered, fed back into each and even used to make melodies. They are exceptionally useful for the improvising computer musician who needs to create rhythms and melodies on the fly.

This arrangement gives us something inspiring to work with as improvising musicians. We are able to manipulate this data in numerous ways, smoothing it out or changing the way it is scaled, sending it to different parameters in our synths to affect any number of processes from microscopic timbral changes to the evolution of rhythms or the spatial position of sounds. Moreoever, we have found these different streams of musical data all have their own unique affordances. Sometimes these data streams are something to react and respond to, and can take on the role of another actor in the improvisation. At other times they become a means to offload some aspect of the performance so we don't have to be controlling everything ourselves.

Discussion: Ecosystems & Immersion

Immersive audio is often understood to mean sound playback over multiple speakers (or rendered through headphones to appear as such). When understood primarily in these terms, sonic immersion becomes a technical challenge solved by more or better configured speakers and spatialising algorithms. A listener can sit in the "sweet spot" and be

completely enveloped - and therefore immersed - in the sound (Grajeda, 2015). However, we follow authors including Agrewall et al (2020) and Biggin (2017) in separating *immersive form* from *immersive experience*. A multi-speaker array is an immersive form that may remove barriers to audience members having an immersive experience, but it does not guarantee it. There are other routes to immersion that may be explored through musical performance.

Heritage, gaming and theatre are all disciplines where audiences have immersive experiences, and as such we may learn from them. Audience interaction and participation emerge as potentially important aspects to immersive audience experiences in these.domainsIn her discussion of immersive heritage experiences, Kidd (2018) detaches immersion from technology and rightly notes that "any and all heritage might potentially be understood as immersive." For Kidd, characteristics of immersive heritage experiences include being "story-led, audience and participation centered, multimodal, multisensory and attuned to its environment.", all of which can also be characteristics of a live electronic music performance

Writing on video games, Collins (2013, p. 141) argues that rather than viewing the game as a separate space that players enter into and are immersed in - as when one listens to music in the "sweet spot" - immersion emerges from interaction with the game and thus "The act of play, including content creation, leads to the immersive experience." Van Elferen's (2016) ALI model for analysing immersion in game music also notes how interaction, alongside affect and literacy, plays a role in player immersion. Writing on VR, Bucher (2017) notes immersion is "less about *telling* the viewer a story and more about letting the viewer *discover* the story".

Drawing on this, we propose that audience interaction and participation can play a key role in creating immersive audio experiences. However, we caution against an overly reductionist concept of audience interaction and participation. Here we look to Small's concept of "musicking" which provides an expanded view of participating in a musical performance. Small proposes we use "music" as a verb, writing "To music is to take part, in any capacity, in a musical performance, whether by performing, by listening, by rehearsing or practising, by providing material for performance (what is called composing), or by dancing" (Small, 1998). Small's concept of musicking therefore reminds us there are multiple ways in which an audience member may participate in a musical event, potentially facilitating immersion.

A further useful idea informing our work is that of the "performance ecosystem", introduced by Waters (2007 and 2021), who proposed that performance, instrument and environment are not to be seen as separate things to be considered in isolation, but as parts of a larger assemblage. Waters also builds on Small's ideas and considers how instrument design can be seen to involve designing "contexts for musicking" when considered from this ecosystemic standpoint, as instruments are made to be played in social contexts.

An ecosystemic approach informed by Waters and Small thus takes into account how audience and space are essential parts of the instrument and performance. It makes sense to us to think of *Lorenz Factor* in these terms. *Lorenz Factor's* instrument is a mutable assemblage of interconnected electronic devices, computers, software and synthesisers. This instrument is embedded in the space and the audience; it is both spatial in how it plays back sound and how it is embedded in and responds to the space and the people in it. The audience is immersed in the sound insofar as it surrounds them, but also insofar as they are invited to participate and *to music* in the space itself. The piece is not composed in a traditional way, rather we have designed a context for musicking wherein audience, performers and instrument collectively actualise the piece.

Conclusion and future work

This paper has described *Lorenz Factor*, a performance developed for the *Everyday is Spatial* conference on immersive audio. This piece uses audience interaction, mathematical models and ancient Greek algorithms to generate streams of data which shape and move the sound. This resonates with an ecosystemic approach to musical performance, whereby we can think of musical instruments as embedded in spaces and social situations. Traditional boundaries between audience, performer, space and instrument become more porous when thought of in this way.

The piece also attempts to offer a counterpoint to theories of sonic immersion that are driven largely by technology. Writing in 2025, many musical practices are completely entangled with proprietary and black-boxed technologies that music makers often have little or no agency over. It may be that we are at a point where we should question the extent to which musical practices become defined by these technologies. It would be bold to claim that *Lorenz Factor* achieve such a thing, but we hope it can be a starting point for some fruitful conversations about sonic immersion.

References

Agrewal, S., Simon, A.M.D., Bech, S., Bærentsen, K.B. and Forchammer, S. 2020. "Defining immersion:: literature review and implications for research on audiovisual experiences." *Journal of the Audio Engineering Society*, 68(6), pp.404-417

Biggin, R., 2017. *Immersive Theatre and Audience Experience*. Basingstoke: Palgrave Macmillan.

Blackwell, A.F., Cocker, E., Cox, G., McLean, A. and Magnusson, T., 2022. *Live coding: a user's manual.* Cambridge, MA: MIT press.

Bucher, J. 2017. *Storytelling for Virtual Reality: Methods and Principles*. New York and Oxon: Routledge.

Collins, K., 2013. *Playing with sound: a theory of interacting with sound and music in video games*. Cambridge, MA: MIT press.

Essl, K. 2007. "Algorithmic composition." in Collins, N and D'Escrivan, J. (eds.) *The Cambridge Companion to Electronic Music*. Cambridge: Cambridge University Press, pp. 107-125.

Grajeda, T. 2015. "The "Sweet Spot": The Technology of Stereo and the Field of Auditorship" in Théberge, P., Devine, K., and Everrett, T (eds.) *Living Stereo : Histories and Cultures of Multichannel Sound.* New York : Bloomsbury Academic.

Kidd, J., 2018." 'Immersive' heritage encounters". *The Museum Review*, 3(1).

Lewis, G.E. 2000. "Too many notes: Computers, complexity and culture in voyager." *Leonardo Music Journal*, 10, pp.33-39.

Small, C. 1998. *Musicking: The meanings of performing and listening*. Wesleyan University Press.

Spiegel, L. 1980. *The Expanding Universe*. Philo Records.

Spiegel, L. 1986. *Music Mouse™ An Intelligent Instrument.* Internet: http://retiary.org/ls/programs.html.

Toussaint, G. 2005. "The Euclidean algorithm generates traditional musical rhythms." In *Renaissance Banff: Mathematics, Music, Art, Culture,* pp. 47-56.

Van Elferen, I. 2016 "Analyzing game musical immersion: the ALI model." in Kamp, M., Summers, T., and Sweeney, M. (eds.) *Ludomusicology: approaches to video game music.* Sheffield, U.K: Equinox, pp. 32-52.

Waters, S. 2011 “Performance Ecosystems.” *Organised Sound*, 16(2), pp.95-96.

Waters, S. 2021 “The entanglements which make instruments musical: Rediscovering sociality” in *Journal of New Music Research*, 50(2).

Notes

[**1**] More details on these, and the web-based instrument, can be found at https://intersymmetric.xyz