Barry Truax *Riverrun* (1986/2004), a case study from the TaCEM project, exploring new approaches to techniques of analysis and re-synthesis in the study of concert electroacoustic works

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Abstract

At last year's EMS in Lisbon we introduced the TaCEM project (Technology and Creativity in Electroacoustic Music), a 30-month project funded by the UK's Arts and Humanities Research Council, and demonstrated the generic T*IAA*LS software being produced as part of this project. This year we present an update on the project, focusing particularly on the first of our case studies, Barry Truax's *Riverrun*.

Eight works have been selected for the project, taking into account criteria such as historical context, the nature of the synthesis techniques employed, and the aesthetics that have underpinned their realisation. Key considerations have included the accessibility of the technical resources and composing materials used in their production, and opportunities to pursue particular lines of enquiry with the composer concerned. In selecting the eight works for detailed study, a further consideration has been the extent to which the composers explored techniques that were already available at the time in ways that are unique and distinctive, or alternatively developed entirely new methods of synthesis in pursuit of their creative goals. The pioneering work of Barry Truax in terms of developing techniques of granular synthesis assign his achievements almost exclusively to the latter classification, and the composition of *Riverrun* (1986/2004) is a landmark achievement in this regard.

Truax's composing environment evolved from the early study of interactive real-time synthesis techniques at the Institute of Sonology, Utrecht 1971-73, exploring the possibilities of using Poisson-ordered distributions in the generation of microsound, to the emergence of entirely granular techniques at Simon Fraser University, British Columbia a decade later, culminating in the development of his program GSX designed specifically for waveform-based synthesis and first used to compose *Riverrun*, and its later extension, GSAMX, that extended these granular techniques to include the manipulation of previously sampled sound material.

At the time of composition conventional minicomputers still lacked the capacity to generate multiple voices of granulated sound material in real time, but for Truax the acquisition in 1982 of a high speed bit slice array processor, the DMX-1000, provided the enhanced processing power necessary for achieving such a goal. The unique characteristics of its special hardware and associated programming environment, managed in turn via a host PDP 11/23 computer, both empowered his creative objectives and also materially shaped and influenced the ways in which they could be practically achieved. The significance of such causal relationships in the evolution of the electroacoustic music repertory has yet to be widely

understood, and this study of *Riverrun* corroborates the importance of such a line of investigation. In this case it has been possible to carry out a detailed study of the original system, still maintained in working order by Truax, leading to a reconstruction of key elements of *Riverrun* using a Max-based simulation of GSX, the authenticity of the results being assessed both subjectively by means of a direct aural comparison and also measured objectively using software.

Our presentation at this year's EMS in Berlin included a demonstration of examples of the software we have developed to enable readers to engage with *Riverrun* interactively, both by analysing the original recordings and by using our emulation of the GSX system to be able to recreate passages of the work and manipulate the techniques employed in order to learn more about them. We also gave examples of other materials we have collected in relation to this case study, including videos of the composer himself working with the GSX system and discussing the composition of *Riverrun*.

Further information on the TaCEM project, and to download current and new software resources related to the project as they become available go to: http://www.hud.ac.uk/research/researchcentres/tacem/

Introduction

Barry Truax's *Riverrun* (1986/2004)[1], the first work of electroacoustic music that was entirely created using real-time granular synthesis, is the first case study investigated by the TaCEM project (Technology and Creativity in Electroacoustic Music), conducted by the three authors of this article and funded by the UK's Arts and Humanities Research Council (AHRC) for a duration of 30 months (2012-2015)[2]. Along with the development of a generic software dedicated to the analysis of any musical work, T*IAA*LS[3], the TaCEM project investigates the relationships between creativity and technology on the basis of an in-depth exploration of several case studies from the electroacoustic repertoire. Eight works have been selected, taking into account criteria such as historical context, the nature of the synthesis techniques employed, and the aesthetics that have underpinned their realisation. Key considerations have included the accessibility of the technical resources and composing materials used in their production, and opportunities to pursue particular lines of enquiry with the composer concerned. In selecting the eight works for detailed study, a further consideration has been the extent to which the composers explored techniques that were already available at the time in

[1] "Up to 32 tracks were mixed in the Sonic Research Studio at SFU [Simon Fraser University, in Burnaby, British Columbia] onto 4-track tape in 1986, slightly revised in 1987, and mixed onto an 8-track digital tape in 2004. The use of a digital delay in the early quadraphonic versions (mainly to help fuse the tracks) was abandoned in the later octophonic version." Barry Truax, "*Riverrun* (1986) for four computer-synthesized soundtracks", n. p., work presentation webpage, www.sfu.ca/~truax/river.html (last accessed 09/14).

[2] For a fuller account on the TaCEM project, see "TaCEM: Technology and Creativity in Electroacoustic Music", project presentation webpage, www.hud.ac.uk/research/researchcentres/tacem/ (last accessed 09/14) and Michael Clarke, Frédéric Dufeu, Peter Manning, "Introducing TaCEM and the T*IAA*LS Software", in *Proceedings of the 2013 ICMC (International Computer Music Conference)*, Perth (Australia), 2013, pp. 47-53.

[3] T*IAA*LS was presented and demonstrated at the previous EMS conference in Lisbon. See Michael Clarke, Frédéric Dufeu, Peter Manning, "T*IAA*LS: A New Generic Set of Tools for the Interactive Aural Analysis of Electroacoustic Music", in *Proceedings of the Electroacoustic Music Studies Network Conference (EMS13)*, Lisbon (Portugal), 2013, www.ems-network.org/IMG/pdf_ems13_clarke_dufeu_manning.pdf (last accessed 09/14).

ways that are unique and distinctive, or alternatively developed entirely new methods of synthesis in pursuit of their creative goals. The pioneering work of Barry Truax in terms of developing techniques of granular synthesis assign his achievements almost exclusively to the latter classification, and the composition of *Riverrun* (1986/2004) is a landmark achievement in this regard. This paper introduces Truax's work, its approach within the TaCEM project, and presents the software that implements its interactive aural analysis in the context of electroacoustic music studies.

1. Barry Truax's *Riverrun*: Origins, realisation, documentation

Barry Truax's composing environment evolved from the early study of interactive real-time synthesis techniques at the Institute of Sonology, Utrecht 1971-73, exploring the possibilities of using Poisson-ordered distributions in the generation of microsound, to the emergence of entirely granular techniques at Simon Fraser University, British Columbia a decade later, culminating in the development of his program GSX designed specifically for waveform-based synthesis and first used to compose *Riverrun*, and its later extension, GSAMX, that extended these granular techniques to include the manipulation of previously sampled sound material. At the time of composition conventional minicomputers still lacked the capacity to generate multiple voices of granulated sound material in real time, but for Truax the acquisition in 1982 of a high speed bit slice array processor, the DMX-1000, provided the enhanced processing power necessary for achieving such a goal. The unique characteristics of its special hardware and associated programming environment, managed in turn via a host PDP 11/23 computer, both empowered his creative objectives and also materially shaped and influenced the ways in which they could be practically achieved.

The twenty minutes of *Riverrun* were assembled in five large sections, each composed of two to four superimposed sequences. These sequences are themselves constituted with four parallel strands of granular synthesis as generated by the DMX-1000 controlled by the GSX program. Each strand is created following either an additive synthesis model for 19 voices of customisable 4-sine waveforms or a frequency modulation model for 8 voices, each with one modulating sine wave and one 4-sine carrier waveform. In both cases, grains are distributed alternatively on the two channels of the stereo field. Grains can be controlled in frequency, duration, density (with a variable delay between grains); these parameters can be randomly deviated within a user-defined range. With the additive synthesis model, the number of voices for three different waveforms and the total number of voices with a maximum of 19 are also controllable; with the frequency modulation model, the modulation index and its random deviation range as well as the total number of voices with a maximum of 8 can be defined by the user. All these parameters can be varied manually from the terminal or submitted to a ramp, which increments or decrements the selected values periodically. The ramp period can itself be modified by the ramp generator, for instance to provide an acceleration of parametric evolution.

The original GSX software enabling the generation of strands of granular synthesis is only running on Truax's own PDP 11/23 and DMX-1000, both of which are still in use at his home studio in Burnaby. To provide a thorough understanding of the relationship between the composer's creative concerns and his technological environment, the implementation of a piece of software emulating the GSX program has been targeted and achieved within the TaCEM project. Several sources documenting the original system were particularly useful in the emulation development process. Mara Helmuth's reference analysis of *Riverrun*[4] provides much information on Truax's development and use of the GSX program, along with reproductions of first-hand records and direct exchanges with the composer. Besides, Truax himself wrote a number of papers on the development of the software that enabled the realisation of this work and several others[5]. Some detailed documentation has also been published on a DVD[6] which comprises recordings of the separate tracks that constituted the final mix of *Riverrun*, general explanations of the implementation of granular synthesis in this work and, more crucially for analysis purposes, parameter charts corresponding to each sequence. Nonetheless, the task of emulating such unique software requires additional research on much low-level information that is rarely available. Discussions with the composer and direct comparisons between his own system and our emulation prototypes have been crucial to achieve a successful reimplementation in Cycling 74's Max. Details of such an investigation and the integration of technical aspects leading to analytical considerations are described in a complementary article[7]; the following section of this paper presents the emulation software and its implementation within an interactive aural analysis environment[8] as it has been demonstrated at the EMS conference in Berlin.

2. A Software for the Interactive Aural Analysis of *Riverrun*

The emulation of Barry Truax's GSX software is to be considered within the broader approach of the TaCEM project, which investigates its case studies in terms of contextual research, technological concerns and musical analysis. The software, as it will be made freely available at the end of the project[9], embeds several interactive aural examples based on either the synthesis emulation or the separate audio tracks available on the aforementioned DVD, aiming at providing a thorough understanding of the elaboration and structure of *Riverrun* on the basis of aural exploration. Figure 1 shows the main panel of the software, which gives access to successive examples. Clicking on one example brings the appropriate window to the front of the workspace.

The first aural example is an interactive structural chart (figure 2). This chart is based on information available on Truax's DVD, but provides a direct access to the listening of separate sequences, labelled A to N, according to their situation within the global form of *Riverrun* and its five sections. The initial display mode (sequence view) enables to listen to whole sections, but also to solo and mute particular sequences, thanks to the original recorded

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[4] Mara Helmuth, "Barry Truax's *Riverrun*", in *Analytical Methods of Electroacoustic Music*, Mary Simoni (ed.), New York, Routledge, 2006, pp. 187-238.

[5] Barry Truax, "The POD System of Interactive Composition Programs", *Computer Music Journal*, 1(3), 1977, pp. 30-39; Barry Truax, "The PODX System: Interactive Compositional Software for the DMX-1000", *Computer Music Journal*, 9(1), 1985, pp. 29-38; Barry Truax, "Real-Time Granular Synthesis with a Digital Signal Processor", *Computer Music Journal*, 12(2), 1988, pp. 14-26.

[6] Barry Truax, *HTML Documentation DVD-ROM*, nº 1, *Riverrun (1986/2004) and The Shaman Ascending (2004-2005)*, DVD, Cambridge Street Records, CSR-DVD 0801, 2008.

[7] Michael Clarke, Frédéric Dufeu, Peter Manning, "From Technological Investigation and Software Emulation to Music Analysis: An integrated approach to Barry Truax's *Riverrun*", in *Proceedings of the Joint Conference ICMC/SMC 2014 (International Computer Music Conference/Sound and Music Computing Conference)*, Athens (Greece), forthcoming.

[8] For further considerations on interactive aural analysis see Michael Clarke, "Analysing Electroacoustic Music: An Interactive Aural Approach", *Music Analysis*, 31(3), 2012, pp. 347-380.

[9] In 2015.

tracks upon which Truax assembled his work. Sequences suffixed with "x2" point to tracks that have been recorded on tape from the GSX output, then played back at double speed (M, J); sequences suffixed with "'" show occurrences of tape reversal after the synthesis recording (A, L, M).

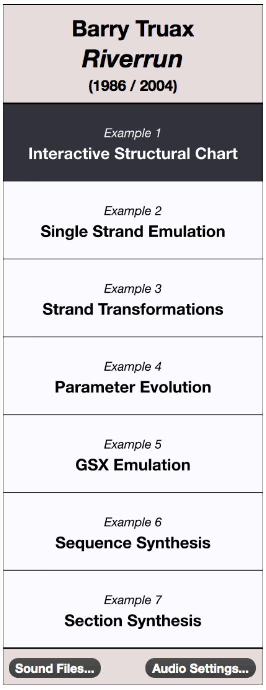

Figure 1: Main panel of the interactive aural analysis program for *Riverrun*, with access to successive examples

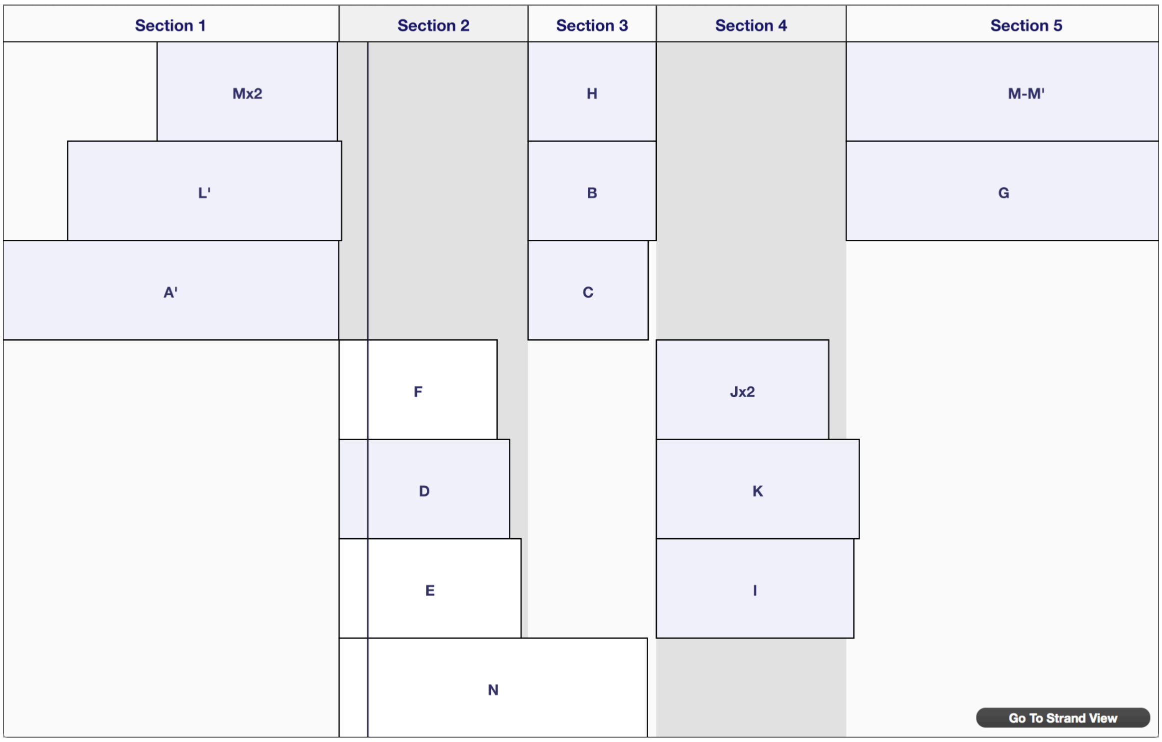

Figure 2: Interactive structural chart of *Riverrun* in sequence view mode. Sequence D is muted during playback of section 2.

This interactive structural chart gives a first insight into the components of the final piece: in figure 2, section 2 is being played with sequence D muted, and only sequences F, E and N being heard. This principle is extended further when switching to the second display mode (strand view) as seen on figure 3. The user can then solo and mute individual strands as produced by GSX and in some cases transformed with tape manipulations.

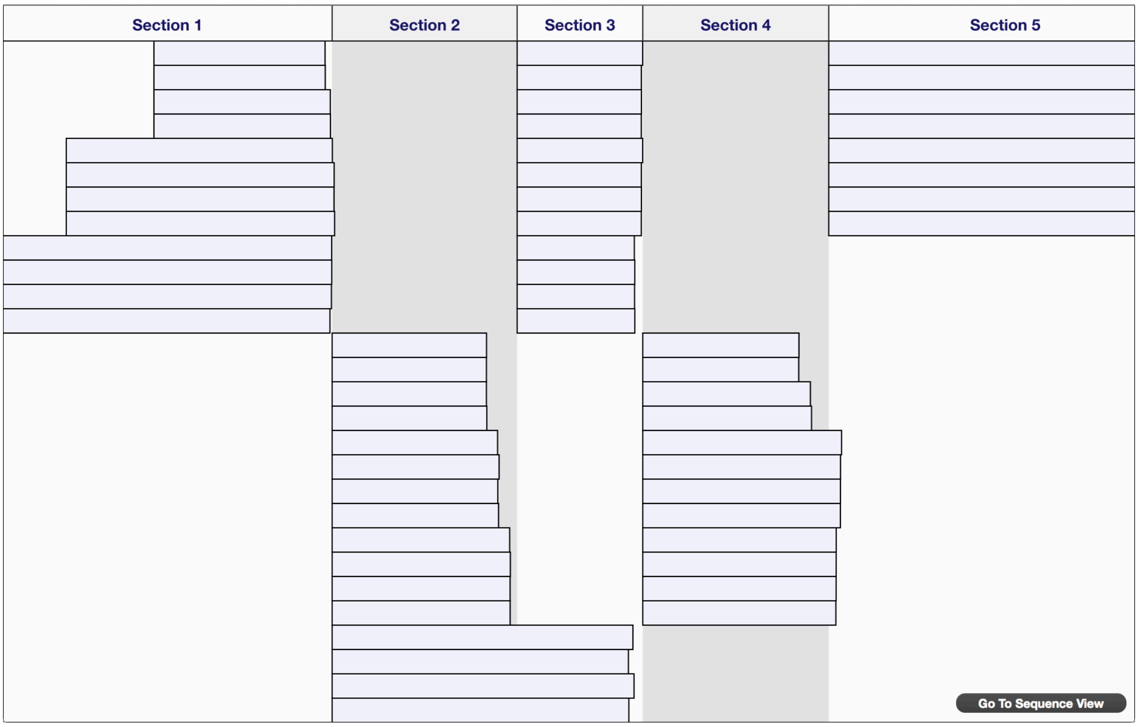

Figure 3: Interactive structural chart in strand view mode

From this possibility to listen to the smallest tape components of *Riverrun*, granular synthesis strands as they have been recorded to form the work, the user of the software can go to the next example, which introduces the GSX emulation with a simple interface (figure 4). Based on the additive synthesis model, a 19-voice strand can be generated and explored according to the fundamental parameters of granular synthesis as implemented by Truax: frequency in Hz, duration in milliseconds, both of which have a random deviation range, and delay between grains in milliseconds. In the example of figure 4, each new grain has a frequency randomly set between 250 and 350 Hz (300 ± (100 / 2)) and a duration randomly set between 40 and 60 ms (50 ± (20 / 2)). A 10 ms delay means that, for each of the 19 voices, a grain starts 10 ms after the end of the previous one.

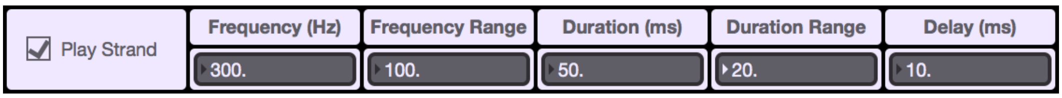

Figure 4: Second interactive example: single strand synthesis emulation

The next interactive aural example demonstrates the simple tape operations that Truax could apply to recorded strands (figure 5). Some of these were reversed, enabling sequences such as A to start, in the final work, with a massive texture of randomly distributed grains and to end with rigorously synchronised grains, which is impossible to achieve with the GSX program alone. The other tape manipulation used in *Riverrun* was playback at double speed, leading to a strand pitched up by one octave and twice shorter than the original.

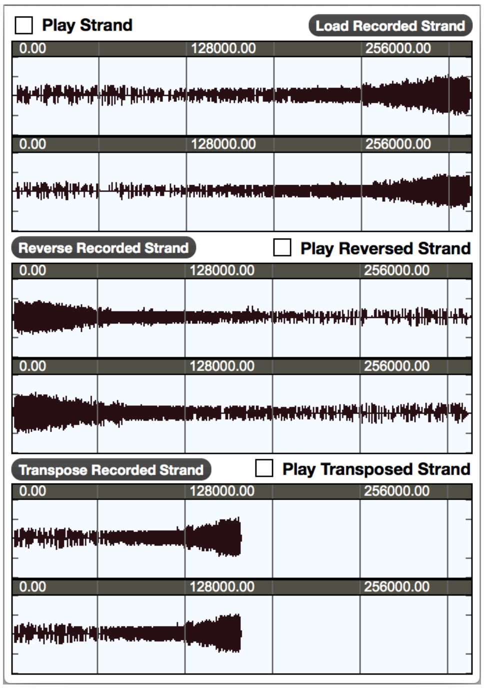

Figure 5: Strand tape transformations: reversal and transposition by speed doubling

The fourth example gives a visualisation of parametric evolutions for some sequences of the work. Figure 6 shows the evolution of frequency for the four synchronised strands constituting sequence M, along with random deviation ranges. Strands 1, 2, 3 and 4 start at, respectively, 5000, 6000, 7000 and 8000 Hz with frequency ranges 500, 600, 700 and 800 Hz.

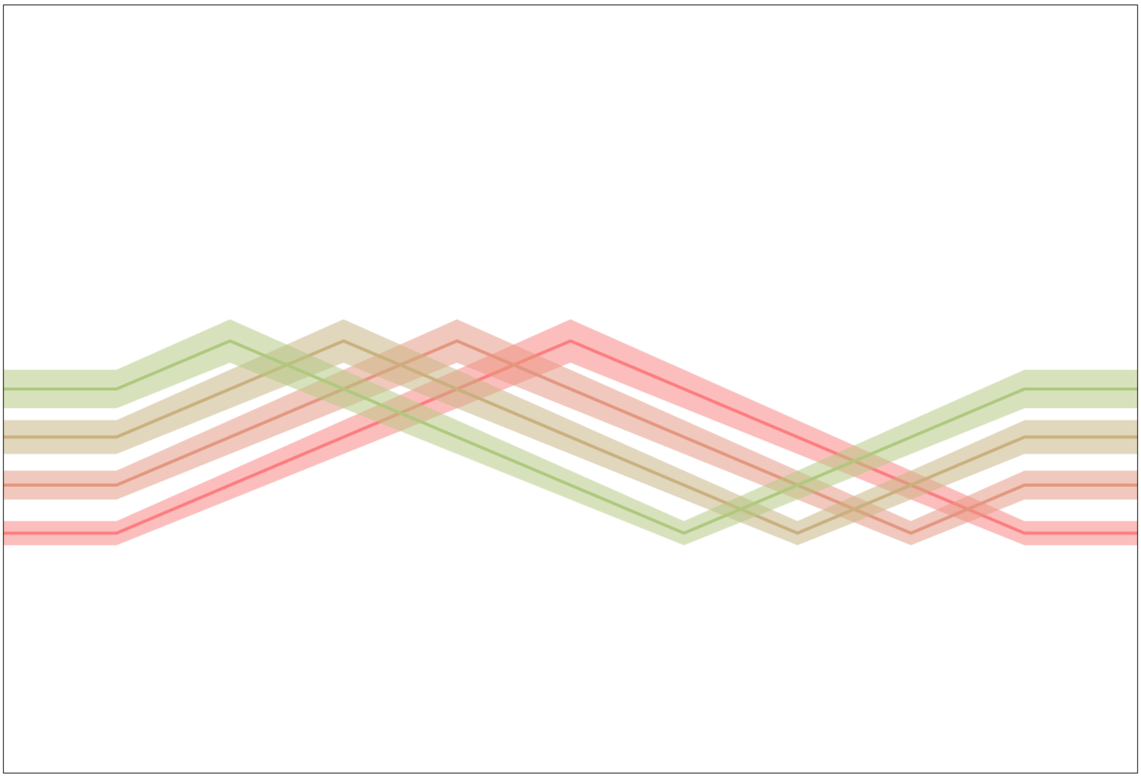

Figure 6: Fourth interactive aural example: parametric evolution of frequency and frequency range for the synthesis of sequence M

For each strand, a ramp progressively increases the frequency to 9000 and the frequency range to 900 Hz, where the ramp descends to 5000 with a range of 500 Hz, before ascending again towards the initial values.

The fifth example is the actual GSX emulation. As with Truax's original system, the user can visualise parametric information on the screen and modify it with keystrokes. In figure 7, parameters for the additive synthesis model are displayed; an ascending ramp ("AMP A") is applied to the frequency range with an increment factor of 2 and to the delay with a decrement factor of 1. In this example, every 200 milliseconds, the frequency range is thus increased by 2 and the delay is decreased by 1, and all other parameters are constant. Out of the 19 voices, 2 play the custom waveform nº 2 and 5 play the waveform nº 3, allowing for timbre variation.

AMP	INC	FREQ	FRQ.RNG	DUR'N	DUR.RNG	DELAY	RAMP	NO.VOI. W.F.#2	NO.VOI. W.F.#3	TOTAL NO.VOI
A	1	500	+62 2	50	10	-28	200	2	5	19

Figure 7: GSX emulation with the additive synthesis model

From another panel of this interactive example, the user can choose between the additive synthesis and the frequency modulation models. For each model, a drop-down menu gives access to presets that correspond to the initial parameters of each strand of *Riverrun* (figure 8).

Default Preset
Sequence A (Tracks 3 & 4)
Sequence A (Tracks 7 & 8)
Sequence B (Tracks 1 & 2)
Sequence B (Tracks 3 & 4)
Sequence B (Tracks 5 & 6)
Sequence B (Tracks 7 & 8)
Sequence D (Tracks 1 & 2)
Sequence D (Tracks 3 & 4)
Sequence D (Tracks 5 & 6)
Sequence D (Tracks 7 & 8)
Sequence F (Tracks 1 & 2)
Sequence F (Tracks 3 & 4)
Sequence F (Tracks 5 & 6)
Sequence F (Tracks 7 & 8)
Sequence M (Tracks 1 & 2)
Sequence M (Tracks 3 & 4)
Sequence M (Tracks 5 & 6)
Sequence M (Tracks 7 & 8)
Sequence N (Tracks 7 & 8)

Figure 8: Menu of presets for initial parameters of strands generated with the additive synthesis model

The sixth example is the extension of the GSX emulation to a whole sequence, including four parallel strands. The user can load one of the fourteen sequences (A to N) into a panel that displays the parameters for each of its four strands, as well as a set of sequential instructions for the evolutions of the strands (individual parameter changes, ramp directions, fade-ins and outs). The sequential instructions can be automated so that a loaded sequence can be synthesized without any intervention, but the user can interrupt the processes and change parameters manually (figure 9).

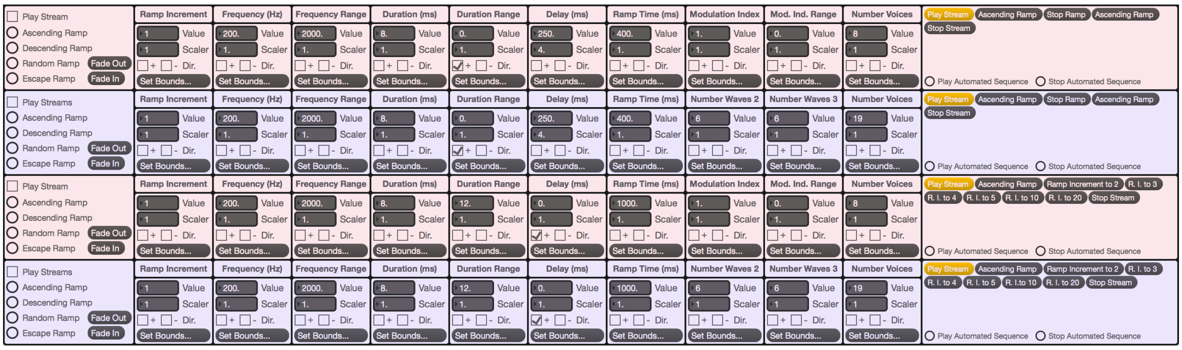

Figure 9: Sequence synthesis example, with parameters loaded for sequence A. The pink panels represent strands generated with the frequency modulation model; the purple panels correspond to the additive synthesis model. On the right are the sequential steps for the successive strand behaviours.

The last example extends the sequence synthesis to the simulation of a whole section. Reduced panels give access to the principal parameters and sequential instructions. Figure 10 shows the superposition of the 16 strands used to compose section 2 (from top to bottom, sequences F, D, E and N each with 4 strands).

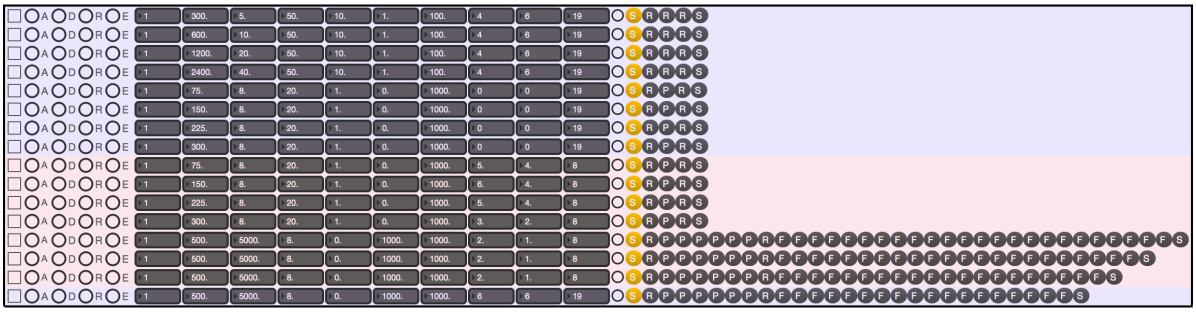

Figure 10: Section synthesis with panels of section 2

Conclusion

The implementation of an interactive aural analysis environment for the musicological study of Barry Truax's *Riverrun*, currently under its finalisation stage, relies on both the integration of existing materials and information such as individual sound tracks and parametric data and the technological investigation leading, with the composer's assistance, to a successful emulation of the GSX software. Navigating through the successive interactive aural examples should help the users of the software to get a better understanding of the creative and technological context in which *Riverrun* was composed, of the principles of real-time granular synthesis, and of the micro and macrostructures of the work. The final outcome of the TaCEM project will include, as for all the other case studies, detailed writings on both the historical and contextual aspects of the composition and on the analytical results of the undertaken investigations. The tight articulation between such writings and freely available software shall meet the aim of interactive aural analysis by providing musicological results under a form that particularly fits the needs of electroacoustic music studies: a direct access to sound exploration.

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References

CLARKE Michael, "Analysing Electroacoustic Music: An Interactive Aural Approach", *Music Analysis*, 31(3), 2012, pp. 347-380.

CLARKE Michael, Frédéric DUFEU and Peter MANNING, "T*IAA*LS: A New Generic Set of Tools for the Interactive Aural Analysis of Electroacoustic Music", in *Proceedings of the Electroacoustic Music Studies Network Conference (EMS13)*, Lisbon (Portugal), 2013, www.ems-network.org/IMG/pdf_ems13_clarke_dufeu_manning.pdf (last accessed 09/14).

CLARKE Michael, Frédéric DUFEU and Peter MANNING, "Introducing TaCEM and the T*IAA*LS Software", in *Proceedings of the 2013 ICMC (International Computer Music Conference)*, Perth (Australia), 2013, pp. 47-53.

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HELMUTH Mara, "Barry Truax's *Riverrun*", in *Analytical Methods of Electroacoustic Music*, Mary Simoni (ed.), New York, Routledge, 2006, pp. 187-238.

"TaCEM: Technology and Creativity in Electroacoustic Music", project presentation webpage, www.hud.ac.uk/research/researchcentres/tacem/ (last accessed 09/14).

TRUAX Barry, "The POD System of Interactive Composition Programs", *Computer Music Journal*, 1(3), 1977, pp. 30-39.

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TRUAX Barry, "Real-Time Granular Synthesis with a Digital Signal Processor", *Computer Music Journal*, 12(2), 1988, pp. 14-26.

TRUAX Barry, "*Riverrun* (1986) for four computer-synthesized soundtracks", work presentation webpage, www.sfu.ca/~truax/river.html (last accessed 09/14).

TRUAX Barry, *HTML Documentation DVD-ROM*, n° 1, *Riverrun (1986/2004) and The Shaman Ascending (2004-2005)*, DVD, Cambridge Street Records, CSR-DVD 0801, 2008.