David Hirst
Senior Lecturer
Information and Education Services, University of Melbourne,
Victoria, 3010. Australia

d.hirst@unimelb.edu.au

Developing an Interactive Study Score for the Analysis of Electro-acoustic Music

Abstract

This paper documents the design and development of an interactive study score for acousmatic music. First we introduce our SIAM framework for the analysis of acousmatic musc, then document previous methods of representation. We then provide an analytical methodology for Denis Smalley's Wind Chimes*, show details of the design of the interactive study score, and make some conclusions regarding its efficacy and future enhancements.*

SIAM Framework

Previous papers have reported on the development of a procedure for the analysis of acousmatic music which was derived from the synthesis of top-down (knowledge driven) and bottom-up (data-driven) views. (Hirst, 2003b; Hirst, 2004)

The procedure can be summarized as consisting of a number of points for consideration, which are not necessarily applied in sequence. They are:

Segregation of sonic objects

Identify the sonic objects; Establish the factors responsible for identification (acoustic, semantic, syntactic, and ecological).

Integration (Horizontal)

Identify horizontal streams consisting of sonic objects linked together and functioning as a "pattern" unit – consider "trajectories" and "gestures"; Determine the causal linkages between the sonic objects within the pattern units; Determine the relationships between "pattern units" - if this level of syntax exists; Consider local organization in time - pulse, beat, accent, rhythm, meter; Consider the horizontal integration of pitch, including emergent properties relating to timbre (vertical overlap).

Integration (Vertical)

Consider vertical integration as a cause of timbre creation and variance; Consider vertical integration or segregation in terms of the potential for psychoacoustic and musical dissonance and consonance.

Assimilation and Meaning

Consider the nature and type of discourse on the source-cause dominant to typological-relational dominant continuum, and the way it varies over time; Consider implication-realization, and arousal and meaning on a moment-to-moment basis throughout the work; Consider global organization in time - identify formal structures, like sectional or continuous organization, and the nature of the relationships between sections - hierarchical relationships.

We have dubbed this methodology the SIAM framework for: Segregation, Integration, Assimilation and Meaning. In order to work through this analytical framework, the questions of how to record the researcher's observations and how to communicate any special insights arise. So to record the results of the segmentation, integration, assimilation and meaning process, a Flash-based interactive was developed to provide a dynamic visual representation along with synchronized playback of the recorded work being analysed. This paper reports on the design and development of this kind of "interactive study score".

Previous Methods of Representation

In another paper I have already noted the "problem of the score" in electroacousmatic music (Hirst, 2003a). There are traditionally two types of what may be called a "score" in electroacoustic music - a list of operational data used to generate the piece, or a sketch of the musical effects obtained. The former is prescriptive, the latter descriptive. Descriptive scores have been criticised as being rather crude and approximate, but in order to communicate concepts discovered in the analysis of electroacoustic music, words and pictures are the main currency of communication, although the inclusion of sound is an aim of this current exercise.

A number of writers have been courageous enough to put pen to paper, and draw pictures too, in order to try and represent aspects of a fundamentally aural music tradition. Lewis (1998) created structural plans in a spreadsheet-like format, produced bar graphs of sound types, graphs of frequency of sound type changes and an elaborate graphical score of Dhomont's *Novars*. In the same journal volume, Dack (1998: 111) created some beautiful frequency versus time transcriptions of Stockhausen's *Kontakte*, Emmerson (1998: 156) graphed the left-right spatial disposition of instrumental motifs in Risset's *Songes*, Roy (1998: 180-183) defined a whole lexicon of terms and symbols relating to implication and functionality such as: orientation (begetting, conclusion, interruption, introduction, suspension, trigger); stratification (background, figure, foreground); rhetoric (affirmation, announcement-reminder, call-answer, deflection, parenthesis, reiteration, sign); rhythm (pedal). Each one of these had its own symbol and Roy created a graphic score of Bayle's *Ombres Blanches* using his functional symbolic lexicon.

In another collection, there were dozens of illustrations such as sketches, tables and study scores (Decroupet and Ungeheuer, 2002); sonograms (DeLio, 2002); and a beautiful "transcription and graphical rendition of a programming sequence" from Risset's *Contours* (Di Scipio, 2002).

More recently, some interesting work has emerged, in particular the "Signed Listening" project which allows a listener to annotate a sound file using certain types of graphic representations (Donin, 2004), and the work of Couprie (2004) which builds on the model of the *Acousmographe* developed by INA-GRM in France. (See http://www.ina.fr/grm/acousmaline/polychromes/index.fr.html)

Couprie has developed a graphical representation tool to produce an enriched listening experience for electroacoustic music.
(See http://www.univ-lille3.fr/revues/demeter/ and http://www.univ-lille3.fr/revues/demeter/analyse/couprie/Bayle.swf).

Practical Analytical Methodology

Denis Smalley's *Wind Chimes* (Smalley, 2004) was chosen for analysis as it is a classic example of the genre described as acousmatic music. The aim of the analysis was to apply our Segregation, Integration, Assimilation and Meaning framework (SIAM) in order to: Discover insights into the work itself; Discover the syntactic forces that may operate between events; Test the appropriateness and usability of the SIAM framework.

The CD recording was digitally transferred to computer disk at 44.1 kHz sampling rate. The original stereo version of the work is used for listening purposes and for examination of each channel's spectrum individually. In addition, a mono version of the work was created by combining the two channels to create a single spectral representation of all components of the work for further examination. The sonogram was chosen above any other form of signal analysis since it provides the most accessible way of assisting with the segmentation of simultaneous sounds.

The program Adobe Audition version 1.0 was used to both play the sound files and to create various spectral displays of frequency versus time. A "patch" was created in the graphical programming language PD (Puckette, 1996). The patch consisted of three sinewave oscillators that could be tuned to any desired frequencies and amplitudes. This allowed the researcher to tune in to certain frequency components in order to identify them precisely. Thus the analytical method was a combination of critical listening and signal analysis.

The work was segmented into 30 second blocks since periods longer than this involve long-term memory considerations. This length of time also provides a convenient screen display to work with. 4 to 5 second windows within the 30 second blocks were used to approximate the "sliding window" notion of our working memory. Having considered the first two factors, the work was segmented at obvious sonic boundaries such as those places where there may be silence or where there is a long, sustained sound. Nine sections were identified within the 15 minute work.

Analysis proceeded in a linear way from start to finish. For each section, a set of observations was recorded in text form, and a pictorial representation of separated sound events was drawn in pencil on paper along a timeline. Analytical data was also drawn on the pictorial representation. The data that was collected included an event's: start time; duration; perceived pitch or significant frequency components or both; graphical indications of amplitude envelope; graphic symbols depicting special features, e.g. pitch glissando. A "discussion" passage was also written for each section in order to interpret the observations that were made.

Once the observations, pencilled pictorial representation, and discussion passages had been completed, an "interactive study score" was created as a Flash interactive (See Figure 1). This attempted to establish a dynamic relationship between the analytical data, the spectral representations, and the audio sounds of the work itself.

Design of the Interactive Study Score

Figure 1 shows a typical screen from the interactive study score for *Wind Chimes*.

The first design question requiring resolution was how to maximise the amount of data displayed while maintaining compatibility with common computer screen sizes. The interactive is designed for a monitor screen size of 1024 x 768 pixels, which was considered the best compromise.

The aim was to display aspects of the frequency spectrum (rather than waveform amplitude) versus time, display graphic symbols depicting individual sound events, display text providing information on the sound events (a label, important frequencies, pitch, special features), display start times, give some representation for duration, display other graphic symbols suggesting relevant patterns (pitch glissandi, filter changes, rhythmic patterns, etc).

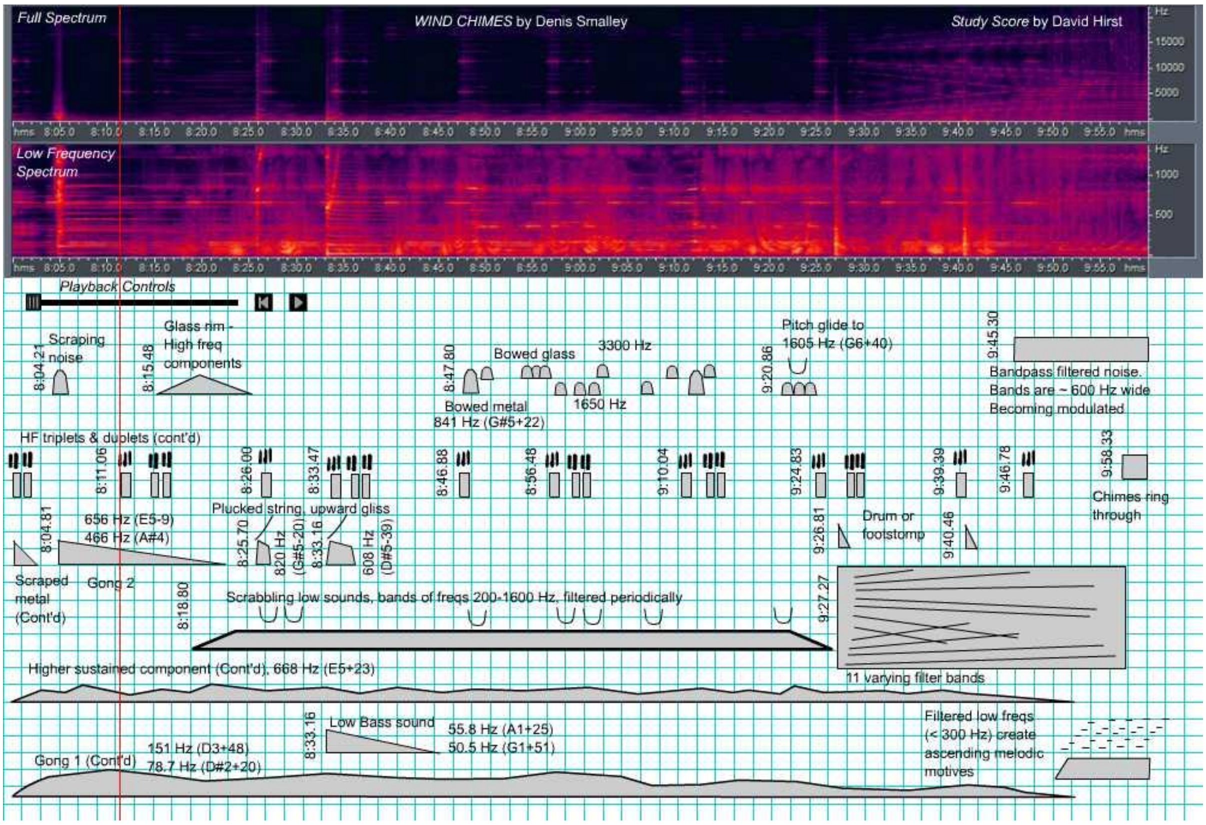

Figure 2. *Screen shot of the Wind Chimes "interactive study score"*

The screen is largely divided into two panes. The top pane provides sonogram-type representation of frequency versus time – the product of signal processing of sections of the work. Screen shots were taken of the spectrum of a mono version of the piece to allow two frequency resolutions to be displayed. The top area shows the full spectrum from zero to 20,000 Hertz. This is especially useful to focus on what is happening in the upper part of the spectrum above 5,000 Hertz for example. Immediately below is the same passage of the work, but displaying the lowest part of the spectrum – up to 1,500 Hertz. Display of this part of the spectrum is useful for concentrating on pitch aspects of sound events in more detail.

Underneath the sonogram pane there is a larger area that is reserved for graphic symbols and text - the product of human analysis of the work. This area is meant to depict the segmentation of the work into separate sound events, and to provide some hard data on those sound events, such as important frequencies and pitches, as well as descriptive information (e.g. "gong-like"). A grid background was constructed to facilitate alignment with the time scale of the sonogram plots.

The symbols are only crudely placed vertically on the screen from lower frequency to higher frequency since some sounds may be spread broadly across the spectrum (noise) whereas others may be very pure and only contain a few frequency components. Vertical placement also depends on the amount of activity at any one time and the amount of screen real estate available, resulting in certain compromises in visual placement of graphic symbols. Horizontal placement represents fairly accurate representation of an event's start time and approximate duration.

Just under the sonogram representation pane, and on the left hand side of the screen, lies a set of playback controls. These are used to initiate the playback of the sound track of the piece, and to control the playback in synchrony with the visual representation. There is a play/pause button, a return to start button, and a scrub-like button that permits the user to move to a particular point in the sound track. It also acts a progress bar during playback. The media controller was derived from the controller developed in the online tutorials provided by the Glasson Murray Group (2005). A uniform duration of two minutes per screen was used to allow the comfortable depiction of sound events on the width of the screen.

Conclusion

Creation of the study score was quite a long and laborious task, but once it has been created, it does provide some insights and benefits. It is quite quick to move from one area to another in the piece, and this is quite a long piece – 15 minutes. Thus the controls are quite usable. This allows some ready comparisons of different parts of the work to expose some of the longer-term formal organisation of the work. Screens can also be printed and strung together to get a total picture of the work. One benefit is provided by the Flash authoring environment in that the study score can be widely disseminated over the internet – subject to copyright clearance.

One aim of the project was to produce hard data that others could use for further analysis. This was seen as a weakness of the other interactives produced by Couprie and INA-GRM. Their interactives are visually interesting, but there is no detailed data that can provide a more penetrating analysis. Our representation, that includes significant frequencies, pitch information, and accurate start-times, does allow these values to be used by other researchers in a more quantitative analytical fashion.

In future versions, other possibilities can be explored. For example the spectrum could be displayed in full screen-size and annotations could be placed in relevant points directly on the sonogram. Having authored one of these interactives should make future renderings of other works more efficient. The authoring environment does lend itself to adaptability and other means of representation, suggested by the “signed listening” approach, could easily be explored.

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