The Harmony of Noise: Constructing a Unified System for Representation of Pitch, Noise and Spatialization

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Abstract. As a composer of both electroacoustic and acosutic works, I have been puzzled by the lasting discrepancy between the theoretical frameworks surrounding instrumental and electroacoustic music theory, particularly with regard to algorithmic composition. This text outlines the basic ideas for my doctoral studies, focusing on the digital representation of sound for composition, analysis and performance, both as data and graphic notation with the aim of bringing the worlds of acoustic and electronic music closer together.

Keywords: Notation, Aural Sonology, Algorithmic Composition, Spatialization

1 Introduction

Computer-assisted composition relies on the idea that musical parameters can be represented and processed as flows of data. Central to this development for pitch-based music has been the MIDI protocol, which interestingly can be used both for communicating with synthesizers and displaying traditional scores. However, there is no established equivalent system for sound-based music that would enable transferring musical ideas from computer to instruments through notation and/or digital representation. Historically electroacoustic music theory has been more closely related to sound parameters and machine functionality. This is not surprising since electroacoustic composers still rely heavily on their knowledge of music technology to achieve a desired result. At the same time, experimental sound-based instrumental composition relies on images and written instructions for the performers to take certain actions, rather than descriptions of a sounding result. Developing an interactive system of representation that can handle pitch, noise and spatialization would provide composers and performers with a unified language for describing and conceptualizing music regardless of its means of production. Such a system could then be used by composers for setting rules governing the co-existence of sounds regardless of their frequency. Such a set of rules could be described as a harmony theory of noise.

2 Aim

The objective of my current research, which is at an early stage, is to explore ways in which a computer-modelled representational system can describe pitch and noise in space in a clear and comprehensible way, with sufficient detail to make it useful in both composition and performance practice, providing graphical overviews and computer simulations of abstract models of music as localized sound. This will be used for the composition of music for various sound sources, such as voices, acoustic instruments, synthetic and concrete electronic sounds, aiming to bridge the gap between the vastly different theoretical frameworks of pitched and non-pitched music. This would, hopefully, lead to a greater understanding of how pitched and non-pitched sounds interact on a structural level regardless of their origin, and of how they create meaning within and outside of their structure, making possible a music created and/or interpreted from the viewpoint of its sounding qualities rather than its practical and technical conditions. Electroacoustic music theory includes several systems for categorizing, organizing and visualizing sound. What I wish to contribute is a system of representation that, like MIDI data, can function as both descriptive and prescriptive of music, regardless of sound source and genre, also taking spatialization into account. By spatialization, I am referring to the concept of sound being projected from one or several defined positions in the listening space, both from electronic and acoustic sound sources.

3 Method

The starting point of my research is a thorough investigation into past and present efforts to classify and notate sound-based and spatialized music, also looking into efforts to expand traditional notation to include these concepts. I will also look into different software-based systems of music representation. I will gradually develop a new system based on successful aspects of previous systems. This new system will be tested for composition, performance and sound-based ear training, generating feedback to calibrate the system's applicability to these three different situations.

I begin by conducting an extensive survey study, covering current research in technologies for music notation and representation. I am also developing a case study where composer students will work with new notation in relation to fixed sound examples as well as their own creative ideas. A key factor here is to see how a sound-based system of music representation on a fixed frequency scale can benefit the work of composers and performers of contemporary music.

4 Points of Departure

The first established systems for representation of sound-based music stem from electroacoustic music theory, beginning with Pierre Schaeffer's *typo-morphology*[1]. In order to describe and classify discrete sound objects in the context of gestural music, this is still a useful theory as long as one is aware of the author's explicitly value-laden sound categories. In Denis Smalley's theory of *spectromorphology*[2] the ability to describe sound in space and sound in transformation was important. Together, the two theories still constitute the foundation for sound-based analysis in Western art music. Lasse Thoresen's *Spectromorphological Analysis of Sound Objects*[3] is an all-encompassing sound notation and classification system combining Schaeffer's classification (his value-laden language toned down) with Smalley's ideas about transforming sounds. In Thoresen's work, this results in an extensive notation system that can describe sound-based music in great detail (see Fig. 1.). There are several systems developed to describe music from a listening perspective, such as the *Temporal Semiotic Units (TSU)* system from MIM[4]. However, these are all systems developed for classification and/or representation rather than composition and performance.

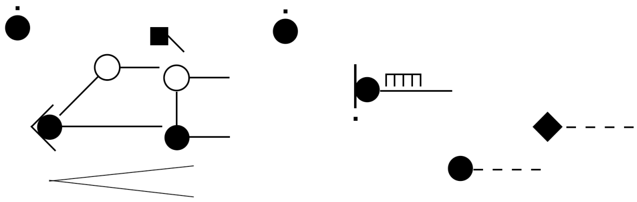

Fig. 1. Notation of a phrase of sound-based music using Thoresen's notation[3].

There are already several software-based systems that allow for algorithmic and real-time processing of music notation: *MaxScore*[5] and *Bach*[6] are examples of systems that introduce traditional staff-based notation in MaxMSP. *FTM*[7] from Ircam also expands MaxMSP's capabilities though the system is not exclusive to MaxMSP as a host. For spatialization, examples are fewer and farther between. A fairly recent example is the *Spatialization Symbolic Music Notation* from ICST[8] which includes printable notation integrated with computer control of spatialized sound. See Fig. 2. below for an example of the symbols used in this system.

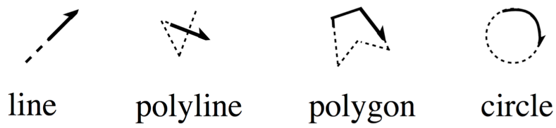

Fig. 2. Examples of symbols from the *Spatialization Symbolic Music Notation* system[7].

An important feature of representation of music in computer music software is the ability to view the same musical structure in different ways. For example, many Digital Audio Workstations provide the possibility to visualize MIDI data in a piano roll editor, as a traditional score, or as lists of MIDI events. This phenomenon can also be found in rock guitar notation, where the same music is commonly visualized both as a traditional score and as guitar tabulature on a two-staff system. This approach could be the end result of sound-based notation for musicians, where I imagine the performers would ultimately write what instruments and gestures they end up using for any given interpretation of a sound-based score.

I have included here an example from the draft of the notation system (Fig. 3.) which I will use in the first case study. Here, Thoresen's notation for spectromorphological analysis of sound objects[3] is combined with traditional notation of pitch and time. For Thoresen, circles represent pitched sounds, square-shaped symbols are non-pitched sounds, and diamond-shapes are *dystonic* sounds – a category between the other two. I am not including Thoresen's concept of using empty or filled note shapes to further specify timbral characteristics since this would risk confusing readers when the symbols are introduced together with the traditional notation of time – instead, I use empty note shapes to refer to half note and whole note durations. To position the notation objects on a fixed frequency scale (which is where this system most significantly deviates from that of Thoresen's phenomenological analysis), the symbols are drawn over a four-staff system covering 20 Hz - 3,5 kHz. Such systems are commonly used to display pitch in software used for computer-assisted composition. An additional staff can be added when necessary in order to cover the whole range of human hearing. For the beginning of each sound, I have introduced a dashed vertical line to the system to specify the bandwidth of the sound – the space it occupies in the frequency range. Attached to this line is an arrow describing how the this bandwidth evolves over time. For the indication of space I am initially working with a two-circle solution similar to the one found in ambisonics panning software. The upper circle shows the 360° horizontal panning while the lower shows the elevation angle. This will be further articulated as this project proceeds. How the timbral and spatial data is then converted and interpreted as actions for performers will depend strongly on the instruments used and the performers' interpretations.

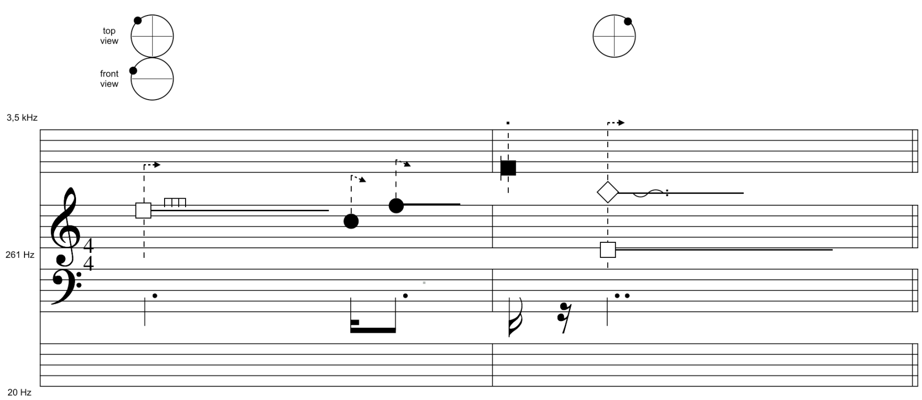

Fig. 3. An example from the draft of the notation system that will be used for the first case study, combining Thoresen's spectromorphological analysis notation with features of traditional music notation. The circles above the staves show the direction of the sound in a 3D-space in the manner of ambisonics panning user interfaces.

5 A Harmony of Noise

In abstracting sound-based musical structures as described here, I'm suggesting the possibility of a harmony theory of noise. Not to be confused with traditional harmony theory, this would refer to any set of rules governing the co-existence of sounds with different frequency content. Just like traditional pitch-based theories may show preferences for which frequencies that may be combined to produce a certain aesthetic expression, the same goes for non-pitch based sounds. For a mixing engineer this is obvious, since handling the co-existence of a given set of sound layers is at the core of their trade, and subject to strong aesthetic viewpoints. Much of the sound-based ear-training resources available is indeed developed for audio engineers. There are exceptions, such as Eldad Tsabary's electroacoustic music ear training, focused on aural atoms[9]. I have myself developed tools in MaxMSP for ear-training purposes, visualizing audio structures – see Fig 4. What makes ear-training interesting in this context is the necessity to ground concepts in a physical reality and accept the fact that we can then in fact recognize and notate sounds correctly or incorrectly; The analysis tools leave the realm of phenomenology and their symbols become quantifiable variables with clearly defined meanings. It is this "act of grounding" that will make it possible to work with the sound objects in an algorithmic composition context.

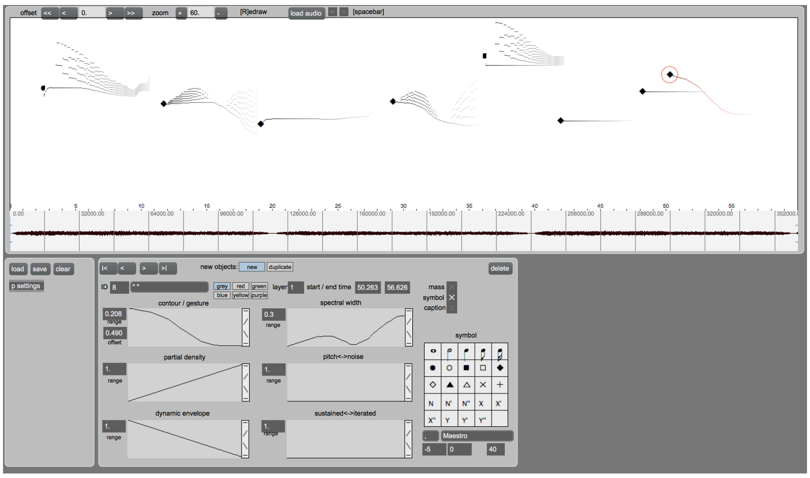

Fig. 4. An example of my own software constructed for working with sound-based ear training and structure listening. Parameters, such as contour, partial density and dynamic envelope are combined to describe each sound event.

6 Implications

A new system as described here will not be perfect in describing and defining sounds – this is not the case with traditional notation either. When combining MIDI data in algorithmic composition systems we don't necessarily imagine that the pitch data *is* the music. But it may be an important structural component of the music, and perhaps a structure that we could not have conceived of without the aid of the software.

Thanks to my experience in teaching aural sonology and sound-based ear training to composition students at the Royal College of Music in Stockholm, I already have some insight regarding the usefulness and musical opportunities that lie in working with sound-based music in this way. There is a conceptual difference between notating a sound as it sounds and notating a sound as it is produced. At first glance, the traditional way of notating extended instrument techniques - often using drawings of the instrument body, symbols and/or written instructions to denote a certain action - may seem both practical and intuitive. But if a performer is instead asked to produce a certain timbre, there is a freedom of interpretation that leaves the compositional structure intact while allowing for different interpretations of the same piece. I also see a strong advantage in the possibility to compose music without first having to define whether the sound source should be electronic or acoustic.

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