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Timbre Networks: An approach to Composition and Performance in Computer Music

1 Introduction

Perhaps the most talked about contribution of electronic media to music composition is the dramatic expansion of the musician's timbre palette. The idea of starting the compositional process from something as protean as the imagination and the production of the sound units that will constitute our basic material is a poetic and fascinating concept present since the early works of K. Stockhausen in the mid-fifties. Equally idealistic and poetic is P. Schaeffer's premise of capturing, extrapolating and re-organising the 'natural' sound universe around us by means of recording and manipulation, in order to generate new semantic discourses.

These two early attempts to incorporate and explore the capabilities of electronic tools for creating a 'new' music, with a 'new' syntax, were also the first to face the aesthetic challenge of how to present these creative results in front of an audience. Although attempts to create new environments and presentation forms for these listening experiences have been made, the traditional conventions concerning how and where to present music persist until today, due to – among other reasons – the socio-political implications of modifying every aspect of what music represents as a social event. While the new musical languages/structures and their relationship to sound have changed dramatically, neither composers nor audiences seem ready to renounce what they embraced as the primary musical communication event by default: the concert situation.

The rapid evolution of technology (and its economic democratization) has progressively made it possible to generate in real time, in front of an audience, similar processes to those early electronic efforts, produced in a dedicated studio. But what are the ramifications of this for music creation and interpretation, beyond the shortening of the time span between production and exposition? And how does that affect our overall musical experience, from producers to consumers?

We tend to divide musical practice in two: *Composition* and *Performance*. How we discover and perceive creativity within these two roles is governed by the ways in which we view the creative process. The creative act of composing has been compared throughout history to a form of alchemy. There is a certain 'magic' in the manipulation and combination of 'isolated' elements to generate something 'new' and 'original'. It has also been compared to cooking. But what seems to be unique to Music is the somewhat artificial historical divide between the roles of composer and performer. Although not a necessary feature of artistic practice, Western tradition has conventionally separated the role of the creator and that of the interpreter, assigning the former a mystical, almost religious character ('the Creator') and investing the latter with a no-less mystical role: the Medium, who holds the key for manifesting in the real world the composer's vision.

Creativity in interpretation, as difficult as it is to describe, is somehow not hard at all to recognize, and is arguably concerned with whether some performers are able to shine and 'add that difference' even to pieces that, on paper, do not necessarily hold anything that seems striking or special. As noted by Veale, Feyaerts & Forceville (this volume),

> Different performers and performances can reveal different ways of interpreting an original composition. Some performances of a familiar musical creation can still take the audience by surprise, and seduce it into an appreciation of the performer's own creative vision.

In early electronic music, the conceptual creator (i.e. the composer) and the implementer (the interpreter) have been re-combined into one. But this time around the 'blending' of roles links the implementer's skills to more technical tasks (the technician/engineer) and takes away from the Medium the artistic and creative powers of a traditional instrumental interpreter.

In early 'pure' electronic music pieces, that existed then in fixed media and still do today, the instrument/agent that gives the creators of this music the ability to preserve the manifestation of their 'magical quests' as pristinely as possible is not the performer, but the actual media itself (e.g. tape, CD's). For the final work preserves both the conceptual process as well as the interpretative process conducted by the composer in a studio. Both of these processes are arguably 'impossible' to reproduce in a performance.

As the development of notation gave birth to music that was impossible to imagine without the abstraction and distance that musical text gives to the material (e.g., the instruments), the creative experimental processes behind early electronic music gave birth to musical structures that could only be shaped by the possibilities and limitations of recorded media. But in the same way that highly complex instrumental scores had to be ultimately decoded by a human interpreter, electronic music had to be presented in a place that was not the composer's studio, a place with different physical dimensions and reproduction equipment and – perhaps this is the most dramatic difference of all – a place that contained an audience!

Dealing with an audience was not the only case where the world of electronic music had to face and address the traditional elements of music. To discover new tools did not mean that composers forgot the experience and familiarity of the old ones. The combination of both electronic and instrumental sources – and its performers themselves – was to give rise to the coexistence of two very different sound universes.

Over the following pages, I will propose and present a method that integrates the sound realm of computer music into the domain of human performance, striving to find a balance between these two worlds by focusing on the importance of timbre in today's music creation. I shall also explore the historical contribution of the performers of contemporary music to its idiomatic development.

2 Timbre Composition

The cultural break produced by World War II pushed artists into a search for new ways and forms of organising their creative material. In music, this precipitated a shift away from the hierarchical importance of pitch and harmony to instead favour other aspects of the sound universe, such as rhythm and timbre, while dealing with a continuous expansion of *what* could be considered 'musical material'.

This search for new sonorities affected the way composers and performers related to their instruments. The break away from tonality made it possible to give room to previously avoided sounds to become part of the palette of an instrument, incorporating and standardising the sounds produced by what we now call 'extended performance techniques' (as present in Luciano Berio's *Sequenzas*, written between 1958 and 2002, for example).

The composer's search for new ways of relating to his instruments pushed the exploration of orchestral texture even further, as evidenced already in the work of Berlioz and Debussy. This new, expanded palette affected the way that overall musical structure is dealt with, shifting the focus of attention from harmony to timbre and providing an opportunity for some instruments – most strikingly the non-pitched percussion instruments – to claim a much more important role in the creative process.

Arnold Schoenberg's vision of a melody of timbres, wherein the temporal evolution of a piece is not marked by melodic lines or harmonic progressions but by the interconnection and sequence of complex sound structures, evolved into the development of the orchestra as a complex generator of timbres. This new perspective inspired composers to find structural complexities not necessarily connected with music tradition, and translate them, at least conceptually, into the musical domain. For instance, Iannis Xenakis' *Phitoprakta* aims to use the orchestra as a sound generator for mimicking the collisions of gas particles. In his book *Formalized Music* (1992: 16), we find some insight into the ideas behind the construction of these complex textures:

> We can control continuous transformations of large sets of granular and/or continuous sounds. In fact, densities, durations, registers, speeds, etc., can all be subjected to the law of large numbers with the necessary approximations. We can then with the aids of means and deviations shape these sets and make them evolve in different directions. The best known is that which goes from order to disorder, or vice versa, and which introduces the concept of entropy. We can conceive other continuous transformations: for example, a set of plucked sounds transforming into a set of bowed sounds, or in electronic music, the passage of one sonic substance to another, assuring thus an organic connection between the two substances.

Other composers expanded the orchestral timbre by means of innovative uses of the physical space and the spatial distribution of instruments. A good example of this is Karlheinz Stockhausen's *Gruppen* for three orchestras. In a Lecture transcribed by *Die Riehe* (1961: 67–82), he offered some insight about what he was searching for with this piece:

> It was necessary to present more or less long groups of sounds, noises and a cross between the two simultaneously in various tempi. So that this could be correctly played and heard, a large orchestra of 109 players was split up into three smaller orchestras: each of these was to have its own conductor and had to be placed at some distance of the other two.
>
> The similarity of the scoring of the three orchestras resulted from the requirement that sound-groups should be made to wander in space from one sounding body to another and at the same time split up similar sound-structures: each orchestra was supposed to call to the others and to give answer or echo.

The use of the orchestral sound as a complex timbre also raised the question of the identity of the micro-elements within that timbre, and how to control them. One composer who sought to answer this question was Gerard Grisey. He combined the idea of orchestral simulation of acoustic spectra with a slow development of the musical material. He argued that

> sound can no longer be compared to a simple static superposition of harmonics, but has to be understood as a temporal object in which micro-events that are imperceptible to the ear contribute to characterising the timbre. Trying to hear these subtleties, sharpening one's auditory perception in order to 'enter' into the sound, requires an adequate temporal slowing-down. (Grisey [1993: 13])

Grisey was 'fascinated' by the *extended time* practiced by composers such as Ligeti, but realised that this extended time was not yet filled with the material he required:

> they filled it with clusters of chromatic music, but that was very different from what, as far as I was concerned, should have happened in this kind of time.[1]

The generation of this material was obtained through a process of instrumental synthesis where each instrument plays a component of the spectrum, re-adjusted into quarter or eighth tones, while considering the time and amplitude differences present in the original spectra. Due to the complex spectral characteristics of the individual instrumental timbres, the result is clearly something far more complex and more interesting than a mere synthesised sound, a result in which the harmonic dimension contrasts with both the atonal uniformity of most contemporary music and with the harmonic issues of tonal music.

2.1 Composing the sound

From the birth of polyphony to stochastic composition, Western music has traditionally evolved towards greater complexities in the relationships of the musical elements.

The expansion of tonality and the conception of the orchestra as an instrument of mutable sonorities gave composers the opportunity to experiment with the idea of texture composition, and to manipulate various parameters of this *meta*-instrument simultaneously. For Schoenberg, the result of these manipulations was not far removed from melodic constructions. For him, pitch was nothing but one isolated aspect of timbre, and a melody of timbres would just be a richer version of a melody of pitches:

> I cannot readily admit that there is such a difference, as is usually expressed, between timbre and pitch. It is my opinion that the sound becomes noticeable through its timbre and one of its dimensions is pitch. In other words: the larger realm is the timbre, whereas the pitch is one of the smaller provinces. The pitch is nothing but timbre measured in one direction. If it is possible to make compositional structures from timbres which differ according to height (pitch), structures which we call melodies, sequences producing an effect similar to thoughts, then it must be also possible to create such sequences from the timbres of the other dimension from what we normally and simply call timbre. (Schoenberg [1911: 471])

1 In a radio conversation with Jean-Yves Bosseur, at Le Temps des Musiciens, Radio-France, 1998

For these reasons, Schoenberg is often cited as an exemplar of transformational creativity, as defined in Boden (1990) and described in the introductory chapter of this volume. Schoenberg here uses the notion of a *realm* to communicate the notion of a conceptual *space* that is more commonplace in contemporary creativity research: the transformation follows Schoenberg's insight that "the larger realm is the timbre", in which "pitch is one of the smaller provinces". In other words, Schoenberg expands and enlarges the conceptual space of music, to identify new areas of value in the hinterland that surrounds the more traditional space. However, in his statement quoted above, Schoenberg does not provide any insight into how other aspects of timbre could be internally structured, in order to achieve a logical sequential construction as perceptually successful as the ones of pitch. Perhaps, in order to learn how these other elements of timbre work, it is necessary to go deep inside the material itself?

In a similarly transformational vein, Edgar Varèse can be considered the first composer to shift the emphasis from the organisation of musical super-structures that are focused on pitch to the organisation of structures centred on other musical parameters, such as rhythm or timbre. An example of this is his concept of *sound-blocks*, a compositional idea where every musical element is related in contrast to another (e.g., short-long, soft-loud, dull-bright). These constructions are designed to be perceived as a single sound unit. Therefore, in order to present more of these blocks simultaneously, one must consider the importance of the contrast of elements and the physical location of the units. For Ligeti,

> one can see most clearly how such (contrasting) conditions articulate the form in compositions where the diverse types of "weave" are accompanied by considerable differences in timbre and density, and are thus even more clearly differentiated. In Stockhausen's "Gruppen", for example, the backbone of the form is given by contrasted types – hacked, pulverised, melted, highly condensed – and their gradual transformations and mixtures one with another…" "…Their mutual indifference is so great that the layers can go considerably 'out' in time, and enjoy, fields of inexactitude of considerable latitude. It is this peculiarity that enables the three orchestras to play together despite the fact that they are widely separated in space: the points of entry for each orchestra are generally fixed, but in the further course of a group the orchestras can diverge to a greater of lesser degree, without any damaging effect to the original result. (Ligeti [1965: 14–15])

2.2 Electronic music

There is no doubt that we can find interesting examples of the manipulation of timbre in instrumental music: consider the timbre modulations in the brass sections in *Deserts* by Varèse, or the middle section of Luigi Nono's *Coro di Didone*. In the latter piece, six performers play an array of cymbals and tam tams, which are used to produce textures ranging from the homogeneous to the quasi-melodic.

But it is in electronic music where the artistic challenge of timbre composition is truly emphasised. It is only in this medium that the compositional process demands an attempt to create the sound idiom itself from its smallest unit, whether it is by redefining the semantics of existing sounds (Pierre Schaeffer's *musique concrète*) or by creating complex timbres from simple sound units (K. Stockhausen's early electronic music). Both approaches have their advantages and their limitations. On these, Jean Claude Risset notes that

> Musique concrète makes any recorded sound available for musical composition: it thus provides a wide variety of natural sounds with complex structures. But these sounds can be transformed only in ways that are rudimentary in comparison with the richness of the original material; this brings in the danger of capitalising on sound effects and privileging an aesthetic of collage. Electronic music, on the other hand, allows precise control of the structure of electronic sounds–very simple and rather dull sounds. These simple sounds can be enriched, but only through manipulations that to a large extent ruin the control the composer can exert on them. (Risset [1985: 115])

In order to overcome these sonic limitations (articulation over time versus inner complexity) it is necessary to combine both sound production processes in an extensive fashion. Furthermore, the availability of the computer as a tool for production of electronic music helps us to gain control over the structure and evolution of synthetic sounds, and provides more complex and interesting ways of manipulating the spectra of recorded material. It was hoped that this added control would resolve the dilemma between richness of sound versus refinement of control.

Yet, even if this dilemma is resolved, we are still confronted with a musical result that lacks a very important element: the sheer instability and nuance that a human performer can contribute to a composition. The history of electronic music has evolved together with the technology that produces it, and sadly, the emphasis when discussing it is usually centred on the tools and technology that make it possible. Thus, some of its more important components are omitted from the scope of analysis: the humans involved in the production and performance of this music, and the specific issues that arise with them.

3 Going Live

When we talk about performance practice in electronic music, we tend to assume that the focus of our attention is on the interpreter of traditional instruments and his/her interaction with the electronic 'system'. Most historical approaches to human/electronic interaction in contemporary music take this as a ground truth; pieces for instruments and fixed media (like Stockhausen's *Kontakte* for piano, percussion and 'electronic sounds', or Luigi Nono's *La Fabricca Illuminata*, for soprano and tape) have been created since the beginning of the electronic composition era and still remain among the most commonly used compositional formats (later examples are composers such as Ton Bruynèl, Horacio Vaggione and Ake Parmerud). While the new possibilities of digital sound synthesis and transformation have been thoroughly explored, the reliability of fixed media has never been abandoned. The development of technology and the possibility of real time processing, analysis and synthesis of sounds have opened a window for the realisation of a new kind of music production, where both the traditional and the electronic sound elements of a piece can be controlled on stage, by a human performer.

Early works exploring the use of live electronics to enhance the timbre qualities of music are Stockhausen's *Mikrophonie* (for large tam-tam, two sound-exciters, two microphonists and two filter-control operators), and Luigi Nono's body of work in collaboration with the experimental studio of Freiburg (*Das Atmende Klarsein* and *Prometeo*, among others). These approaches, while bringing new sonorities in real time to the musical world (e.g. ring modulation and filtering, or the extensions in time and space by means of reverberation and spatialization), have the limitation of being dependent on the original sounds of the traditional instruments involved in the piece, leaving us with the impression that in order to gain real-time generation qualities the role of the electronics must compromise its potential for timbre complexity.

One of the main interests of the IRCAM institute in Paris for the last 25 years has been to create innovative ways of using technology to achieve real-time interaction between the instrumental and electronic elements of a musical system. A primary goal was to liberate the performer from the rigidity of a pre-recorded electronic material, and to provide him/her with the means to control more complex and timbre-independent electronic material. Examples of this approach are Pierre Boulez' *Repons*, for ensemble and computer system, Phillipe Manoury's *Jupiter* for flute and computer, and on later years, Cort Lippe's *Music for sextet and ISPW*. Although reaching great levels of flexibility and timbre complexity, this approach still maintains the master-slave relationship between instrumentalist and electronics, making the musical gestures and nuances of the electronic material dependent upon the articulations of the instrumental part.

A departure from this approach would involve a dedicated performer for the electronic elements of a piece, someone who would have the freedom to articulate the predefined parameters of the synthetic sounds and/or of the instrumental sound manipulation.

3.1 Timbre Networks: A Definition

If we can describe a network as a system of asymmetric relations between discrete objects that allows the exchange of information between connected objects, then we can describe timbre networks as a means of organising the threads that connect different musical elements in live electronic music. With timbre networks I thus aim for a systematic organisation of the possible relationships between computer, musical instrument(s) and performer(s). By focusing on timbre – both as a representative of an individual component, as well as a mutable entity that can be transformed by its relationships to other components – I thus seek to define a compositional structure that focuses on systematising the relationship between sound objects and their potential interdependency, leaving in the hands of the performer the responsibility for unfolding the musical structure over time. In many respects then, a timbre network is a conceptual space of musical states in which a creative composer/performer can search for novel pathways to goal states.

Structurally, a timbre network can be defined as a complex organization of interdependent sound objects, in which behavioural changes over time can be induced by means of performance. The essence of a timbre network as a conceptual space lies in our answers to the following questions:
- What are the elements/nodes of the network?
- What are the threads between them?
- How malleable are these nodes and threads over time, either in response to the real-time manipulation of a performer or in relation to predefined interdependent variables?

Once these initial states are defined, other compositional procedures to develop the time structure of the piece can and should be used. The question then arises: would it be possible to derive the musical time structure from the timbre network structure?

Timbre networks aim to provide a compositional procedure for generating 'outside-time' structures, by focusing on the composition of predefined initial states of a musical system that can (and should) evolve in time by means of performance. In this respect, it is possible to understand the results of this procedure as hybrids that can be closer to the structure of a *meta*-instrument, where timbre networks can be seen as a way of applying compositional thoughts to mapping procedures.

The idea of creating a system that generates both the sound and the time structure of a composition has been explored by other composers, most notably by G. M. Koenig. His vision of

> an unbroken continuum of all timbres; not only of all timbres, but the continuum between the timbre, stationary in itself, and the musical structure. The aim was the contoured, the fluctuating timbre. (Koenig [1992: 78])

was successfully realised on his *Terminus* of 1962. In this composition

> a complex sound metamorphosis results from the superimposing of semi-automatic modulation processes, which are not object to further manipulations once the machine has started. The composer does not control the sound elements themselves, but the steps of sound-forming. The musical form –describing a path through the steps of sound modulation– guarantees that structures can be recognised and distinguished. (Ungeheuer [1994: 32])

The reason for my departure from that goal, and to separate the time structure composition from the structural composition of the timbre network, is to emphasise the importance of having a performer actively contributing to the musical structure, leaving him/her with the responsibility of its manipulation and evolution over time. This is possible by considering and implementing a compositional strategy that is intended for the creation of 'initial-states' music.

I consider that an interesting set of relationships for one system (the timbre network and its sound-interdependent variations) does not necessarily have an intrinsic time structure for its development. If we define this development as a piece of music, we must accept the constraint that music is something that occurs over time, and therefore it requires a different set of rules than those used to define fixed relationships. It is my aim that those 'rules' can be understood as the musical contribution of the performers involved in such system. By analogy, what defines a sphere as a recognisable shape is not quite the same as that which defines that shape as a ball. To kick it and see it roll is what gives a ball its identity. To use a sphere as a ball is to respect the geometry of the sphere will imbuing it with additional meaning and function. Likewise, performers approach a musical piece in much the same way as ball-players approach a sphere: with an understanding of how the affordances of their object allows them to achieve goals that are not actually pre-determined by the object.

3.1.1 Composing the network

We can consider that timbre is a multidimensional music parameter. Therefore, it is important as a first step in our network composition to define the behavioural limits of our sound objects/sources (the initial nodes of our network). We can then focus on the inner complexities of these nodes, and show how they can be streamed within the network as either:

- Control information for another fixed node (a thread between two sources)
- Intrinsic richness of the node in itself (still subject to variations through performance)

The elements of a timbre network can be divided into nodes and threads. The nodes are the instruments (or sound sources) that are responsive to the physical control of a human performer. These can be traditional instruments, or electronic sound sources like a computer, or indeed part of a larger computer system. Threads are best understood as the predefined inter-dependencies between each sound object or sound source. They can be seen as placing constraints on the system, yet can also been seen as defining the intrinsic characteristics of the system. Most elements of the sound transformation of a source can be described as a thread, as well as by the translation of changes of the inner characteristics of a source, as induced by a performer, into changes in the sound print of a different source.

A timbre network allows a number of computer systems to act in harmony in a range of alternate configurations. Computers can be used as independent sound sources, with or without the ability of being influenced by a performer; thus a computer system can be seen as both a static or an active node in the network. Computers can also serve as dedicated signal processors for other nodes, or as signal-to-control translators, working as threads between elements of the network. If more than one computer is used within a structure, one computer must assume the role of the 'core' of the network. The core of a timbre network is that place where node characteristics are extracted and transformed into threads (control parameters) for other nodes, and where the initial settings of node/thread relationships can be stored, recalled and modified.

As an illustrative example, imagine that our network consists of three nodes: a violin, a computer-generated percussion instrument (similar to a kalimba or thumb-harp) and a recorded text. The violin will play only open strings, in groups of 1, 2 or 3 strings at the same time, and will play either bowed or plucked. The synthetic thumb-harp's amplitude is controlled by a human performer (via onsets) but, as in the mechanical instrument, the pitches are predefined. Onsets are controlled by the network. The recorded speech is controlled by the changes of the network. Its variables are *speed* and *onset*.

We can define the following threads in this example:

- The number of strings defines the pitches of the thumb-harp
- The changes of excitation in the violin starts/stops the speech
- The onsets in the thumb harp controls the speed of the speech
- The speed of the speech defines the number of strings played
- The onsets of the speech define the pitches of the thumb-harp
- Certain pitches on the thumb-harp determine the changes of excitation mode in the violin

3.2 Practical Implementation: Accumulation of Hesitation

An example of an actual implementation of the timbre network concept is *Accumulation of Hesitation* (AoH), a piece that the author started to compose as a 'Timbre Network in a box'. In this set-up, all nodes and threads are generated in a single system implemented in the *Max/Msp* computational environment, and manipulated by a single performer. A later expansion to the AoH network is a non-input mixer, that serves as an extra source for the network, both as sound and control generator.

3.2.1 Architecture of the system

AoH consists of 5 basic sound sources and 4 kinds of sound manipulation method. Additionally, each sound source is translated within the network into control information to trigger global changes in the initial boundaries of the sound manipulation engines (threads). The pace of these changes within the predefined boundaries of each state is under the control of the performer.

3.2.2 Sound sources: NODES

There are 5 continuous sound sources in the AoH piece: two pre-composed sequences realised in the 'BEA5' analogue studio of the Institute of Sonology in The Hague, two instances of 'GENDYN' (a synthesis algorithm developed by

Iannis Xenakis)[2], and a small analogue mixer modified to generate pulses and clean, near-sinusoidal tones.

The pre-composed sequences are 2-minutes long and based on similar analogue patches to the ones used in my earlier 2005 composition, *Lonquimay.89*[3]. In that piece, fixed timbres were created to be further articulated by a series of behavioural control patches generated in the AC-toolbox environment. The sequences used in AoH each comprise 4 superimposed layers of sounds: tone to pulse, pulse to tone, static tones to silence, and static pulses to silence, each with its own independent rate.

The second group of sound sources (that is, nodes in the timbre network) comprises two instances of 'gendy~', an abstraction of the dynamic stochastic synthesis algorithm developed by Iannis Xenakis and ported into the Max/Msp environment by Peter Pabon at the Sonology Institute of the Royal Conservatory in The Hague, Netherlands (Pabon [2005]).

The third and last sound source in AoH is a small analogue mixer whose audio outputs are connected to its own inputs. This permits the generation of simple pulses and quasi-sinusoidal tones from its internal feedback. Although audible throughout the piece, the main contribution of this last sound source is the provision of continuous control-information threads for the manipulation engines of the other two sources.

3.2.3 Sound manipulation engines: THREADS

Each of the sound sources communicates with the others through a sound manipulation engine that affects its sonic properties directly and which provides control information for the sound manipulation of each of the other sources. An exception to this connection is the external analog mixer that only provides control

2 A note about the GENDYN: created by Iannis Xenakis, the dynamic stochastic synthesis consists of waveforms that can vary continuously according to pre-formalised stochastic function. As noted in (Penov [2006: 2]), "Instead of 'curving' the waveform, Xenakis interpolated the breakpoints (samples) in a linear way. The horizontal and vertical proceeding of the points in the successive cycles is calculated on the basis of a probability formula, causing a kind of stochastic amplitude modulation (vertically) and frequency modulation (horizontally). To control the timbres, Xenakis must determine the range of the variation of points of a cycle, so that the more radical the variation, the noisier the timbre, and vice versa."

3 For more information on *Lonquimay.89* including media samples, please visit www.juanparrac.com

information to the other sources, and does not receive control information from anyone but the performer. The types of sound manipulation are:
- Sound spatialization
- Reverb/freezing
- Pitch Shifting
- Granular synthesis

Additionally, every node has its own set of parameters that are already defined and stored in presets. In the case of the pre-recorded sequences, these parameters are playback speed, playback direction and loop points. For the gendy~ engines (Pabon [2005]), the parameters are:
- Frequency
- Distribution warping
- Jitter mask for period-to-period fundamental frequency variation
- Size of the random number tendency mask for Y-axis variation
- Number of break point samples in the buffer for Y-axis variation
- Time warping factor
- Size of the random number tendency mask for time axis variation
- Number of break point samples in the buffer for time axis variation

The preset changes for every node are triggered during performance in two ways: 1) by means of crossing predetermined threshold-values with any of the sound manipulation engines; or 2) by inducing sudden shifts on those values by means of signals produced by the analogue mixer.

3.2.4 Connecting the network

Each sound source in AoH is connected to two different sound manipulation engines. However, only one of the results is audible. The non-audible result is transformed in control information that continuously modifies one parameter of every other sound manipulation engine. For example, sequence 1a is sent through pitch-shifting and granular synthesis. While the granulated output is audible, the transposed sequence is converted into a numeric value to control:
- Reverb size value (audibly affecting gendy~ 2)
- Sound spatialization, randomly chosen from a list of starting and ending points and time durations of the trajectory (audible in sequence 2b)
- A random mask for grain density (audible on sequence 1a itself)

3.2.5 Performance control

AoH is intended to have a performance-driven compositional structure, so in addition to the internal changes of the system due to the network connections, a performer is required to control the pacing of the overall result and refine the variations of every sound transformation parameter. Additionally, the performer has complete control over the main parameters of a granular synthesis engine (grain pitch, size and density) that is mapped to an external hardware controller.

The development of the piece over time evolves from the performer's manipulation of pre-defined initial settings that are stored for each of the sound sources. This means that rather than having a predetermined sequence of events, the structure of the piece emerges from the choices made by the performer as to when and how elements appear, interact and transform each other. This non-traditional, non-timeline approach to time-structure is justified for the following reasons:

- The character of the sound sources: The common denominator that unites the composition of the pre-recorded sequences, Xenakis' Gendyn and the nature of the no-input mixer sounds is that they each possess a rich inner complexity, yet on a macro-scale they all exhibit a rather static behaviour. The latter quality encourages real-time manipulation by the performer as a means of putting a distinctive personal and artistic stamp on the music.
- The character of a network: For similar systems, where more than one performer is involved, a pre-conceived time structure might be preferred. The intrinsic nature of a timbre network is rather static; that is, it is not so concerned with time evolution as it is with material interconnectivity.
- The character of a performer: This approach emphasises the importance of the performer as a contributor of not only musical expression, but of musical structure.

On a performance level, the goals of a timbre network as a structure are:

- To define the initial sonic limitations and their interconnecting expressive constraints.
- To preserve the original network blueprint during a performance.
- To leave in the hands of the performer(s). the responsibility to expand, pace and control the dynamics of the musical result.

4 The computer as music performer

To this day, the role of the electronic performer is sometimes confused with that of the sound technician behind the mixing desk, who maintains the balance between the electronics and the traditional instrument levels. However, that role requires the technician to be in an ‘ideal’ audience location, far from the stage and far from other performers. A technician may thus require additional cues to follow a specific passage of the electronic part (if it is pre-recorded). In the case of a live processing system, where accurate notation for the traditional performer is less relevant than the exploration of the gestures that the computer system is able to identify and react to, the musicians on stage might need to be cued as to when a particular kind of playing is required. For example, the computer system may require the incoming signal to be without vibrato for a period of time in order to react as expected.

These quasi conductor-like actions, and others more closely related to the ones of a traditional instrumentalist, make up the role of what I call the *computer performer*. Some of the characteristics of this new performer are:

- The capability to resolve a number of technical challenges during a performance, dividing the logistical responsibilities between the performer and the sound engineer.
- The ability to contribute to the music as any instrumentalist with their own sound-print and articulations, so as to be able to interact with other performers in a piece both at the timbre (sound) level and the gestural (control) level.

These individual developments have been greatly enhanced by increased access to computer technology in recent years, which has spawned a new generation of ‘laptop artists’ and other technology-enhanced *computer performers*. Ambitious, gesture-controlled systems include Michel Waisvisz’ ‘hands’ and the ‘LiSa’ system, both developed at the STEIM institute in Amsterdam, and Atau Tanaka’s, ‘BioSensors’ system. The undeniable contribution of these new artists/creators, immersed in finding new ways of controlling complex electronic music systems in a performance situation, begs one final question: Is it possible to divide up the role of the composer and that of the performer when creating and using these complex systems?

The quest for beauty in electronic music forces us to generate first as composers an imaginary cosmogony of sound elements and later, to justify – by means of creative structuring – how this cosmogony works, mutates and exposes a musical meaning. The computer performer faces similar challenges. In a way, the alchemical role often connected to the work of a composer or to extremely innovative improvisers (sometimes dubbed 'real time composers') must be adopted by this new interpreter to create not only the instrument that he or she will perform on, with its possibilities and limitations, but also to generate a consistent set of performance skills that will allow a creative interaction with composers and fellow music interpreters.

Having succeeded in this, the next step is to collaborate with composers on the design of software and hardware musical instruments that respond directly to the demands of the sound qualities and creative constraints that a particular piece or set of compositions requires. This in turn requires further research into the status quo, to avoid re-inventing already efficient tools that can be re-utilised. It also requires a renewed focus on the development of new general purpose tools in less explored areas like real time convolution. At the same time, researchers should be encouraged to produce dedicated practical implementations, in the form of software instruments and physical controllers for particular projects.

We can then propose new means of production and performance with new electronic voices like Timbre Networks, where musical aspects such as material exchange, gestures, interlocking and layer density control both challenge and give the interpretative freedom that this new performer should demand: a kind of music that sees the electronic media as a musical source capable of standing on its own.

5 Conclusion: A journey, and a point of departure

It is now almost a given that contemporary composers think of electronic media (which is to say, synthetically produced sounds or systems for real time processing) as a potential source of rich and complex timbre contributions to their creative palette. An equal truth is that composers think of a traditional instrument and its performer as an indivisible entity. But for the same composers to think of electronic media as material to be enriched by nuances of personality, pacing and intention, in short, the interpretative musicianship of a human performer, it is necessary to formulate a strategy from both ends. For example, we need to find a set of organisational rules that determines the intention and the extent of the interpretative influence on the material, and to identify efficient and artistically meaningful ways of delivering this control in a performance situation.

This does not mean that composers should think of electronic media as 'traditional' instruments, no more than an electronic performer should aim to emulate the gestures and other conventions of performance that are a product of hundreds of years of musical tradition. By revisiting some positive constraints of traditional instruments and performance, one can instead aim for a productive and mutually enriching interaction between composers and interpreters of electronic media.

One possibility is to simply divide these roles. As it is now, composers perform the electronic parts of their own pieces, chiefly because they are most familiar with the piece. Since we are far from reaching a consensual standard on the electronics front – not only with regard to the tools used, but also with regard to parameter descriptions – the effort of defining a meaningful notation that will deliver enough information to the potential interpreter can be bypassed if composers perform their own electronic pieces. The price to pay, of course, is that these pieces can only be performed by their composers, thereby limiting the dissemination of their music. In response, some composers have adopted the approach of creating event-based scores and self-contained computer applications that can be performed by a technician. While this approach solves the dissemination issue, the contribution of the electronic part to the overall piece in a concert is really not that far removed from that of a traditional pre-recorded tape.

Yet perhaps the greatest benefit of being able to divide this role is to regain the collaborative potential of music. After all, it is through this interaction that music has continuously evolved through history, by expanding the sound palette of instruments through the development and formalisation of extended techniques, and by combining the personal backgrounds of particular performers with the structural ideas of the composers. But skill development and focused understanding is only reached if we are able to reintegrate these separate roles. As pointed out by Veale, Feyaerts & Forceville (this volume):

> Creative duality is *concise* duality, in which a plurality of meanings or functions is achieved not by simple addition, but by fusion and compression.

Once we succeed in dividing and fully developing these roles, we can move forward to our final goal: to re-combine the roles of composer, performer and instrument maker in a productive blend with new, emergent properties. In effect, we aim to create a new, multi-threaded role in the guise of the computer musician, in whom the creative singularities of different aspects of musical practice will intertwine and fuse together. The limits of individual roles as we understand them today will be thoroughly blurred, allowing us to discover new and emergent pathways to creative musical performance. By using computers, and timbre networks in particular, to dis-integrate and creatively re-integrate our conception of what it is to be a musical performer, we aim to recover, for practitioners and audiences alike, the fragility, surprise and unexpectedness that presenting music on stage is all about.

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