This is not a C♯: What My Computer Means

DANIEL IGLESIA

Columbia University Computer Music Center, 632 West 125th Street, New York, NY 10027 USA
E-mail: dei2101@columbia.edu

Computers contain layers of abstraction between the raw audio bits and the user experience; each layer requires a method of traversal that reflects the attitudes of the programmer/composer/performer. The navigation of this hierarchy results in modes of thought that affect notions of how musical signifiers can be subverted and redefined. This explosion of individualistic technological systems defines meaning for new sonic results, devoid of traditional communicative signs; the manipulations within these systems directly assail the traditional signification of artistic value and of institutional canonisation. A few pieces and scenarios are presented as examples. Additionally presented are two opposing tendencies (with some empirical manifestations) in the creation of live performances systems, here labelled as extensional and algorithmic. The article posits that a performance system cannot amplify human expression without necessarily having either predefined processes or predefined limitations, and that the choice in this design is reflected in the composer's attitude towards layer-traversal.

1. INTRODUCTION

Here is a simple exercise in remapping, done trivially by computer (and easily accomplished by hand). Each of the twelve tones of an octave is randomly mapped to another tone, in a one-to-one correspondence. Now, any note played into this system emerges as its replacement. Figures 1–4, on a familiar and oft-employed tune, are the original and three sets of randomised remapping.

Traditional harmonies are most likely obliterated, and, with them, the expectation for the functional chords that define tonal music. Enthusiasts of tonal music (or of other hierarchical traditions leery of indeterminacy) will probably state that these reorderings have no meaning, as they are not parsable into recognisable structural systems. Yet I have deliberately chosen this particular source piece for two reasons: it establishes a tonal firmness by repetition, and it defines simple chordal relations by keeping similar notes in common between chord changes. Because of these qualities, one can grasp the formation of new musical patterns quickly, even if they are severely abstracted from tonal practice. The degree of volatility (i.e. the perceived distance from traditional tonality) within each phrase changes from phrase to phrase; the arpeggios may sound close to a traditional tonally functional chord, or they may sound like an atonal collection devoid of voice-leading properties. Once built, the reassignments are controllable in real time. One can create new random mappings mid-performance, or create several beforehand and select those judged interesting for use in performance. With an array of many mappings, they could be arranged by perceived distance from tonal intelligibility; once so arranged, this array of templates is assignable to a knob, allowing a performer to, in real time, easily 'dial in' a particular degree of tonal intelligibility without concern over the precise content of the template. With a turn of a knob, then, one is able to continually redefine the strength of the bond between the structural harmonic foundation and the notes sounded.

This instantaneous speed with which a computer can reassign or reformat data within dynamic hierarchies suits it perfectly as a tool to shift, subvert or reimagine many similar categories of musical relationships. Where traditional musical signification ends, however, the vacuum is newly filled by the nature of the technological means; this concept of composition is therefore based not only upon knowledge of the layers of abstraction and interactions within digital sound, but also upon the particular attitudes towards their navigation.

2. REFASHIONING MUSICAL SYSTEMS

2.1. Computer architecture as shared practice

Before the recent technological past, a composer's source materials were generally divided between intelligible concrete sounds and the melodious abstractions of notes and pitches from which concert music was built. Before the technical power to meld the qualities of these two types, a sound was either a concrete signifier of a real object or event, or an abstract sign with a historically defined signified. The subjectivity of these musical/aural elements becomes all the more extreme when the music's surface sounds or structural frameworks are at all nontraditional, deliberately obscured, or otherwise experimental. Many experimental composers became specifically famous through defining a musical meaning for previously unincorporated

Organised Sound **13**(3): 217–224 © 2008 Cambridge University Press. Printed in the United Kingdom. doi: 10.1017/S1355771808000319

https://doi.org/10.1017/S1355771808000319 Published online by Cambridge University Press

elements: silence, noise, feedback, concrete sounds, unpolished vocals, and so on. To a listener unaware of the conceptual underpinnings of each of these elements, they may not, however, point to their intended referent, but instead to the general constellation of signs that define the experimental tradition; in other words, for some, silence may 'correctly' refer to the specifics of Cage's compositional philosophy, where for (many) others, it refers only to the general class 'experimental' or 'uncategorisable'.

The synthetic power of a computer makes this task of musical incorporation even more demanding. Instead of, as before, defining the musical value of naturally occurring but 'non-musical' sound, a computer generates new, never-before-heard sounds devoid of both concrete *and* cultural reference. How then does one attempt to assign meaning? The same way as every other artistic practice looking to define a new set of symbols: by examining similar practices and defining goals retrospectively. Yet if a stylistic cohesion is necessary for a unified (and publicly understandable) signification to blossom, then the multiplicity of electroacoustic music styles renders this task virtually impossible. Yet, no matter its aesthetic diversity, the domain of digital music has just this sort of unified foundation of set definitions and limitations built within the very history of its development: the common construction, outside of any aesthetic concerns, of the layers of abstraction of computational power. This historical and technical commonality has done more than any musical/aesthetic theorisation to define the conceptual content of an electronically generated sound.

At the very start, the elements of computer music were most referential of their own mechanical properties: the most basic element, the square wave, is made by turning one bit on and off. Every advance in digital audio technology has added a distance between our user concept of sound manipulation and the actual operation of raw bits. Ones and zeroes have been abstracted to machine code through the RISC architecture, opcodes and assembly language, which have been abstracted to text programming languages through interpreters and compilers, and onwards to graphical user interfaces, physical interfaces, and so forth. The creation and traversal of these layers of abstraction is itself the history of computer evolution, and, with it, the history of techniques for making and controlling computer sound. Atkinson's thorough overview of extant semiotic approaches to electronic music (Atkinson 2007) reveals attempts to incorporate elements outside 'the work', including perhaps most interestingly the musicological notion of topics within a tradition (i.e. *Sturm und Drang*, the hunt, etc. within classical music); yet missing there is an account of topics within electronic music that foregrounds their very means of production – the traversal from idea to code to bits to sound. Cascone (2000) defines a specific technological topic within a strain of electronic music: failure, here realised as a focus (and valuation as musical process and content) on the imperfections of digital audio (quantisation noise,



Figure 1. Original.



Figure 2. Random remapping #1.



Figure 3. Random remapping #2.



Figure 4. Random remapping #3.

https://doi.org/10.1017/S1355771808000319 Published online by Cambridge University Press

clicks, errors, misread data, etc.). Few writings have delved into the practical implications of low-level computer design, a most notable exception being several of Kittler's essays (Kittler 1997a, 1997b, 1997c); he celebrates (along with computer programmers and some artists) electronic technology's transparency from idea to result: 'Whoever manages to hear the circuit diagram itself in the synthesiser sounds of the compact disc, or to see the circuit diagram in the laser storm of the discotheque, finds happiness itself' (Kittler 1997a: 30). Yet he sees within the evolution in microprocessor design (i.e. the creation of instruction sets to guide ever-higher levels of abstraction away from the chip's functioning, especially regarding the then-developing concepts of multitasking and privilege levels) a specific reflection of bureaucratic obfuscation: 'What remains a problem is only recognising these layers which, like modern media technologies in general, have been explicitly contrived to evade perception' (Kittler 1997b: 148). It seems unfair to hold microprocessor language to the same level of transparency as human language; yet regardless of its difficulty, literacy in these low-level layers is inscribed both in computer science curricula, and in the practice of many electronic musicians.

Navigating between precisely these same layers of abstraction has led to the staggering breadth of techniques for digital audio. It therefore becomes more and more useless to attempt to create a standardised curriculum of computer-music techniques, since the possible paths towards a sonic result grow exponentially as we add layers of abstraction. Yet the proposed existence of a curriculum, or of a standardised family of techniques, is one of the few remaining signifiers of institutional value, and so institutions and genres have codified and 'claimed' particular sets of techniques, as a generalised pillar of one's own particular tradition. Ask a musician what computer software he or she uses, and the answer usually implies the musical tradition in which he or she participates, or from which he or she developed. Each piece of software places itself at a particular location along the spectrum of degrees of computational abstraction; on the lower end are both general-purpose and music-oriented text programming languages, in the middle are graphical programming environments, and at the high end are fully formed applications for a specific use. This is not to portray different classes of musicians as narrow-minded, but quite the opposite: in most cases, people decide what kind of music they want to make, then decide to what level of computer abstraction and power do they wish to delve (with drastically differing learning curves), and eventually find a software that serves that method and level of creation. The shortcoming is in the promulgation of this knowledge, when, under the guise of general electronic music techniques, a student instead receives a specified methodology aimed at a particular aesthetic.

Fortunately, between even unsympathetic musical traditions occasionally appears a seemingly implicit agreement: that creative work should preferably take place at lower levels of abstraction (rather than those of preshaped high-level applications) in order to create new and individualised musical systems (Dorin 2001). High-level abstractions within commercial software, since usually created for wide use, are built upon the assumptions of pre-existing relationships. It is ironic, then, that computers, early in their development as tools for musical composition and creation, were exclusively lauded as rational, structural tools (which they are by nature, though not necessarily exclusively so in artistic practice) to make a rational, structural music (ignoring the power to expand upon any musical norm, in favour of solidifying the codification of post-serial methods). Yet as computer power (and public access) grew, so did its ability to destabilise traditional relationships by allowing users to reassign relationships across familiar boundaries, even improvisationally and in real time.

2.2. Defining sound through means

Traditionally, one hits a piano key and gets a note. Now, one also hits a MIDI controller key and gets an abstraction of the qualities of that note (pitch, loudness, duration) that can translate to any type of result: any number of synthetic notes, triggering samples, control of a predefined process, painting a colour on a screen, turning on a light bulb, checking the stock market or your e-mail or GoogleMaps, flipping a TV channel, and so on. Even with a fixed 'musical' input format, data remains data, devoid of the implications of its realisation into a medium, and capable of transformation into any other code. The potential results from a particular input are now just as broad as the set of potential inputs: this exponential opening of musical means adds a new maze of decisions to be made regarding the allegiance towards, ignorance of, or rebellion against pre-existing causes and effects. A simple example introduced this paper; here follow others.

Ikue Mori has built a gripping performance practice upon the imaginative use of samplers. Traditionally, the listener could expect the same stimulus to give us the same sonic result. By constantly swerving through sound banks while keeping other sequence parameters consistent, Mori eliminates that cognitive obligation. In several pieces from the albums *Hex Kitchen* and *Labyrinth*, for example, Mori plays, over a steady tempo, a series of additive and subtractive patterns in the MIDI domain; the rate of change of the of the patterns, however, happens at a slower rate than the reassignment of the performance data to different samples. Given the repetitions of each cell, the underlying patterns remain recognisable even as their sonic results change (impressive, given that the different samples contain widely differing pitch, timbre, and

https://doi.org/10.1017/S1355771808000319 Published online by Cambridge University Press

volume envelope information). The process here is very similar, then, to the transformations of the Bach, in which shifting, unexpected remappings are made coherent by repetition and by the continual similarities between each cell.

Compare the example of Mori's works with a mental exercise in real-time digital signal processing: taking an audio input as the root of a tree (in the computer science concept of the word), we can chart out a signal processing chain made up of nodes and branches, showing processes that occur in series and in parallel, with leaves that show the resultant audio. Imagine we have a DSP system with an input (microphone), an output (speakers), and four sound-processing modules (echo, transposition, etc.). We can hook up these elements into any configuration, and we can represent any configuration of these elements by a 5×5 two-state matrix: 2^25 = over 33 million possible states of this system (however, a large percentage of these states will not be 'legal': they may not have a connection from the input or to the output, or they may have internal loops that will overload the system with feedback). The point of all this number crunching is not to serve any type of quantitative analysis, but to ask a qualitative question. In a simple configuration, such as microphone to echo to output, we can envision what the result will sound like, even without hearing an empirical demonstration: it will obviously sound like audio with a series of echoes on it. Inversely, one may hear the resulting sound of this system and be able to mentally draw the processing chain as a sound with added echoes. This routing is a system with a strong and simple conceptual intelligibility that occurs outside of the nature of the source sound. Yet as we create more complex processing chains, our ability both to envision a sonic result and to mentally reverse-engineer a processing chain quickly diminishes. Given how streams cross, interrupt one another, and reach the output at different stages, it is unlikely that we can conceptualise the result before hearing it, and, inversely, virtually impossible for us to hear the result and create this chain mentally. Is the conceptual intelligibility of this sound system therefore lost? Similarly, at what point does a processing chain surpass the limit of aural definability and become sonic goop? Is it when the original sound is obliterated, or when we cannot linguistically define what we are hearing? Given the ability to modulate the parameters of each module, and to use new processing matrices mid-sound, it seems as if we may lose this conceptual intelligibility very quickly.

This may explain why musical works based on heavy signal processing (one of the most abstract aesthetic outputs possible in any art), which may not have any pre-existing referential basis (i.e., have deliberately scrambled the indexical nature of their source sounds), are easily dismissed by extant compositional schools of thought. Kane's analysis of Pierre Schaeffer's phenomenological model of acousmatic listening elaborates on Schaeffer's desire to eliminate the indexical source of a sound as its content: 'A sound object is only possible when a sound no longer functions for-another as a *medium* (as in the case of indicative and communicative signs), but rather is perceived *immediately* in itself' (Kane 2007: 18). Updating this view from *musique concrète* to digital processing, a composer must decide if the sound's technological manipulation is itself indexical of digital technology (and therefore equivalent to the type of real-world reference Schaeffer hopes to avoid); *or* if, though integrated with the resulting sound's technological-causal origins, the distinctiveness of the technological system nevertheless contributes to signification since it is itself *invented* by the composer in the process of defining the piece.

The preceding examples show how common computer-music techniques assault the artificial interdependence of form and content: specifics of the content (i.e. the source sound, or Mori's sample banks) are easily interchangeable, while the aims of the system are left intact. The notion of interrelatedness between form and content of course remains strong in many compositional aesthetics where the form of the piece is intrinsically linked to properties of a pre-selected source (whether a real-world sound, a system of tonality or atonality, etc). For these aesthetics, the computer remains mostly only an analytical tool (or a high-powered coin-flipper); it may, for example, tease out the parameters of a source sound and quantise it to musical notation, or generate fragments within a tonal/atonal system, or make decisions regarding the syntax of the piece. The use of a computer here (unlike the many musical uses of the computer at large) does not alter any pre-existing relations; it cements traditional systems while remaining easily linguistically ratified. This ignores Schaeffer's considerations by explicitly casting the empirical qualities of a source sound towards the result, rather than manipulating a sound's phenomenological characteristics in a perceptual realm.

2.3. Tropes, metadata, legitimacy

The sudden onset (and wide distribution) of manipulative power has led to whole musical genres more rapidly devolving into their own simulacra, each ultimately only referencing itself and the conventions of juxtapositions/manipulations/etc. it has created. Examples that spring to mind include the thoughtless intercultural layerings of western-produced 'world music', and the over-reliance on sampling by contemporary pop music used to induce nostalgia. Given the aesthetic congealment of many basic electronic music techniques, electronic music is certainly rife with tropes worth identifying and tearing down, as done in Mark Appelbaum's multi-channel tape piece *Pre-Composition*. The piece consists of multiple interior-monologue

https://doi.org/10.1017/S1355771808000319 Published online by Cambridge University Press

streams of Appelbaum's voice discussing and debating the construction of a tape piece out of familiar tropes. To an electronic composer, it is a very smart and cutting satire: the very mark of an individual's voice is turned into a plethora of distinct simultaneous streams of the voice that characterise themselves by placement in multi-channel space, and the aural discussion of tropes occurs simultaneously with their vocalised exhibition. As witty as the piece is, it is stuck with satire's basic paradox of simultaneously defacing a convention while upholding it as the norm. Appelbaum obviously hopes to educate me against clichés, yet one can't help but wonder if he is also cementing their legitimacy.

This ubiquitous concern with legitimisation leads to a family of musical relationships affected by digitisation: the relationship between music and signifiers of artistic value. A piece of electronic music often warrants very little metadata: there are no orchestras or conductors to recognise, no publishing or recording history to document. Unless commissioned for credentialled high-art institutions, there may not be a performance history or professional practice to define. The usual theoretical explanations may be omitted, especially if a composer does not wish to share the details of a piece's construction, either conceptually or technologically. The attachment to institutions is further reduced by the explosion of personal computing and home music production: a fine computer usually costs less than a quality acoustic instrument, putting the means of electronic music production in the hands of anyone with a modicum of money and technical knowledge. The Internet has of course transformed the means of collaboration, promotion and distribution of music, which now flows outside previous arbiters of both high and mass culture (and occasionally creates new legitimating institutions of its own). Heard only through home speakers, the music loses the implication of venue or social setting. And as files are swapped around the virtual ether, the attached core metadata of title and composer are easily lost, rendering a piece of audio absent of any clue towards its significance: a truly terrifying prospect for any style of music requiring external institutional legitimisation … which, cynics may claim, is any music aspiring to the traditional definition of art.

And so a composer may cling to elaborate acoustic instrumentation and virtuosity as a last measure of differentiation. An instrumentalist performing acoustic music of virtuosic complexity is a display of wealth. And when the difficult instrumental effects evoke a sound easily realisable by electronic means, the scenario takes on a distinct pallor of conspicuous consumption. In a similar defence mechanism, the type of segregation originally used to create racial and cultural divisions (such as the notion that western Europeans create a universal art whereas other cultures' musics are bounded by particulars) are increasingly re-applied to genres of electronic music: an excellent electronic composer (or even entire genre) denied legitimacy based upon the tradition (popular or dance music, performance or visual art, etc.) from which either he or his music emerged. Fortunately, the prevalence of institutional critique has created a self-consciousness within institutions who wish to avoid stagnancy; and so, it has become more acceptable to laud some electronic music figures with roots or influences in the pop world (e.g. Eno, Autechre, Matmos).

While this newfound liberalism is of obvious benefit to art music's horizons, it contains another institutional defence mechanism within its historiography or analysis of popular electronic forms. The musicological focus on contemporary music (both popular and 'serious') comes with an inherent taxonomic impulse that requires attempts at the immediate (and inherently hindsight-less) identification, fixation and codification. This analysis does not assume the current state of a musical style as a particular point along a trajectory, but instead fixes it as an archetype, which is subsequently easily shelved as a dead end or as an ultimate result of a practice that has exhausted itself. As soon as a genre shows a small amount of aesthetic repetition, these recurrences become fixed as tropes that define the genre and mark it as being 'over' (instead of merely approaching a point of shared practice). The experimentalist need to make every piece conceptually original furthers this type of acceleration, with whole potential subgenres or styles reduced to single pieces that exemplify an idea. This manner of categorisation only further solidifies the 'universal' position of self-defined high-art electronic music, while outsiders produce a 'folk' music once again bounded by particulars.

Admittedly, electronic genres (both experimental and popular) have a faster turnover rate regarding what sounds dated. This is not merely due to the progression of technology (given that analogue devices and other historical methods remain popular), but of a whole particular sonic aesthetic sounding dated (only to be rediscovered, or cannibalised, years later). Much popular electronic music is on the forward edge of consumer-available processor power, but still on the tail edge of using non-standardised software systems. Fortunately, those groups or performers who display technical skill or ingenuity in the creations of new systems are often those who become recognised. They display not only skilled use of new technology, but also a conceptual play and imaginative use of familiar technology that places them close to the experimental tradition. Of course, outright borrowing of old experimental tricks, repackaged as groundbreaking to a new unfamiliar audience, is common. But the affiliation with experimentalism is often at a much broader level, such as affinities for indeterminacy, live performance, and music where the result is not known beforehand; these

https://doi.org/10.1017/S1355771808000319 Published online by Cambridge University Press

qualities are often lauded in acts that become known for live improvisational performances.

While popular electronic music remains mostly self-copying, a worthwhile artistic item is occasionally promoted to the mainstream due to the music industry's desire to overfeed every nascent popular subgenre. The increased fragmentation of popular music traditions has led record companies to mine and evaluate alternative musical sources in ways previously unimaginable; for business, the Internet is a problem, as songs can become popular and profitable without production/publication/promotional costs or middlemen. Witness the explosion of acts discovered (and made famous) on the Internet, having never even publicly performed. This business desire to capitalise on every trend contributes to the most ingenious (even if accidental) institutional protection yet: the commodification of dissent. Now, every social or artistic movement is sapped of any transgressive potential: a message cannot threaten the status quo if the status quo absorbs the message and repackages it for sale. This has affected 'serious' music criticism as well. The 'rugged American individualism' cited as the foundation for Thoreau, Ives, Cage, and so forth has by now inversely hurt the possibility for individualism by making a simulacrum of transgression commercially (and artistically) ubiquitous, and therefore dismissible as infantile (or merely overdone). The notion of a common vanguard of aesthetic transgression is effectively destroyed; what is selectively dismissible effectively becomes selectively ignored or accepted based only on its usefulness to further a particular group's critical purpose.

2.4. Limitation == craft?

Limitations define musical traditions: the numbers of fingers we have, the number of tracks we can record, the historical structural systems (harmony, counterpoint, etc.), native/national traditions, the need to be either popular or institutionally supported in order to survive, or the computational power necessary to realise a sound. Let us hypothesise that we no longer have any of these aesthetic or technical limitations; admittedly, we still have the same number of fingers, though we can possibly count machines as an extension of physicality, so that the *physiological* limit of control may now perhaps be some sum of mental speed combined with total physical acuity. While we are certainly nowhere near at the end of useful digital audio research and experimentation, the canvas of technological possibilities appears sufficiently vast as to reduce the tendency and necessity of developmental-technology experimentation; that is, pieces created solely to illustrate a new technology. Artists take new technological developments as a challenge, or feel an onus to explore their artistic use; yet a common contemporary focus seems to sway further away from cutting-edge developmental technologies, and towards the inventive refashioning of more common electronics. Is this because advances in technology are more and more out of the reach of a normal user/artist? Or is it also because the exponentially increasing aesthetic possibilities are more and more devoid of the type of limitations that endow a work with 'craft' or the potential for a common practice? A desire for the latter seems evident in the growth of low-level/DIY technological art: a practice focused on building hardware out of simple electronic components, often harvested freely from the technological detritus of a cutting-edge-obsessed culture. Here, the nature of limitations and of individual skill and 'craft' is very evident. This inversion of notions of progress, with artists using cheap, common materials as elements of an art music, and focusing on the use of basic systems over complexity and multiple layers of abstraction, certainly seems historically familiar: is low-bit-rate music the remaining strand of minimalism?

3. MANIFESTATION IN LIVE PERFORMANCE SYSTEMS

3.1. Two contrasting aims

Part 2 of this paper discussed a few musical and extra-musical relationships that electronic music reimagines through the navigation of technological layers. The focus here is on the application of these decisions to the design of a live performance system; programming, composition and performance are here considered as an essentially unified act. In listening to laptop performers[1] (and, more usefully, discussing the design of their equipment and software), the enmeshed man-machine system often reveals its creator's particular attitude towards the relationship of human performance, computer control, and the resultant sound. These attitudes tend to be on a spectrum between two tendencies, which, for ease of reference, are naively defined (using two terms already laden with semantic baggage) as extensional (using specific physical interfaces to gesturally control moment-to-moment sound parameters, often associated with a belief that computational power amplifies human expressivity) and algorithmic (harnessing pre-designed rule-based autonomous procedures to generate material or control parameters, associated with an interest in process, chance and artificial intelligence). Philosophically, the former reflects McLuhan's view of technology as an extension of man's physicality (McLuhan 2003), while the latter reflects Kittler's view of technology as an autonomous force; these two poles also have a pleasantly poetic correlation to the classic definitions of Dionysian (immersed, intuitive, irrational, sensual)

[1]My primary frame of reference is the live media performance scenes in New York City, combined secondarily with experiences in international festivals (both academic and non-academic).

https://doi.org/10.1017/S1355771808000319 Published online by Cambridge University Press

and Apollonian (detached, self-aware, rational, philosophical). Both approaches have their criticisms; for example, that the extensional model merely turns a powerful machine into a crude reapplication of an acoustic instrument, or that the algorithmic model is merely 'a kind of ''generative tape recorder''' (Grossman 2008: 10). While these models are not necessarily allied with particular aesthetics or genres, some general historical associations seem evident: algorithmic tendencies are ingrained in serialism, minimalism, many strands of experimentalism, and many technologically interested arts; these can value generative processes, the reliance upon or amplification of chance or chaos, and other removals or denials of human creativity. The extensional outlook is associated with nearly all instrumental traditions, especially those that value improvisation; in its manifestation in laptop performance, there is a desire for tangible instrumentness, for 'natural' interfaces between human and computer (a rather imaginary concept, that of a 'natural' interaction with a machine).

When positioning a particular performance system among these poles, there is a difference between placing weight on the aural result, versus on the ideology of the musician, or versus the nature of the composed technological system. This last element is of primary importance, especially since with it comes implications regarding the first two criteria. The specifically contemporary difficulty arises when technological systems themselves (and not just a fixed notated or aural result) require treatment as a 'work'; the already unstable concept of a musical 'work' has perhaps slowed the incorporation of technological considerations. Goehr's analysis of the musical work-concept mentions computers only once, and only as filling just two limited roles: 'determining the identity of aleatoric music', and a reference to a 1937 treatise imagining that 'with electronic equipment, one could create music of fixed values that would be unalterable in successive performances' (Goehr 1992: 32).

Many individual pieces are drawn towards one pole or another, while some pieces exist as a synthesis of the two: for example, computer-assisted improvisational systems, such as George Lewis' *Voyager* performance system (Lewis 1999). Others, such as Nick Didkovsky's *Zero Waste* are delightfully ambiguous:

> *Zero Waste* is a duo for pianist Kathleen Supové and computer, which challenges the live performer to both create and sight-read a new piece on the spot. The computer displays two measures of software-generated music in common music notation. Once Kathleen begins playing, the software begins to transcribe her performance into the score. The performer in turn, 'sight reads' this score. As the performer continues to sight read and play, the computer continues to listen and notate, creating an interactive synergy where performance errors and expressive deviations lead to new musical worlds. Over time the challenge of sight reading and the limits of music notation evolve the piece into something very different than how it began. (Didkovsky 2002)

Played by a skilled pianist, the piece is an engrossing evolution of the friction between the capabilities of machine and human. Yet, by amplifying and exposing human imprecision, does it mock it or celebrate it? This particular evaluation of imprecision seems to comment upon the impossibility of human control. Here, a composed technological system deflects attempts at management, refashioning a human-centered (rather

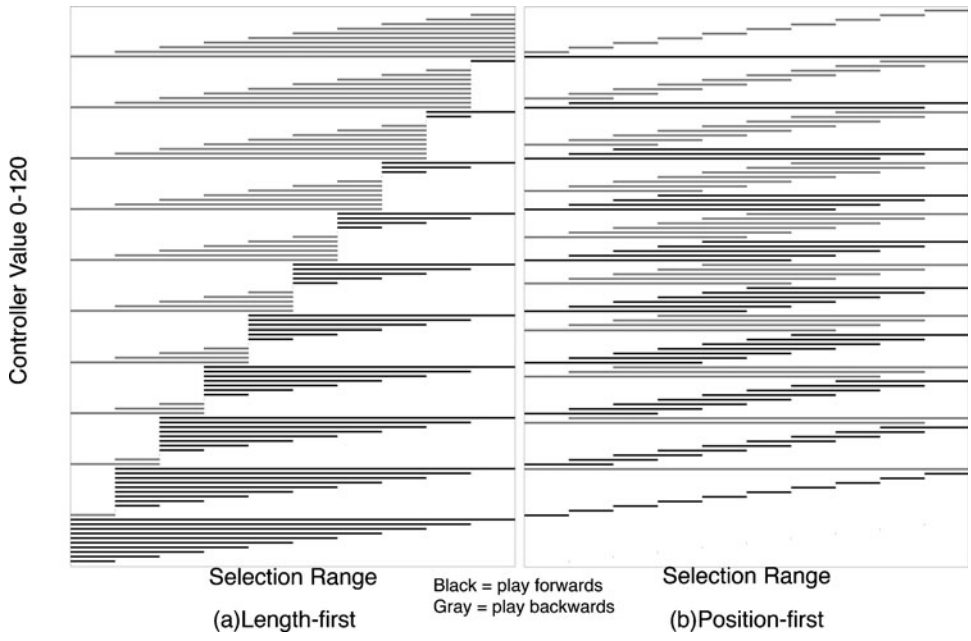


Figure 5. Mapping one-dimensional input to two-dimensional output.

https://doi.org/10.1017/S1355771808000319 Published online by Cambridge University Press

than technologically centered) notion of the aesthetics of failure.

3.2. Judging meaningful performance data

The creation of a rich and dynamic sound on a computer in real time involves the management of many variables. We cannot physically control all variables in real time, so (especially in the algorithmic model) many control tasks are assigned to deterministic or randomised processes, so that when a parameter changes there will be a lower-level relegation of control information. *We cannot, however, add meaningful data*: the resolution of the input (controller data, physical precision, etc.) cannot be 'up-sampled' to a higher-resolution output. We can, for example, extrapolate simple gestures into more interesting behaviours; but at some point, if we rely on automatic modulation or stochastic/chance operations for the definition of low-level parameters, the difference between our input and output will be reducible to noise.

Here is a practical exercise illustrating this notion of information resolution: I want to control two parameters (the start and end points of a looping sample), yet I do not want to devote two knobs to the task. I only wish to devote one knob (values 0–127) to this task. So instead of having two knobs (and 128^2 possible definitions), I now have only 128 possibilities, which correlates to the set of possible loop points comprising 11 possible start and stop points (figure 5).

I can implement them in a length-first (a) or position-first (b) manner. So, with one knob, instead of moderately fine control over one parameter, I have crude control over two parameters. In terms of the precision or resolution of controlled information, I cannot gain or lose. Yet in user-defined terms of control, have I gained or lost? Is sacrificing depth of control for breadth of control a similarly zero-sum proposition? Your answer to this question may depend on the aesthetic of the piece – that is, the degree to which fine control is necessary for the 'success' of the result, and to which data loss equals aesthetic failure. In short, the choice depends upon a personal evaluation between the extensional or the algorithmic.

3.3. Implications

Ironically, the extensional desire to amplify human expression seems necessarily to contain an algorithmic stance, since it entails the belief that human musical creation can be modelled and reduced (without data loss) to a system of logical conditions and mappings. So is the information bandwidth between human and machine physically limited? If so, how can a computer become a tool of expression with a greater (real-time) expressive power than that of a traditional instrument? The only solutions so far are to have certain system elements either pre-scripted or controlled on the fly by automated or predefined processes. Yet these elements are still, precomposed, even if only loosely; what a paradox that in order to increase the extensional/expressionistic range of the result, we must resort to algorithmic means.

REFERENCES

Atkinson, S. 2007. Interpretation and Musical Signification in Acousmatic Listening. *Organised Sound* **12**(2): 113–22.

Cascone, K. 2000. The Aesthetics of Failure: 'Post-Digital' Tendencies in Contemporary Computer Music. *Computer Music Journal* **24**(4): 12–18.

Didkovsky, N. 2002. *Zero Waste* for sight-reading pianist and transcription/notation software. http://www.punosmusic.com/pages/zerowaste/index.html.

Dorin, A. 2001. Generative Processes and the Electronic Arts. *Organised Sound* **6**(1): 47–53.

Goehr, L. 1992. *The Imaginary Museum of Musical Works*. Oxford: Oxford University Press.

Grossman, R. 2008. The Tip of the Iceberg: Laptop Music and the Information-technological Transformation of Music. *Organised Sound* **13**(1): 5–11.

Kane, B. 2007. *L'Objet sonore maintenant:* Pierre Schaeffer, Sound Objects and the Phenomenological Reduction. *Organised Sound* **12**(1): 15–24.

Kittler, F. 1997a [1985]. Gramophone, Film, Typewriter (preface). In J. Johnson (ed.) *Literature, Media, Information Systems: Essays*. Amsterdam: GB Arts International.

Kittler, F. 1997b [1989]. There is No Software. In J. Johnson (ed.) *Literature, Media, Information Systems: Essays*. Amsterdam: GB Arts International.

Kittler, F. 1997c [1993]. Protected Mode. In J. Johnson (ed.) *Literature, Media, Information Systems: Essays*. Amsterdam: GB Arts International.

Lewis, G. 1999. Interacting with Latter-Day Musical Automata. *Contemporary Music Review* **18**(3): 99–112.

McLuhan, M. 2003. *Understanding Media*. Corte Madera, CA: Gingko Press.

DISCOGRAPHY

Appelbaum, M. 2004. *Pre-Composition*. On *Intellectual Property*. Saint Paul – ACF/Innova CD 602.

Didkovsky, N. 2002. *Zero Waste*. http://www.punosmusic.com/pages/zerowaste/index.html.

Mori, I. 1995. *Hex Kitchen*. New York-Tzadik TZ-7201.

Mori, I. 2001. *Labyrinth*. New York – Tzadik TZ-7068.

https://doi.org/10.1017/S1355771808000319 Published online by Cambridge University Press