FFT ANALYSIS AS A CREATIVE TOOL IN LIVE PERFORMANCE

Dr. Michael Young and Sebastian Lexer

Music Department, Goldsmiths College, University of London, UK
m.young@gold.ac.uk Sebastian@lexers.freeserve.co.uk

ABSTRACT

This paper describes the use of real time spectral analysis to enhance the creative opportunities in improvised live electronics/instrumental performance. FFT analysis allows musicians to observe in performance a visual representation of the spectrum, displaying the spectral characteristics of audio resulting from performance activity and/or computer processing. These characteristics can then be explored during performance, assigning areas of special interest within the spectrum to parameters which in turn control (or at least influence) electronic processing. This creates an effective, easily manipulated but potentially highly complex performance environment, encouraging further interaction between improvising performers, and allowing subtle and complex links to emerge between the timbral features of actual music (result) and the act of performance (cause). We hope to increase awareness of the performance-specific potential of familiar analytical tools, of which FFT is one example, and their unfulfilled creative potential.

1. PERFORMANCE MODEL

1.1. Musical Context

Our approach has been developed in the context of free instrumental improvisation. In this setting only the most broad compositional criteria might be agreed upon in advance; rather, the creative impetus and close listening skills of each player is fully integrated into the performance and its musical product. This environment is extended through the use of computer-based live electronics which augments the role of performers, some of whom may interface directly with the computer during performance, and drastically extends the timbral possibilities of the available resources. Concerns for gesture, texture and especially timbre, tend to take precedence over the traditional assumptions such as the musical 'note', equal temperament, rhythm, metre and so forth. Historically, the piano has provided fertile ground for such sonic experimentation (as in the works of Henry Cowell, John Cage, George Crumb) and it provides a effective platform for our work here, either in a duo format with two pianos or in a larger, mixed ensemble.

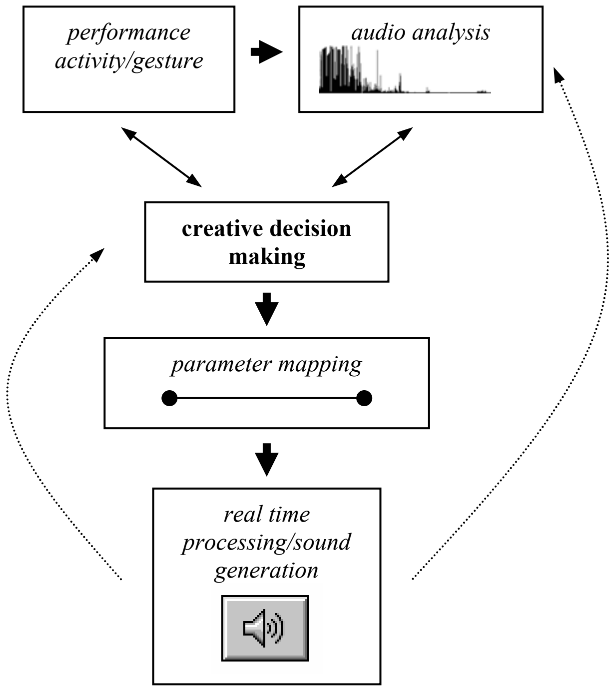

Figure 1: *Overview of the performance model.*

1.2. Integrating Audio and Control Parameters

Our performance model is summarized in figure 1. It seeks to establish strong links between performance activity and computer response. The model envisages that any musical activity tends to embody, or is perceived to represent, a fundamental relation between physical cause (real or imaginary) and sonic outcome. This has be argued by Smalley in the case of electroacoustic or *acousmatic* music, where even visual cues, physical gestures and so on are absent [1]. Performance activity involves the generation of sound materials, by any means possible, and direct interface with the laptop computer; but the performance model focuses on the *integration* of audio and control parameters. Audio is used as a form of 'wireless' communication that carries information about itself, information that instigates a response from the computer: These responses implement functions from a range of real time sampling, granulation and effects algorithms which generate materials closely related to or divergent from the sounds produced by the performer(s), and may retain links to the rhythmic flow of live events or be quite independent from them. There is a continuum which evolves from traditional instrumental sound (via extended techniques of production) to live effects processing and, ultimately, to sample triggering. In this extreme case there is no longer any necessary musical relation between the triggering event (performance activity) and sonic outcome, although the possibility remains for shaping the characteristics of pre-recorded samples during live playback. Connections can also be established, in performance, between audio from sample playback and control parameters that engender further computer responses.

Consequently, all sound material, whether performed or processed, exists in a permanently mutable form, subject to the influence of both input gestures and the sound events themselves (depending upon how audio and control parameters are mapped). To use Stroppa's terminology, sound material does not exist in a "composed state" but should only be considered for its "interpretative potential" [2].

1.3. Inclusiveness and Uncertainty

This mutability extends into performance practice within the ensemble. An *inclusive* practice is favoured, whereby all players may share ownership of the material produced and electronic processes implemented. This collaborative ethos encourages performance activity that seeks to influence, or disturb, ongoing events, or to interfere with the capacity of another performer to do the same. These feedback loops provide the basis for collective improvisation, in which, from the perspective of any individual player, indeterminacy exists on several levels; the outcome of any performative act, the nature of equivalent contributions from other players, and, most critically in this model, the influence of these sounds on computer-based processing activity or vice versa.

Actions are therefore always explorative; performers may seek to provoke events or react to those already underway, but can rarely be certain of the actual outcome and their role in the interactive process. In this performance model the relation between subject (performer) and object (sonic outcome) is never "circumspective", to use Heidegger's term, rather a breakdown is engineered between expected patterns of cause and effect (as described by Hamman [3]). Although uncertainty is favoured over authorship and intention, it is not our aim that this should be at the expense of the intuitive and personal, whether expressed through musical performance or direct control of computer processing. The performance model seeks to expand the possibilities of improvisation, to embed technology fully in the social act of music making.

2. CONTROL PARAMETERS

2.1. Strategies for Mapping

At the heart of this model is the interpretation by the computer of inputs, and how decisions are made to map one type of event to another. Any control system involved for live improvised performance raises problems of gesture-to-parameter mapping. This performance model is focused particularly on instrumental gesture mapping. Rovan et al have addressed these problems by suggesting three strategies for mapping physical input to control parameters; "one-to-one", "divergent" and "convergent" [4]. The simple relation between action and result ("one-to-one") describes a simple, linear response of a computer or electronic instrument to a performance input. Conventional computer input devices and MIDI peripherals, as well as more sophisticated input devices, are examples of this strategy. "Divergent" mapping suggests an extension of this approach, assigning one input controller to a number of potentially unrelated musical parameters.

The "convergent" strategy envisages much more complex systems of control, employing a number of interdependent controllers that influence a single parameter. This strategy can be noted for its greater expressive potential and its more accurate reflection of the actual practice of playing acoustic instruments or singing, in which a whole host of both conscious and unconscious physical actions can influence the timbral and gestural characteristics of the resultant sound.

2.2. Audio as a Controller

Given the wide array of available input devices, the choice of suitable controllers is a fundamental consideration, as is the subsequent interpretation of controller gestures. Audio itself is the preferred source of controller information as this carries information directly from the performer's natural musical expression. Pitch tracking, and to a lesser extent, amplitude following are both unsatisfactory, reflecting a reductive approach that simplifies the musical input to the note-orientated language of MIDI. The technical limitations of MIDI, for instance its fixed bit depth, have been frequently noted, e.g. by Wessel [5]. Wessel has also proposed that audio signals may be used as an alternative to conventional formats such MIDI, providing control streams with vastly improved flexibility, resolution and responsiveness. Adapting this approach, we suggest that audio-based control parameters may be derived from the live performance by means of spectral analysis, providing immediate visual feedback into the performance environment.

3. IMPLEMENTATION

3.1. FFT Analysis

Our implementation seeks to foster the collective improvised performance model discussed above, in particular emphasizing inclusiveness, listening and responsiveness. Performers may view a spectral analysis of incoming audio by means of an FFT based representation of the spectrum. This allows areas of activity (or lack of activity) in the frequency spectrum to be identified visually, and to be considered in relation to perceived musical activity or attendant physical gestures observed during live performance. Quite subtle changes in timbre, e.g. resulting from minor variations in the upper spectrum, can be identified. Such areas of interest may have a very narrow or wide bandwidth and can be extracted easily and spontaneously using the computer interface. These frequency bands can then be assigned (mapped) as independent streams of control data to one or more of the numerous parameters for processing, sampling or granulation.

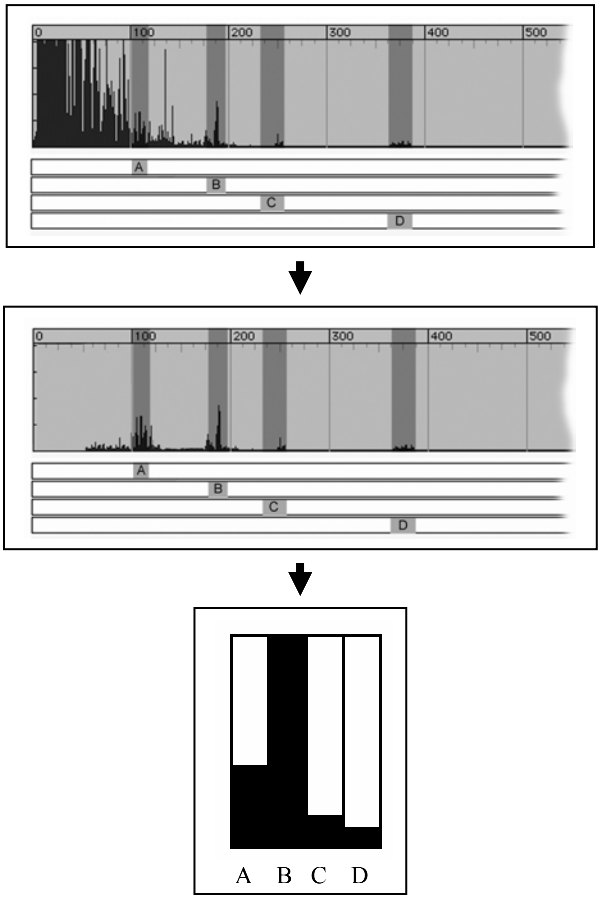

Figure 2: *FFT analysis and frequency band selection.*

The implementation uses a Max/MSP patch for analysis and all subsequent audio processing. Initially frames of 2048 bins are read into a *buffer~* object and displayed by *waveform~*. To smooth the display, every four frames are averaged, providing a representation of every 86ms of sound, updated at the frame interval of 21.5ms. This provides a practical compromise between accuracy and usability. Two displays are used (see figure 2). One shows the spectrum of all sonic activity. A second display removes data from the computer generated audio (by subtracting FFT frames) allowing only direct sound to be observed, which proves advantageous in practice. In figure 2 four frequency bands *a, b, c, d* are selected by the performer from the spectrum analysis; these bands are mapped to four control parameters.

The performers are thus provided with a detailed description of all sound materials, forming the basis of their creative decision making. Nevertheless, in future, alternative analytical methods could be explored that allow pitch-based representation of the spectrum and better low frequency resolution.

3.2. Participation using LAN

A scenario with more than one computer is preferred, to allow active participation in the selection and mapping process by more than one performer, thus creating a dialogue at the technological level. This also provides a solution to the CPU intensive nature of analysis and synthesis. Open Sound Control (OSC) is used to implement a Local Area Network, which provides many advantages over the most likely alternative of MIDI, as discussed by Wessel [5]. Both control data and FFT data can be transmitted over the network, so that individual computers can undertake dedicated tasks within the analysis/synthesis MSP patch, and performers can influence processing tasks underway on another laptop.

3.3. Convergent Mapping

Decisions about frequency band-to-controller mapping are highly significant. To identify an area of interest within the spectrum constitutes a subjective and creative response to the audio environment; a decision to map a given spectral area to a particular control parameter is a compositional decision, which will potentially feedback into the entire system. A “one-to-one” mapping strategy has proved unnatural to engage with, as minor changes in playing can result in relatively crude parameter changes, whereas radical shifts in timbre and texture are not necessarily matched by a commensurate parameter response. One solution, implemented here and shown in figure 3 is to map incoming data (in this case, the four control parameters *a, b, c, d*) to freely accessible *table* objects, so that ongoing control information can be reshaped, in performance, to produce a more desirable aural outcome.

Overall, a “convergent” strategy yields better results. Overcomplicated when applied to a range of faders and switches, it proves efficacious when applied to strings of control data generated from real time audio analysis, and informs the ability of individual performers to determine the musical outcome of their decision making. For example, logical AND or NOT allow a given control parameter to preclude or require activity in another in order to obtain a positive effect. Audio processes dependent upon the upper partials generated by one instrument, for instance, may be inhibited by the appearance of a low frequency drone in the spectral landscape. Parameter assignment creates only potential scenarios for exploration by the improvising musicians; performers may provoke, but not directly control, parameter changes which in turn have a palpable effect upon live signal processes.

CONCLUSION

The analysis process enables visual feedback of the sonic environment during performance. Thus the detection and selection of interesting and suitable changes in the frequency spectrum become possible which in other cases might be masked by other more dominant frequencies. The feature of extracting gestural controls out of particular frequency bands (fft bins) of the spectrum is particularly significant in that, by comparison to pitch tracking systems, aurally dominant frequency areas can be ignored, but minute changes in the timbral output of an instrument can be utilised to influence controls governing computer effects processes.

These changes in the timbral output occur mostly in direct relation to the playing techniques of musical instruments, involving one's own playing as well as that of other members of the ensemble. This intimate and direct influence of playing technique and electroacoustic processes is particularly significant for a successful improvisation which seeks to embrace both human sociality and computer technology.

ACKNOWLEDGEMENTS

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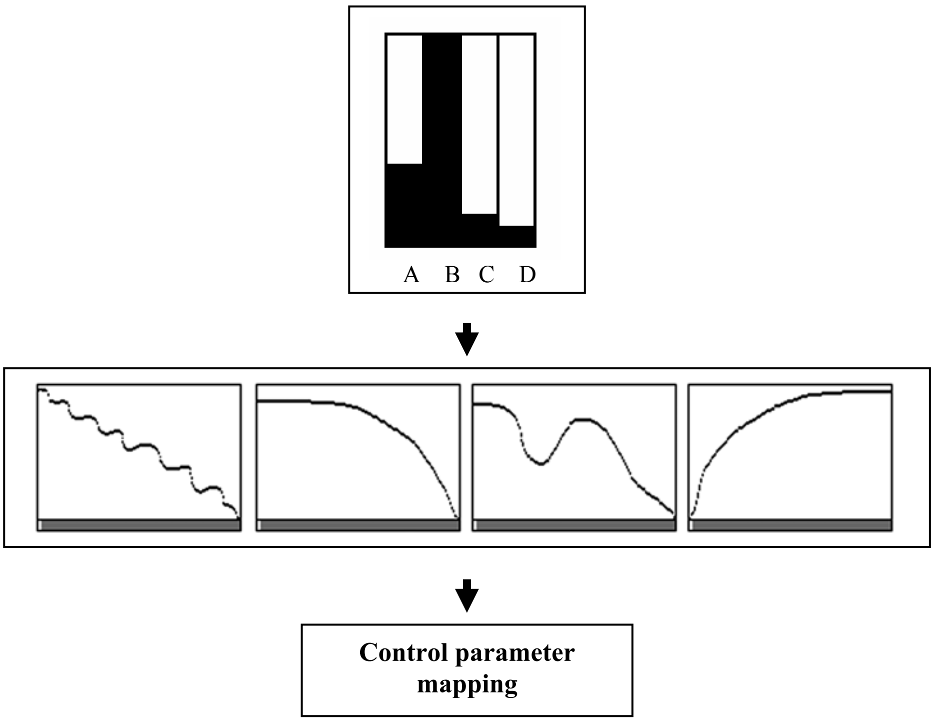

Figure 3: *Shaping controller data with table objects*