Partial-balancing Instruments with Dynamically Refreshed Wavetables

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ABSTRACT
A compositional application is described with a new type of electroacoustic instrument design. The novel features of the instrument are: 1) real-time dynamic refreshing of source wavetables, enabling instantaneous or gradual timbral change, and 2) the instrument's self-adjusting of its spectral content in response to real-time input control- a kind of spectral 'morphing'. The control input permits 'grabbing' one or more partials and amplifying or attenuating them; simultaneously the instrument adjusts the balance of the other partials contributing to its timbre in accordance with its built-in algorithm.

The research underlying the work reported in this paper depends upon the merging of an algorithmic composition system, Tabula Vigilantes I, with a protocol-driven multi-processor network, MIDAS-MILAN. In this combined system a host computer - typically an SGI Indigo or Indigo - is installed as a node on MIDAS-MILAN, and runs the high-level Tabula Vigilantes (TV) program. TV interprets a composer's script which defines the rule-set for an electroacoustic performance. The initialising, network and performance data are translated into MIDAS protocols and launched on the MIDAS-MILAN network, where the performance takes place using appropriate unit generator processors (UGPs).

The application described in the title of this paper highlights certain features of both TV and MIDAS. The partial-balancing instruments rely upon a constraint feature of TV which is illustrated in the following two lines of script:

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lock a
a sum b, c, d, e, f(...etc.)
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The normal operation of the second of these two lines would be to place in the output cell 'a' the sum of the values in the input cells 'b', 'c', 'd', 'e', 'f' etc. However, the meaning of the previous line is to lock the value of cell 'a' to its current value so that it cannot be changed. As a result the 'sum' rule is constrained to balance its inputs and output by distributing any difference across its unlocked inputs. Providing there is at least one unlocked input, the 'sum' rule guarantees that the two sides of the effective equation do indeed balance.

The constraint rule 'sum' may be used to design a partial-balancing instrument which has the interesting property of complex timbral behaviour from simple input controls. Consider an additive-synthesis instrument where the 'sum' output is locked to the current total amplitude required. For simplicity we might regard this as a dynamic, which can then be scaled by an appropriate multiplier obtained as the current value for a desired envelope. (See Figure 1) The inputs to the 'sum' rule then correspond to the amplitudes of the successive partials. With the output locked, further selective locking and unlocking of groups of input cells, together with the 'automotive' balancing provided by the 'sum' rule, can result in complex timbral behaviour. The control of the locked input cells may be determined from an algorithm specified within the script, or it may be assigned to some real-time control input, such as may be derived from the movement of a mouse.

Figure 1

Inputs to 'sum' rule: Output 'a' = \text{sum inputs } b \ldots l

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An early design feature of MIDAS-MILAN was the instantaneous (i.e. between two audio-rate output samples) updating or refreshing of stored wavetables. This means that instantaneous changes of timbre can be effected. Algorithms progressively modulating the wavetables are yet to be extensively developed, though this approach looks promising for novel musical applications.

In the instrument model referred to above, using the 'sum' rule, it is easy to see that the inputs to the rule could refer, not to sine-wave components of an additive-synthesis instrument, but indeed to components which themselves have a more-cri-ler complex timbral structure. Evolving wavetable algorithms and dynamic refreshing of wavetables have a significant part to play in the evolution of such complex instrumental designs. Indeed we see importance in the development of cascading instruments, where successive components of balancing processes are themselves complex timbral entities embodying the same rules which implement the original partial-balancing instrument. (See Figure 2) Such designs as these are implementable only because they incorporate simple but efficient control structures.

Figure 2  
Quadded timbral balancing entities

An interesting situation emerges in the applications of Tabula Vigilans and MIDAS such as those described here. TV can certainly create algorithms which determine successive sample values, and thus in theory can run at audio rate. The multiple processors in any practical MIDAS implementation are likely, however, to run at a speed much higher in real terms than any host computer. On the other hand, while many MIDAS UGPs have some algorithmic capability, they do not have the flexibility of algorithmic control that the use of Tabula Vigilans is likely to require. For a given compositional application, then, the user’s dilemma is where to ‘draw the line’ between what TV generates from its rule set and what it passes on as work for MIDAS to undertake within its set of UGPs.

The ‘rule of thumb’ adopted so far, and which has been followed in the applications described in this paper, is that processes which generate audio-rate samples are undertaken on MIDAS; lower-rate control processes are undertaken within TV. This neatly divides the tasks into audio-rate and control-rate processes observable in other systems. However, we believe that there may be compositional applications where this division is not the appropriate one. The parallelism of TV rules and MIDAS UGPs means that the design of the combined system can be kept under review and modified as necessary to accord with compositional intent.

References