A Composition for Clarinet and Real-Time Signal Processing: Using Max on the IRCAM Signal Processing Workstation

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Introduction.

The composition *Music for Clarinet and ISPW*, by the author, was created using the IRCAM Signal Processing Workstation (ISPW) and the software Max. The piece was commissioned by the Center for Computer Music & Music Technology, Kunitachi College of Music, Tokyo and realized at IRCAM during 1991, and at the Kunitachi College of Music during a composer-in-residency, 1991-92.

From 1988-1991, IRCAM developed a real-time digital processing system, the IRCAM Signal Processing Workstation (ISPW)[1]. Miller Puckette has developed a version of Max for the ISPW that includes signal processing objects, in addition to many of the standard objects found in the Macintosh version of Max [2][3]. Currently, there are over 40 signal processing objects in Max. Objects exist for most standard signal processing tasks, including: filtering, sampling, pitch tracking, threshold detection, direct-to-disk, delay lines, FFTs, etc. With the ISPW version of Max, the flexibility with which one creates control patches in the original Macintosh version of Max is carried over into the domain of signal processing.

Prototyping Environment.

The ability to test and develop ideas interactively plays an important role in musical applications. Because of its single architecture, the ISPW is a powerful prototyping and production environment for musical composition [4]. Prototyping in a computer music environment often combines musical elements which traditionally have fallen into the categories of “orchestra” (sound generators) or “score” (control of sound generators). Mainly due to computational limitations, real-time computer music environments have traditionally placed hardware boundaries between “orchestra” and “score”: the sound generation is done on one machine while the control is done remotely from another. When developing a synthesis algorithm which makes extensive use of real-time control, it is extremely helpful, if not essential, to develop the synthesis algorithm and the control software together. This is greatly facilitated when sound generation and control run on the same machine and in the same environment.

Control and Signal Processing.

Real-time signal analysis of instruments for the extraction of musical parameters gives composers useful information about what an instrumentalist is doing. One of the signal processing objects found in Max offers rapid and accurate pitch-detection. In *Music for Clarinet and ISPW*, the incoming clarinet signal is converted via an analog-to-digital converter and analyzed by this pitch-detection algorithm. The pitch tracker outputs MIDI-style pitches which are sent to a score follower [5] (using the *explode* object [6]). As the score follower advances, it triggers the "electronic score" which is stored in event lists. The event lists directly control the signal processing modules. In parallel, compositional algorithms also control the signal processing. These compositional algorithms are themselves controlled by the information extracted from the clarinet input. Thus, the raw clarinet signal, its envelope, continuous pitch information from the pitch detector, the direct output of the score follower, and the electronic score all contribute to control of the compositional algorithms employed in the piece (see figure below).

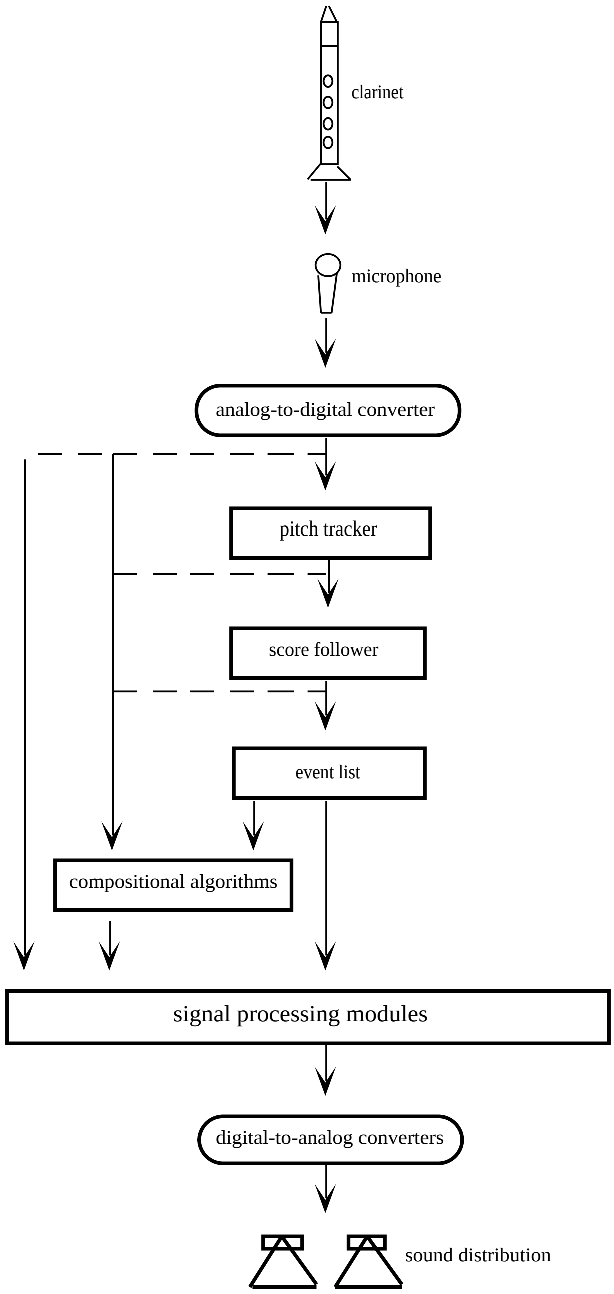

Figure 1. Control and signal processing flow.

The signal processing used in *Music for Clarinet and ISPW* include several standard signal processing modules: reverb, delay, harmonizing, flanging, frequency shifting, spatializing, and frequency/amplitude modulation.

Several non-standard sampling techniques are used also, including a time-stretching algorithm, developed by Puckette, which allows for the separation of sample transposition and sample duration. Thus, one can slow down a sample playback while maintaining the original pitch, or change the pitch of a sample playback without changing its duration. Another sampling technique, a kind of “granular” sampling developed from techniques described by Xenakis [7] and Roads [8] for sound synthesis, is also used. Ten-second sound samples can be played back in a variety of ways and orderings, taking approximately 20-millisecond “sound grains” of the sample at a time. (All of the samples are made up of clarinet phrases sampled in real-time during the performance of the piece.) Finally, using an automated signal crossbar (similar to a studio patch-bay) to connect modules to each other, signals can be sent from the output of practically every module to the input of every other module. This signal crossbar maximizes the number of possible signal paths and allows for greater flexibility when using a limited number of signal processing modules [9] (see figure below).

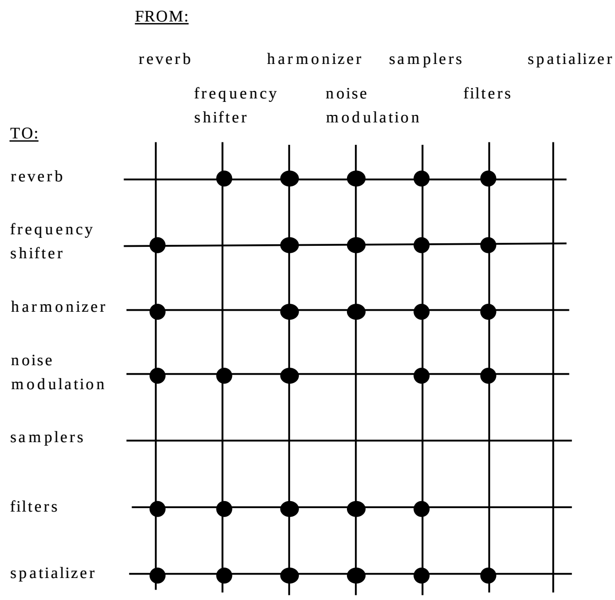

Figure 2. Crossbar of interconnections among signal processing modules.

Real-time Continuous Control Parameters

Real-time audio signal analysis of acoustic instruments, for the extraction of continuous control signals that carry musically expressive information, can be used to drive signal processing and sound generating modules, and can ultimately provide an instrumentalist with a high degree of expressive control over an electronic score [10]. In the frequency domain, pitch tracking can be used to determine the stability of pitch on a continuous basis for recognition of *pitch-bend, portamento, glissando, trill, tremolo,* etc. In the amplitude domain, envelope following of the continuous dynamic envelope for articulation detection enables one to determine *flutter-tongue, stac-*

cato, legato, sforzando, crescendo, etc. In the spectral domain, FFTs, pitch tracking, and filtering can be used to track continuous changes in the spectral content of sounds for detection of *multiphonics, inharmonic/harmonic ratios, timbral brightness,* etc. High-level event detection combining the analyses of frequency, amplitude, and spectral domains can provide rich control signals that reflect subtle changes found in the input signal.

The Musician's Role.

The dynamic relationship between performer and musical material, as expressed in the musical interpretation, can become an important aspect of the man/machine interface for the composer and performer, as well as for the listener, in an environment where musical expression is used to control an electronic score. The richness of compositional information useful to the composer is obvious in this domain, but other important aspects exist: compositions can be fine-tuned to individual performing characteristics of different musicians, intimacy between performer and machine can become a factor, and performers can readily sense consequences of their performance and their musical interpretation.

References.

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