Prelude for Clarinet and Computer: a Confluence of Technological and Musical Choices

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ABSTRACT

This paper describes the compositional and technical aspects of the author's composition *Prelude for Clarinet and Computer*, a work for amplified clarinet and real-time audio processing using the Max/MSP graphical programming environment. The audio signal processing technologies and musical choices for this piece have a tightly interwoven relationship: many of the technological developments were motivated by musical necessity, and conversely the construction of some of the musical material was a direct result of technological considerations.

1. BACKGROUND

Prelude for Clarinet and Computer is the second in a series of pieces for solo instrument and live computer processing. It is worth briefly mentioning its predecessor, the *Prelude for Flute and Computer*, for the simple reason that they both owe their existence to an important development: the gizmo~ object for real-time transposition of audio signals in the Max/MSP environment [1]. The gizmo~ object was developed by the author specifically with the first of these compositions in mind, and the subsequent compositions in the series also rely on it.

With the release version 4 of Max/MSP, the signal processing capabilities of the program were vastly expanded beyond the basic toolkit of objects that was provided with the first release of MSP [2]. Nonetheless there were still a few necessary musical tools that were missing from the environment. Some of these gaps in the tool set were addressed by diligent third-party developers who made their work available to the Max/MSP user community (for example Mille Puckette's pitch tracking objects, such as fiddle~ [3]), yet other tools were absent entirely, or of an unsatisfactory musical quality. One important musical item lacking in the environment was a way to transpose sounds in a natural, realistic manner. Therefore the author embarked on the creation of a spectral-domain transposition object based upon published research into the phase vocoder and spectral domain effects by Laroche and Dolson [4]. The result was the development of the gizmo~ object as a standard part of the Max/MSP object set.

2. COMPOSITIONAL PROCESS

The instrumental score of the composition was generally composed first, keeping in mind the electronic processing that would be used in different sections of the piece. The realization of the computer part, in the form of a Max/MSP patch, was designed afterward according to indications in the instrumental score. The melodic and harmonic aspects of the composition are freely composed, using no pre-determined system for note choice. Generally, however, the melodic aspect of the composition follows diatonic sets of pitches and modulates to different sets via common tones. Formally, the piece is structured in an asymmetrical rounded binary form: a slower, rhapsodic A section followed by a faster, canonic B section and concluding with a short coda based on musical material from the A section.

3. COMPOSITIONAL CHOICES AND NECESSITIES

As with the other compositions in the series, the computer part for the Prelude begins with an "empty slate" – there is no pre-recorded material and all sounds originate from the onstage performer in concert. Some sounds from the live clarinet are recorded for use later in the piece (for example the first note which is used again the coda), while other sounds from the live clarinet are delayed using multiple delay lines in the patch (namely in the canonic B section). The delay times are set using a tempo derived from the live performer, an aspect which will be discussed later in this paper.

An early compositional choice was the decision to use multiphonics throughout the piece as a means to blur the distinction between live and processed clarinet sounds. The multiphonics selected, in consultation with several clarinet players, tend to be on the more quiet end of the spectrum – mostly, but not exclusively from the sets which Rehfeldt [5] designates as category 2 (soft attacks), category 3 (quiet) and category 5 (dyads). The series of multiphonics at the outset of the coda was actually the first musical material composed, and used subsequently as the basis for the computer transpositions at the beginning of the piece. The multiphonic dyads used at both the end of the A section and the end of the piece were also chosen for their resemblance to electronically-processed transpositions of the clarinet sound, with the final double-pitched note performed by the clarinet without additional sound processing.

One additional but unfortunate compositional necessity imposed on the score during the realization of the Max patch was the addition of notes in passages which had one or more repeated notes. Although human performers and accompanists are adept at recognizing discrete note events, even when the same note is repeated multiple times in a musical passage, the current computer-based score following systems are less adroit. Therefore additional notes, not harmonically related to the repeated notes, were added in some places throughout the score in order to aid the computer pitch tracking system. Although future pitch trackers may be more capable of dealing with a wider variety of musical input, these extra notes have, nonetheless, become part of the final composition.

4. EXISTING TECHNOLOGIES

There are two important pre-existing techniques without which this piece could not exist: pitch tracking and score following.

4.1. Pitch Tracking

The composition uses a modified version of an older pitch tracker by Miller Puckette called pt~, which was originally designed for Max/FTS on the Ircam Signal Processing Workstation (ISPW) [6]. This object has proven to be much more responsive than newer pitch tracking objects for MSP such as Puckette's fiddle~ and sigmund~. Although pt~ will often report erroneous pitches one octave from the actual fundamental with many instruments, the author has found that with the clarinet and its odd-harmonic spectrum, the pt~ object is rarely incorrect in its pitch and octave estimation.

The original object needed to be modified to allow larger window sizes for the object's internal FFT, thereby accommodating more accurate pitch tracking of the lower notes in the clarinet's chalumeau register. Another modified version of the object, named ptg~, was also compiled specifically for this composition. It can be used inside a standard MSP pfft~ subpatch, and therefore contains only the pitch tracking code, not any code specific to the Short Term Fourier Transform, which is handled by the pfft~ object. Having the pitch tracker inside the pfft~ subpatch is useful for two reasons: 1) if a the pfft~ object is already being used in the patch for spectral-domain sound processing, a second (computationally expensive) Fourier Transform is not necessary when adding pitch tracking to the patch, and 2) it facilitates synchronization of the reported pitch estimation with any spectral-domain effects that need to use that information.

4.2. Score Following

A updated version of the score following system designed by Miller Puckette and Cort Lippe on the ISPW was used for this piece [7]. Although in the future it may be replaced with a newer system (the author's earlier flute Prelude now uses Arshia Cont's antescofo object [8] for score following and event triggering), for the moment it works robustly, and makes use of objects in the standard Max/MSP distribution. The system uses the afore-mentioned pitch tracker in conjunction with the Max detonate and qlist objects. Both objects have been a regular part of the Max distribution since the mid-1990s. The three-part system works thus: the pitch estimation from the pitch tracker is sent to the detonate object, which contains a piano-roll MIDI representation of the entire score [9], in addition to cues which are output as the follower advances through the score in response to the pitch-tracked input. These cues are then sent to the cue list in the qlist object, and the events of each cue are then remotely sent to control different parameters in the patch.

5. COMPUTING TECHNIQUES

In addition to the techniques described above, this piece uses several novel techniques that are important developments with respect to the series of preludes. Some of these techniques are extensions of existing technologies, whereas others were designed specifically for use in the piece.

5.1. Rhythm and Tempo Detection

A series of cues are used at several occasions in the piece in order to set the tempo of various computer-processed events. The first of these occurs at the outset of the piece, where a series of cues sets the tempo for a sequence of transpositions of the live note. Additionally, the opening notes of the B section are used not only as a bridge from the musical material at the end of the A section, but also to allow the clarinetist to define the tempo for that section. In both these cases, a collection of delta-times are obtained from the series of cues, the values are sorted and the highest and lowest values are thrown out, since they could potentially be false readings, or inaccurate rhythms on the performer's part. The remaining timing values are averaged, producing an accurate tempo estimation. This tempo is used to calculate the timing and rhythm of the chord changes in the third bar, and in the B section to accurately set the canon entries, thus allowing the performer to set a comfortable tempo for the canonic entries in a natural, and musical manner.

5.2. Timbral Modification

Since the clarinet's instrumental acoustics generate odd harmonic partials only, a principal effect used in this composition is to fill-in the even-harmonic gaps in the clarinet's spectrum. This has the effect of transforming the clarinet sound into that resembling an alto saxophone. The effect is achieved simply by pitch-tracking the clarinet sound and using the fundamental frequency as a Hertz value to frequency-shift the audio. When the frequency-shifted audio is mixed with the original signal, it fills in the even harmonics in the clarinet spectrum. The frequency-shifted audio may be added to the original sound at any arbitrary volume level, thereby allowing smooth changes in timbre along the continuum between clarinet and saxophone.

5.3. Spectral Delay with Transposition

Although the Prelude generally is structured with four transpositions of the original instrumental sound which can each be delayed an arbitrary amount of time, two sections in particular required a special recursive transposition and delay effect: the end of the A section and the end of the coda. For these places an alternate spectral-domain transposition patch was made. In it, each of the four gizmo~-based transpositions is delayed a certain number of FFT frames in the spectral domain sent to the subsequent gizmo~ object. The fourth transposition is sent in a feedback loop to the input of the first. By using carefully-adjusted parameters for the transposition and volume attenuation of these transpositions, a "hazy" or "out of focus" decaying echo sound is produced, quite different from the effect that would be made if the effect were designed in the time-domain.

5.4. Glissandi

Although not a novel technique per-se, the use of an S-curve for portamento is more musically effective than a linear glissando. The standard curve~ object for MSP implements a signal-rate quasi-exponential or quasi-logarithmic curve. Two curves can be triggered successively in order to create an S-curve, which approximates well the effect of a human glissando, such as that of a finger on a violin string: starting slowly, accelerating through the center portion of the glissando and slowly easing into the destination pitch.

5.5. Pitch Grid

The most important development for the *Prelude for Clarinet and Computer* takes a small inspiration from the world of algorithmic composition, albeit performs it in the context of a digital signal processing effect. The author designed a pitch-class corrector as an event-level Max patch, whereby all incoming (MIDI) pitches are modified to fit to a pre-defined pitch grid. Each input note is compared to a given pitch-class set, and then transposed to the nearest note in the set. When used in conjunction with the robust ptg~ pitch tracker and the gizmo~ object, each note played by the clarinet may be adjusted to a different fundamental frequency in real-time. In some ways this is the antithesis of the ubiquitous auto-tune effect in popular music, as it does not correct the fine tuning of the note, but rather moves the entire note event to a different pitch-class level, preserving vibrato and microtonal nuances inherent in the original sound.

This effect is used heavily in the canonic B section of the composition. In this section the computer-delayed canons of the live clarinet sound are transposed to different key centers, but the individual notes of the canons are modified in order to match the current harmonic context implied by the live soloist. The effect enters subtly at first, but becomes more obvious as the piece progresses. By bar 31, the transposed canons are no longer following the original diatonic material, but rather are transposed to fit to a triadic harmonic grid.

6. CONCLUSION

The technology and musical ideas behind the author's *Prelude for Clarinet and Computer*, are at once a culmination of previous work and a new springboard for future compositions in the series. Especially, the algorithmic nature of the pitch-grid processing lends itself to the concept of hybridizing digital signal processing techniques with ideas taken from algorithmic composition. This is something that was explored further in the following composition in the series, the *Prelude and Fantasy for Alto Flute and Computer*, which relies less on delays and live sound processing and more on algorithmic playback of recorded fragments of the live instrument.

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9. AUTHORS' PROFILE

Richard Dudas holds degrees in Music Composition from The Peabody Conservatory of Music of the Johns Hopkins University, and from The University of California, Berkeley. He additionally studied at the Franz Liszt Academy of Music in Budapest, Hungary and the National Regional Conservatory of Nice, France. In addition to composing music for acoustic instruments, he has been actively involved with music technology since the late 1980s. As a computer musician, he has taught courses at IRCAM, and developed musical tools for Cycling '74. Since 2007 he has been teaching music composition and computer music at Hanyang University in Seoul, Korea.