Exploring Cognitive Process Through Music Composition

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Abstract
The piece Golden Looking Glass is a computer music work made up of algorithmic elements that were designed for tape and live performance. This piece experiments with the listener's ability to relate to musical experience by eliminating the most basic component of the tonal system: the octave. This is achieved through mathematically scaled down versions of both the harmonic series and equal temperament. A synthesizer called Golden Tune was implemented in Max/MSP featuring both synthetic timbres and alternative tuning systems. The algorithms employ a balance between randomness and deterministic patterns.

1. Conceptual Background
As we listen, we re-enact previous sonic experiences that comprise our personal environment, simultaneously redefining our personal environment (Keller & Capasso, 2006). It is possible for a listener to relate to synthetic sounds in a non-musical context thus creating new sonic meaning. The idea behind Golden Looking Glass is to explore the relationships between synthetic sounds and musical forms of organization based on a mathematically consistent tuning system.

Without having heard the Golden Tune synthesizer, we can make certain assumptions on how this instrument behaves in a musical context. This context relates to everything musical one has formerly experienced, establishing one's unique listening history called the 'personal environment' (Keller & Capasso, 2006). The conceptual scheme behind the Golden Tune synthesizer intentionally poses several questions regarding the individual's personal environment. Is it possible to listen to a scaled-down version of harmonic structure in relation to the tonal systems that are pervasively present in our perceptual history? In pursuit of an answer to this question, we must consider the complexities bound therein.

1.1. Algorithmic Composition
In Golden Looking Glass, the algorithmic realm has two roles that are held in tension. It serves as both composed material and composer: a dichotomy of order and chaos. In regard to the computer algorithms, there are two issues at play in this balancing act. One is randomness constrained within predefined patterns. The other involves structured elements that are affected by random processes.

In this diagram, every time metronome 1 outputs an event there are two processes triggered. The first consists of a random number that designates the interval above the base pitch produced according to a previously defined pattern of intervals. This method determines an element from a redefined set of possibilities, thereby randomizing the structure. The other process iterates through a set of possibilities for the base pitch, always adding or subtracting one interval each time a value is generated. Thus another level of structure (as well as an easily identifiable pattern) is created in relationship to the mentioned random element.

When metronome 2 outputs this, the most recognizable structural element, is given a randomness of its own. The direction of this iteration can be up, down, or up and down. Direction changes if the opposite direction is randomly selected. This cohabitation of elements works as a compositional system that is both predictable and unpredictable on multiple levels. A very interesting
question comes to mind. In this balance of randomness and constraint, structure could be perceived from patterns that yield specific expectations. Momentum, that is, pitches with a tendency to ascend could be expected to keep doing so. Velocity, acceleration and deceleration yield similar expectations. It is perhaps not only the ordered constraints that create the expectations, but one can also expect some elements to be unpredictable or chaotic. In this algorithm, there is an overall scheme at play rendering expectations both predictable and unpredictable on multiple levels.

1.2. Mankind Meets Machine

Tonal music provides an interesting example when analyzed for a similar relationship of composed material as a balance between constraints and possibilities. In the past, there was only a certain set of possibilities for what one could compose, lest people think you were crazy or not a composer of music at all. Consider further this social scenario where a composer is confined to do anything at all that he or she pleases within a certain predetermined structure; a framework that is modified as each successful musical work adds to its growing history (much like one's perceptual history or personal environment). The difference here between a cold, heartless algorithm and this individual composing music within the confines of societal designations is of course the role of a musician as a conjurer of emotional meaning. A computer could be taught to compose music within these exact same constraints but there would be no greater sense of purpose. This is the reason for adopting a certain point of view: as composers of music, we must hold in tension the complex relationship between humanity and technology. The previously mentioned compositional computer algorithms would not be effective musically without a human to interact with them; this interaction creates that essential sense of purpose in music composition.

2. Synthesis Implementation

The synthesizer for this piece was realized in Max/MSP. For the accumulation of spectral components, this synthesizer implements additive synthesis: sine waves, as partials, are summed up to create a composite tone (Risset, 1971). Sixteen-voice polyphony handles most of the material that my algorithms might output (within reason).

2.1. Substitute Octave

It could be said that the predominance of the major scale comes from its close relation to the overtone series. The scale's most important elements coincide with the harmonic structure of a normal musical tone described by the overtone series (Aldwell & Schachter, 1989). With the purpose of abolishing the octave, when the Golden Tune synthesizer was created for this piece, instead of an octave having the value above another pitch where \( f_{\text{syne}} = f \times 2 \) this interval is replaced by a substitute definition for an octave. In this redefinition, the golden mean replaces the factor of two:

\[
(1) \quad f_{\Phi} = f \times 1.618
\]

2.2. Retuning to Substitute Octave

Unlike more common alternate tuning systems where an octave is divided up by some number other than the usual twelve, this piece has a tuning system that divides twelve equidistant tones from this substitute octave. This system will never actually produce a real octave. It is a tuning system that mimics the tonal system as a scaled down version. In order to create such a system, it is advantageous to consider redefining the value of a cent. A cent is defined by such an equation where \( 1.0005778 \times 1200 = 2 \) (Hall, 2002). In order to retune according to cents, one would have to arrive at a solution for a similar equation:

\[
(2) \quad \Phi_{1200} = 1.618
\]

2.3. Spectral Components

Most musical tones are composite sounds or tones that can be analyzed as having a multitude of component frequencies. Harmonic sounds divide themselves evenly into segments creating frequencies above the fundamental frequency (Aldwell & Schachter, 1989). Inharmonic tones are composite sounds that do not have the normal even segmenting of the fundamental frequency. The synthesizer made for Golden Looking Glass is able to create unnatural spectral components in two different ways. The first is by shifting down all of the would-be, natural harmonics according to the substitute octave. This means the harmonics are adjusted to accentuate the substitute octave. The ratio for the substitute octave 2:1.618 works out to 1:0.809 and can be used to scale down the factors that define the overtone series. So the \( n^{th} \) partial \( f(n) \) where \( f \) is the fundamental frequency is described as follows:

\[
(3) \quad f(n) = f \times n \times 0.809
\]

The next way is by scaling down the harmonics proportionate to the overtone series. Where the previous version only moved the partials in relation to the first substitute octave, this version scales everything down in proportion relative to the overtone series.
Table 1 shows the factor to be multiplied by the fundamental frequency for each partial rounded off to the nearest cent. In order to scale these partials down one must use the same equation that defines the value of a cent as \( \Phi \) for the aforementioned tuning system. Therefore, to find the nth partial one can reference Table 1 to find the value of \( x(n) \) cents for the following equation that defines the frequency for all partials in this inharmonic spectral system:

\[
(4) \quad f(n) = \Phi^{x(n)} f
\]

### 2.4. User Interface

The interface includes a multi-slider that lets the user control the loudness of each partial. This provides for a great amount of control over timbre and spectral content. A menu lets the user select which of the previously mentioned spectral models is to be voiced. There is breakpoint function interface that allows the user to draw out the amplitude envelope and control the duration in milliseconds. The base frequency is the root from which every note on the keyboard is derived mathematically. It defaults to 110 Hz but is fully adjustable down to no lower than 20Hz. The patch connects to a MIDI input so the user can play from a keyboard.

### 3. The Piece

The making of *Golden Looking Glass* involved recordings of improvisations with computer algorithms executing in response to human input. It seemed preferable to work with two instances of these algorithms at a time in order to improvise with them in relation to each other. The input controls the rate at which the metronomes in Figure 1. output. This determines the velocity of some perceptible motion; therefore, as a function of any such change in velocity over time, it determines acceleration. An integer input to metronome 2 varies the rate at which the direction (ascending or descending) randomly changes.

### 3.1. Processing Recordings

Although the only source material for *Golden Looking Glass* came from the Golden Tune synthesizer, it should be made clear that the tape element of this piece is not limited to sounds generated by the synthesizer. A few types of processing were used during production. The idea of randomness is again incorporated into this specific level of the creation process. One of the ways in which sounds were processed involves granular synthesis. This was done in a way such that grains were randomly repositioned in respect to certain user inputs and was used to create a couple of gestures that help frame the form of the piece. Another process involves the use of delays that randomly adjust their own timing. Yet another is a shuffler that takes fairly large grains and shuffles their timing around randomly. Both of these processes are implemented in order to add texture to some of the sounds and keep the momentum of an ever-changing sea of sound. These random elements are constrained within the exacting scrupulousness that is the mixing process.

### 3.2. Room to Improv

The score for *Golden Looking Glass* is laid out for both a performer on the Golden Tune synthesizer and a performer of an eight-channel diffusion. The instructions given to the keyboard player give a specific set of possibilities within which the performer is to improvise. In this way, the outcome of such a performance is comparable to that of the interactive computer algorithms. It is a parallel dimension of algorithmic composition.

**Notation and instructions.** Music notation is used to give the keyboard player a specific octatonic scale from which he or she must not stray. This notation is to be interpreted just the same as one would read for a piano (in relationship to the keys and not actual pitch). For example, pitch class zero as indicated on the score would be played as a C-natural on the keyboard regardless of the frequency produced. The performer is instructed to keep both hands within an octave each voicing no more than one note at a time. Both hands are to move in the same general direction, but they are two voices independent of each and can move in opposite directions (think of this more general movement as the constraint that designates the voices within an octave as having its own motion). Leap-wise motion of a voice is only acceptable within a major third.

**Following the Score.** A sonogram analysis is the main visual tool for following the score. It is marked with rehearsal letters for the keyboardist and with specific times for diffusion. Rehearsal letter B denotes an easily identifiable gesture in the recording followed immediately by rehearsal letter C where the keyboard is to begin playing. Rehearsal D marks the closing gesture (also easily identifiable by ear) where the keyboardist is to cease.
4. Conclusion

Interfacing with the Golden Tune synthesizer from a keyboard helps us examine the previous inquiries. A highly suitable scale for the purpose of exploring these cognitive relationships with this instrument is an octatonic one, as implemented in this piece. The nature of the repetition of intervals (half-step, whole-step, half, whole, etc.) affords an easily identifiable pattern. It is a means by which one may begin to predict what he or she is about to hear. I contend that this example of acquirement could not be independent of one's personal environment and is an accretion of said perceptual history, and the modification embodied by this interaction. If this result is to any degree expeditious, then one can only assume that these patterns are being related in the same manner one would relate any musical pattern. It seems that this is something best understood through an individual's own experience with the instrument. In this case we can view the instrument as a tool for exploring one's own conception of cognitive process. Keep in mind that this is not so much an experiment as it is a contrivance at the service of a musical experience.

As composers, in the pursuit of mastery of our craft, we have a duty to our work to explore anything and everything we can imagine. This idea becomes more and more feasible as technology continues to develop, thereby giving us means to imagine even further. The computer has proved to be a most valuable platform for developing tools to promote this pursuit. The more tools we create, the evermore vast grows the multitude of dimensions we can explore.

References


