Music from an “evil subterranean beast”

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Abstract

Two recent compositions have capitalized on the great expressive range of a custom-designed music synthesis algorithm. The "Animal" plays a part in Tomato Quintet (a music installation) and Phasor (a contrabass and computer piece). The algorithm is played with live controls, respectively, updates from environmental sensors and signals from a sensor bow. Nuanced deflections of parameter values elicit characteristic and sometimes quirky behavior. The bounded set of sonic behaviors go into making up an identifiable personality whose moods or temperaments can be traversed in the music which exploits it. "The computerized sounds were spacey and sometimes menacing, sounding at times like Chafe was trying to tame an evil subterranean beast." [1] Animal's algorithm is comprised of two parallel resonators with the logistic map in their feedback path. Animal can be categorized as a "meta-physical" model or modeling abstraction as seen in earlier integrations of families of physical models [2] and recombinations of physical model components in physically-impossible ways [3]. Abstraction opens the door to inclusion of mathematical "parts" from other domains. In Animal's case, the logistic map[7] has been borrowed from population biology.

1 Introduction

“Building character” into musical synthesis is a quest similar to giving life to characters in computer graphics. The quest for creation of recognizable personalities is basic in time-based art forms, some of them very old whether theater, novels, film, animation, or other media.

In the musical realm, physical instruments are identifiable by type e.g., “flute” and can be manpulated to fill distinctly different musical roles. One identity can assume a role which mimics another's (flute “percussion”) or borrows from extra-musical identities (bird song). Expression comes into the game when a musical voice communicates a musical “something” – or idea. This could be an idea like a melodic construction or gestural figure, or it could be a modest change in comportment. No list of these “somethings” could ever be complete.

Of interest here, are the essential components of the carriers of musical ideas. In conventional usage, these are easily described and are targets for modeling: the instrument is that which sounds when manipulated by a performer. The performer is responsible for communicating ideas. They may be inventing the ideas on-the-fly as in improvised music or artfully rendering ideas which have been pre-baked into a composition.

2 Easy “instrument-ness”

Algorithms based on general-purpose synthesis techniques like additve synthesis and waveshaping (which includes FM) can be factored into multiple instrument identities. A specific “synth instrument” implies an algorithm tuning endowed with instrument identity. The Animal algorithm cannot be factored into more than a single identity.

To take this a bit further for the sake of clarity, FM's many algorithms and their timbre tuning possibilities have produced a magnificent range of synthesis instruments across many families (brass, winds, keyboards, vocals, and new identities). “Voicing” or tuning an FM algorithm is an art in its own right requiring specialized knowledge, intuition and some amount of luck [4]. Voicing in this sense is creating both a coarse identity (recognizable) and a finely-tuned instrument responsive to the perfomance of subtle shades of expression (like voicing a piano).

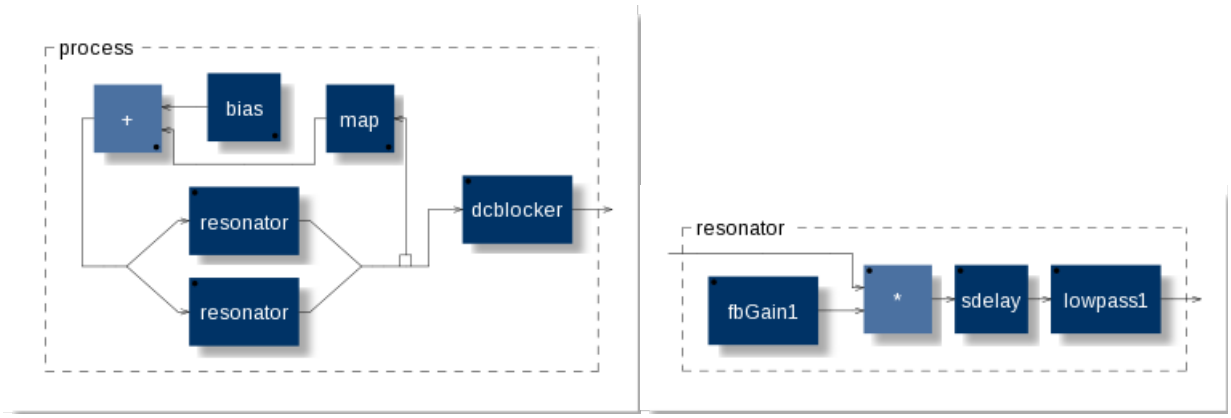

Figure 1: The Animal algorithm is two parallel resonators with the logistic map in their feedback path.

In contrast, Animal's algorithm is mono-identity. No amount of voicing distorts its one identity. The same can be said of many algorithms such as the Karplus-Strong plucked string [5] belonging to the physical model class of techniques (though not all).

Further endowing this one identity with "character" is up to the performer. In the case of Animal, two performers will be discussed below. First, the algorithm itself will be described.

The idea that non-linear iterated maps might be of interest in music synthesis dates back to studies of physical acoustics of instruments in the early 80's [6]. Self-sustained oscillations were newly described as dynamical systems. The edge tone instruments (flutes), reed instruments and bowed strings were shown to be negative feedback systems coupling a resonant system to a non-linear excitation mechanism.

Animal's parallel resonators are delay / low-pass filter units with delay times in the pitch range. First-order Butterworth low-pass filters are used in series with the delays. The logistic map $x_{n+1} = rx_n(1 - x_n)$ is applied to the sum of the resonator outputs and fed back to their inputs. A dc blocking filter is applied to the output and a tiny dc source biases the system to kickstart it and avoid computing of subnormal numbers. The algorithm is "self-excited" as opposed to having the usual external energy source common in physical models (which are blown, bowed or struck in simulation). The use of dual resonators in feedback through a chaotic system produces acoustical behaviors including mode quenching, dual sidebands (from AM), period doubling, multimodal regimes and various distortions.

The basic parameters available are

gain of resonators

length of resonator delays

frequency of resonator filter cutoffs

r of logistic map representing the rate of combined reproduction and starvation in population dynamics [7]

The algorithm doesn't mimic any particular physical instrument intentionally though at times it has a clarinet-like or brassy tone that depends on parameter manipulations. It does intend to produce a palette of sounds whose time-varying transitions are rich in features, filling similar spaces of temporal / spectral variation in which ordinary instruments and human voice are also projected.

3 Refining "character"

What does it mean to say that creating character is up to the performer? First of all, it requires that identity of instrument type be stable. Or, if multi-identity, that the choice of identity is being made by the performer. Either way, the choice of instrumental source is bound and sounding it is in their hands. A melodic figure with an always "croaky" timbre when at its most lethargic, and a sharp crisp, rippling, piercing

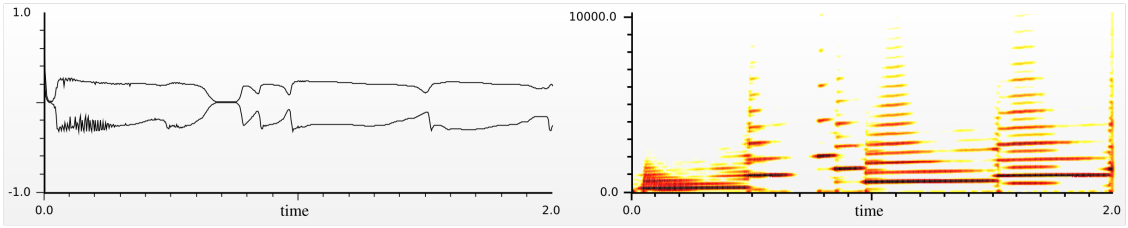

Figure 2: Traversing ratios of resonator delay lengths from 1.04 to 8.0. One resonator delay length is held constant while the other's length is shortened. Varying ratios create a variety of pitches similar to overblowing or *sul ponticello* effects.

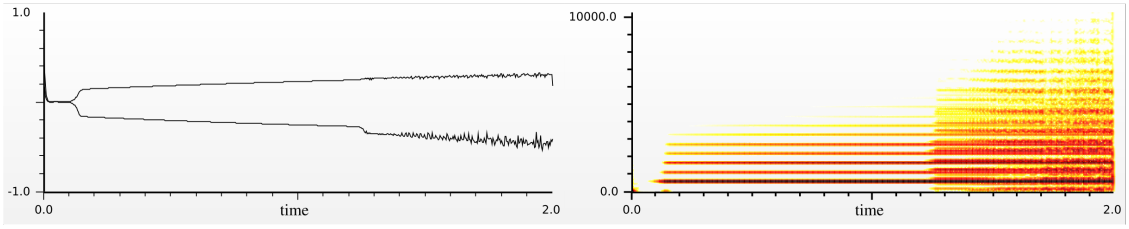

Figure 3: Ramping up feedback gain to both resonators from 0.0 to 1.0. Animal is self-excited by the slight bias injection which is constantly present. The algorithm will not speak with a feedback gain of 0.0. Increasing feedback gain energizes the system and tonal quality traverses from muted to brilliant eventually hitting modes which are gravelly and forceful.

quality when awakened and leading would constitute a recognizable character. As a thought experiment, call this one Animal 'A' and conjure an Animal 'B' of contrasting sets of elements. Animal 'B' might simply be a stutterer that tries to hit pitches but only sporadically manages it. Both 'A' and 'B' are recognizably instances of Animal. They are both necessarily constructed from the set of sonic "moves" afforded by Animal's identity so they share the identity but differ in character. As musical voices they are separable and could play contrasting roles. Or because this is music and anything goes, these characters could hold forth with a duo and the duo could start badly and end happily, etc. – all up to the musical ideas being constructed.

Can there be musical expression without character? In simplest terms, no, because if expression is the planting of ideas from one consciousness into another, as listeners we tend to construct a source communicating to us even in its absence. Ascribing character is the essence of this tendency. We conjure the performer whether the provenance of the music is human or mechanical. A robot is a valid character, as are the "actors" in the recorded sound of a tropical rain forest. Once we take it in as music that is "communicating to us" its source entities are endowed with what can be called "character." If that fails, does the music fail? Can the rainforest itself be communicating? (for my part: yes, music sometimes fails and yes, we can hear music in many ways and things)

The following will illustrate timbral "moves" which are available to the performer constructing a character with Animal. As a lab experiment, all but one parameter is held at a its medium value. The independent parameter is varied in a linear ramp from a low value to a high value. Many acoustical features present themselves in these isolated contexts. In particular,

envelopes shaping amplitude and spectral evolution

pitches supported by harmonic and subharmonic series, possibly multiple at the same time

effects similar to overblowing, *sul ponticello, sul tasto,* and "creaky voice"

non-harmonic sideband modulation and distortion

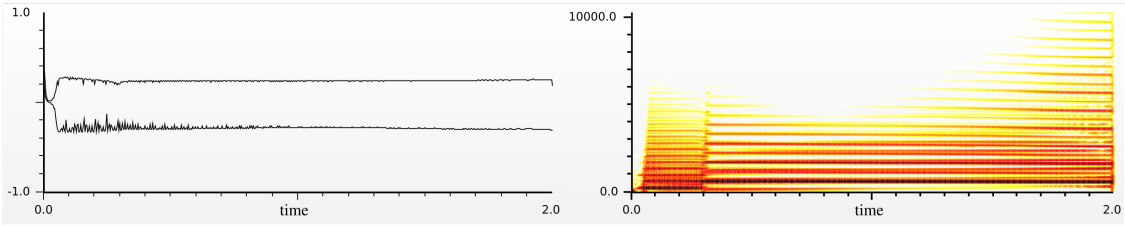

Figure 4: Sweeping the balance between resonators. With resonators holding non-coincidental tunings of delay length and/or lowpass frequency, effects can be derived from altering their relative contribution. The figure shows three pitch regimes obtained, including subharmonics.

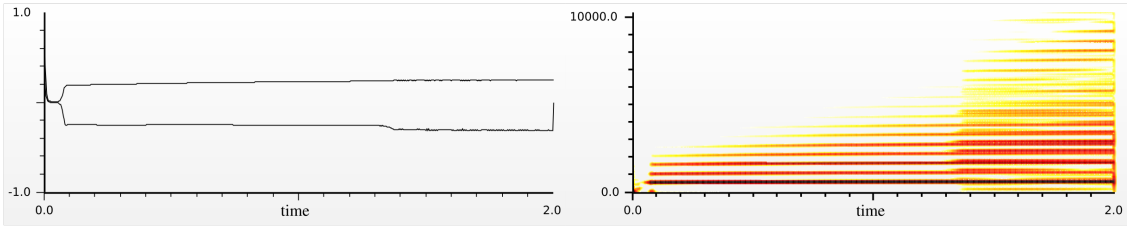

Figure 5: Ramping the lowpass frequency from 550 to 9000 Hz. Akin to increasing feedback gain, but without the gravelly sound in Figure 3, the higher lowpass cutoff frequency toward the end of the sound creates a brightness effect.

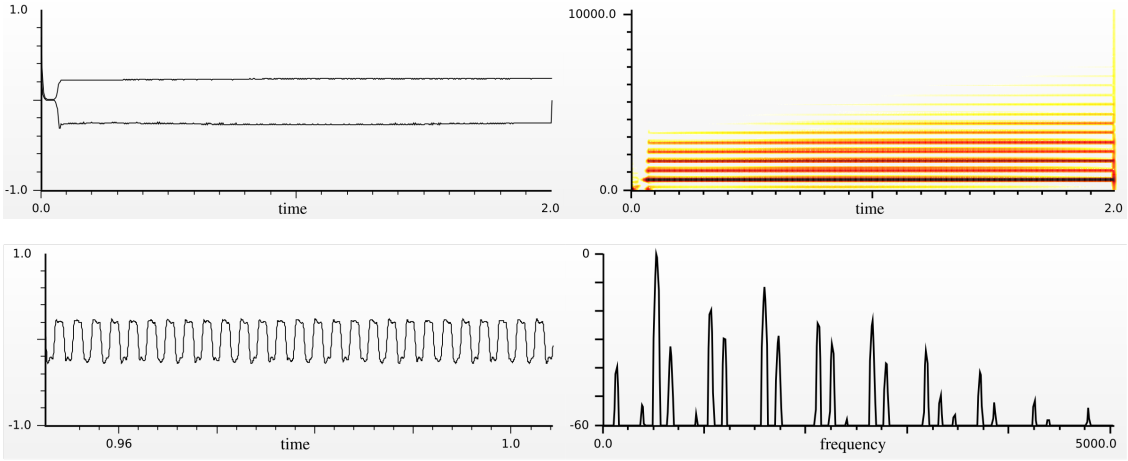

Figure 6: Traversing ratios of resonator lowpass frequencies from 1.003 to 4.0. Almost indetectable in the sonogram, but visible in a zoomed spectral slice, the ratio of resonator lowpass frequencies creates a quality shift by traversing a region with sidebands. The overall percept is strongly pitched. An inflection in tone is caused by sidebands growing and diminishing in strength.

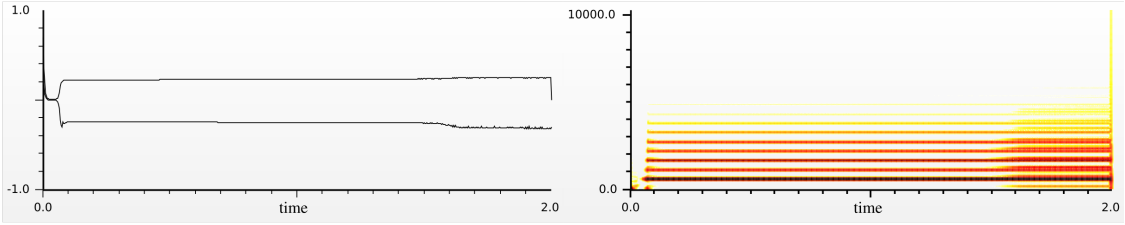

Figure 7: Ramping up the parameter r of the logistic map. Increasing the logistic map parameter r grows the second (octave lower) subharmonic as seen in the end of the figure.

4 Applications

To summarize, Animal is a computer algorithm manifesting a single instrument identity. From it, its performer can construct personalities of different character fit to the intended musical role. Its sonic "moves" or capabilities are intended to be manipulated expressively. The performer is free to construct characters that are as convincing as the music itself.

Its application in the multi-media piece *Tomato Quintet* stretches this notion to its limit. Its performers are ripening tomatoes. A transference is its goal, in which listeners ascribe to the tomatoes the quality of character which they infer from the music.

Tomato Quintet is a digital museum / gallery installation employing real-time music generation. Its co-creator, Greg Niemeyer, considers it a new media "still life." The music contrasts slow time scale material (the ripening process) with much faster time scales (corresponding to human activities and attention). Animal provides characteristic music on both levels. An ambient voice consists of pitched material created with the algorithm and driven by slowly-changing signals from CO_2 gas level sensors near the ripening tomatoes (other ambient layers use other algorithms and include sounds of wind and transient, percussive phenomena reminiscent of hail on a roof). Faster time scale figurations are also synthesized using Animal and come from motion of accelerometers induced by visitors touching the sensor systems.

Phasor is a concert piece for solo contrabass plus computer-generated sound. The composition employs Animal (along with several other materials). A chorus of Animals achieve a pitched texture performed via bowing gestures. The bassist uses a special-purpose bow, the K-Bow, to provide gesture signals from its accelerometers and strain gauges which are connected to the accompanying sound generating computer via Bluetooth. The character evoked is one of pitch-based structure whose modulations are interspersed with abrupt rhythmic surprises and textural intrusions.

References

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