SeedBack: Interactive Soundscape Using Feedback and Karplus-Strong

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ABSTRACT

SeedBack is a Max/MSP patch that generates interesting soundscape from a signal input, or sonic seed, using feedback between the system's microphone and loudspeakers. The sonic energy generate by SeedBack comes from regulated positive feedback with in the system, using multiple Karplus-Strong strings as resonators. The current iteration of SeedBack can only generate a limited pallet of sound, and is intended to serve as a proof of concept that can eventually be incorporated as a component into a interactive music installation.

1. INTRODUCTION

SeedBack is a interactive music system that is intended to be driven by live input signals. It runs the input signal through multiple resonators before feeding it back into the same space through loudspeakers. The outputs of the system are constantly regulated by checking both the amplitude of each resonator, and the roughness of the entire system. These control datas are used to steer different parameters of the resonators to achieve an interesting soundscape, that is seeded by the inital audio input. SeedBack is implemented in Max/MSP, and the resonator used in SeedBack are recirculating delay lines in the style of Karplus-Strong. [1]

2. RELATED WORKS

Computer generation of soundscape using feedback is not a new topic. There are many pieces and projects that uses feedback as the main method of driving a musical composition, and perhpas the most well-known of all is *I'm sitting in a room* by Alvin Lucier. [2] It is difficult to improve upon Lucier's own description of his piece:

> I am sitting in a room different from the one you are in now. I am recording the sound of my speaking voice and I am going to play it back into the room again and again until the resonant frequencies of the room reinforce themselves so that any semblance of my speech, with perhaps the exception of rhythm, is destroyed. What you will hear, then, are the natural resonant frequencies of the room articulated by speech. I regard this activity not so much as a demonstration of a physical fact, but more as a way to smooth out any irregularities my speech might have.

While Lucier's choice of resonator is the physical room, the chosen resonator that are used in SeedBack Karplus-Strong delay lines, which achieves similar results in a fraction of a second, as opposed to tens of minutes that's evident of the orignal Lucier setup. The feedback procedure used for SeedBack will be described in details in the Method section.

Interactivity is an intrinsic part of music. Whether it's between the performer and the audience, between performer and composer, between performer and the instrument, or between multiple performers, interactivity defines musical experiences. While Lucier's *I'm sitting in a room* is an excellent example of using feedback in a composition, Nicolas Collins' *Pea Soup*, composed in 1974, highlights a more immediate interaction between the active agents in the space and the system. [3].

Collins was no doubt influenced by Lucier, for both of them were at Wesleyan University at the time when *Pea Soup* was conceived. Similar to *I'm sitting in a room*, *Pea Soup* is driven by the feedback between the speaker and microphone sitting in the same room. In a nut-shell, *Pea Soup* uses a envelope controlled phase-delay unit to process the incoming signal from the microphone before reintroducing the result back into the same space. Its difference from Lucier's earlier work is in that *Pea Soup* is designed to work with a real-time performer, and arguably more interactive. SeedBack's interaction is more akin with *Pea Soup*, in which the system is intended to be driven by live signals, or an external agent.

Of course, through out the years, many more works has drawn on the same principle. Michael Musick's *Sonic Spaces Project* are excellent embodiment and realization of similar principles of interactive music systems. [4]

3. METHODS

3.1 Karplus-Strong Resonator

At the heart of SeedBack are 8 units of Karplus-Strong Resonators.

While Karplus-Strong delay lines are traditionally excited by either noise or triangle impulses to conform to it's capacity as efficient physical model of plucked strings [5], the input

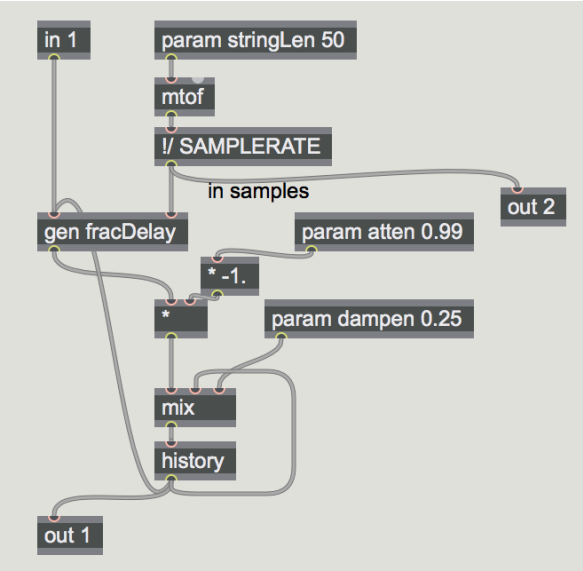

Figure 1. Implementation of the Karplus-Strong Algorithm in Max using gen~.

to the delay-line can also be any arbitrary signal. When used with such a signal, the Karplus-Strong delay line act as a resonator with a prominent resonating frequency that is related to the length of the delay line. Keeping inline with the classical design of the Karplus-Strong algorithm, each time before the signal is recirculated back into the delay line, it is attenuated and low-pass filtered. The Karplus-Strong resonators used in SeedBack are implemented in gen~ within Max, and the length of the delay line as well as the attenuation factor can both be modified in realtime, providing interesting possibilities for feedback control. Implemtation of the Karplus-Strong resonator engine are shown in Firuge 1.

3.2 Monitoring and Controlling Volume

In order to control tame each Karplus-Strong resonator from diverging due to positive feedback, the volume of each resonator's output is regulated by adjusting the `atten` parameter of each resonator, with a delay. The attenuation factor is allowed to vary between 0.97 and 1.03, with numbers less than 1 indicating decay and numbers higher than 1 indicating growth. The attenuation factor, or `atten`, is contorlled by a envelope follower that is constantly monitoring the output volume of each resonator.

3.3 Monitoring and Controlling Sensory Roughness

Besides volume, SeedBack also attempts to regulate the sensory Roughness, or dissonance, of the resulting output. Sensory roughness is measured by looking at interaction between close-by frequencies. Explicitly, beating between frequency components of a given sound produces perceived roughness, and such interactions between close-by frequencies are measured in a systematic way to represent the sensory roughness. SeedBack uses the CNMAT object roughness~ to achieve this measurement. [6]

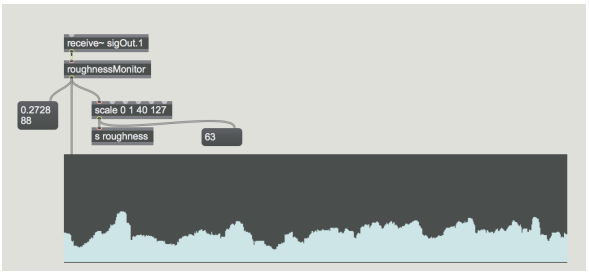

Figure 2. Roughness of the output signal during a typical run of SeedBack recorded over time.

The roughness is analzed and used to control the varying speed of the length of each Karplus-Strong delay lines. This is based on the intuition that changing the delay lenghths of resonators faster and more abruptly would cuase a "rougher" output soundscape, and vice versa. The roughness measure is combined with some uncertainty to ensure all resonators are slightly independent, achieving a more interesting sonic outcome. Figure 2 shows the roughness measured over time of a typical output.

4. BEHAVIOR AND SONIC RESULT

Currently, SeedBack generates some interesting soundscpaes, especially when impulsive sonic seeds are given; events such as snaps, claps and clicks will generate a florish of sounds. It is also fun to speak into the system. However, because of the volume feedback control mechanism, the system output is constanting hovering around a predetermined volume, even when there is no external agent present to provide the sonic seeds. It'll pick up the most minute fluctuation in the ambiance and resonate and amplify. That along with the intrinsic construction using Karplus-Strong delay lines, the sonic palette of SeedBack is quite limited currently. However, the correlation between the input and the output is obvious and traceable, even for non-musicians, and this is a desirable feature that the author is intended to keep.

5. FUTURE WORKS

5.1 A Natural Decay

There can be some attempt to address the issue of the never dying sonic output even when there is no driving sonic seed. This would require the system to distinguish between its own output slightly transformed by the space and any sound provided by the external agents.

5.2 A More Diverse Pallet

Using Karplus-Strong resonators as the only method for generating sound through feedback in general limits the diversity of the output soundscpae. Other schemes of feedback sonic generation can be added, and can be triggered in conjunction

or instead of the current resonating scheme, controled by certain features of the external agents input sonic seeds. This can be done through feature extraction, and converting these features into control signals that could steer the direction of the algorithm for a more diverse and structured result.

6. REFERENCES

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