GrainProc: a real-time granular synthesis interface for live performance

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ABSTRACT

GrainProc is a touchscreen interface for real-time granular synthesis designed for live performance. The user provides a real-time audio input (electric guitar, for example) as a granularization source and controls various synthesis parameters with their fingers or toes. The control parameters are designed to give the user access to intuitive and expressive live granular manipulations.

Keywords

Granular synthesis, touch screen interface, toe control, real-time, CCRMA

1. BACKGROUND

Granular synthesis encompasses a wide variety of methods for processing and synthesizing sounds, based on the manipulation of time-windowed "grains". Greek composer Iannis Xenakis composed electro-acoustic works in the 1950s (including *Concrete PH*) by manipulating microsounds [6], informed by the work of physicist Dennis Gabor on wave-particle duality [3]. Granular synthesis builds upon this foundation, treating audio source material as particles instead of waves. The first digital implementation was made in the 1970s by Curtis Roads [4], and the first real-time implementation was done by Barry Truax [5] in 1986 (as demonstrated in his composition *Riverrun*). Granular synthesis underlies many popular techniques for independently manipulating the timing and playback rate of sounds, but it is also useful as an artistic tool in its own right. Numerous operations can be done on grains to create a very wide variety of sounds, from simple pulsing effects to complex soundscapes, from jagged deconstructions of the sound to ambient smears.

Granular synthesis has long been a mainstay in experimental music software (Common Lisp Music, ChucK, CSound, Max/MSP, Supercollider, etc.), but plugin implementations designed to run in traditional Digital Audio Workstations exist as well (the Grain Delay plugin in Ableton Live, Propellorhead's Maelstrom synthesizer, etc.). Recent smartphone applications, such as The Strange Agency's *Megacurtis*, 31tone's *Nebula*, and Apposite Labs' *Microcosm*, betray a continuing fascination with granular synthesis. This family of synthesis applications focus on real-time granular synthesis of fixed sound sources or oscillators, and have found a culmination in Chris Carlson's *Borderlands* [2]. However, the expressive potential of a parallel rhetoric of granular synthesis, granularization of a real-time input stream, remains untapped.

2. MOTIVATION

Rackmount and "stompbox" processors are widely available for most conventional audio effects (reverb, delay, chorus, distortion, etc.), but granular synthesis has been less accessible to the performing musician. Part of the reason for this is that granular synthesis is a powerful, open-ended technique with many controllable parameters, and typically lends itself to expressiveness in a production setting, rather than in real-time performance. As well, many interfaces for controlling audio effects (such as "stompboxes"), only offer on/off toggles or occasionally feature a single continuous control (as seen in volume and wah pedals, the Digitech Whammy, etc.). A useful implementation of granular synthesis for real-time audio manipulation needs to have a manageable number of parameters to control, without sacrificing expressiveness, and needs to feature an interface that allows for detailed control of these parameters.

3. INTRODUCTION

GrainProc runs on the iPad, a commonly available tablet computer that features audio in/out and a multi-touch screen. The tablet computer's form factor makes it highly suitable as a platform for interactive musical control, due to its ubiquity and portability. *GrainProc* is designed to be an accessible, intuitive, and expressive granular synthesis tool. To this end, it has a synthesis algorithm and linked control parameters selected for simplicity and expressiveness, an ergonomic interface designed for use with fingers or toes, and clean, useful visual feedback.

GrainProc employs an implementation of granular synthesis called *Tapped Delay Line Granular Synthesis* [1], where multiple streams of grains are drawn stochastically from a common delay line. The common delay line is continuously filled with input audio and an attenuated feedback from the output, and can be frozen to prevent update and act as a fixed source granulator. Grains of random length (between 10 and 100 ms) are time-windowed, with a Hann window, here selected for its smoothed edges rather than its spectral effects.

The block diagram is shown in Figure 1.

4. INTERFACE DESIGN

A control layout and general interactive scheme were developed with toe ergonomics in mind. Control parameters

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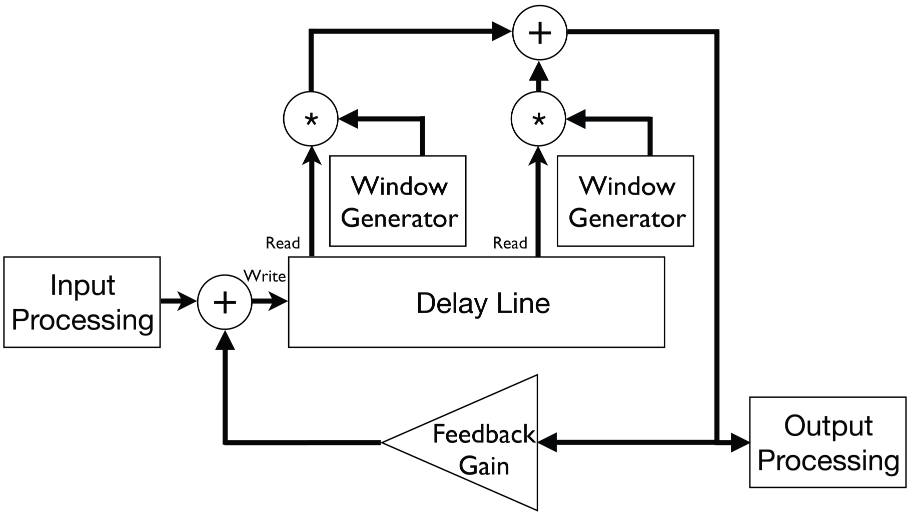

Figure 1: Block diagram for granulator

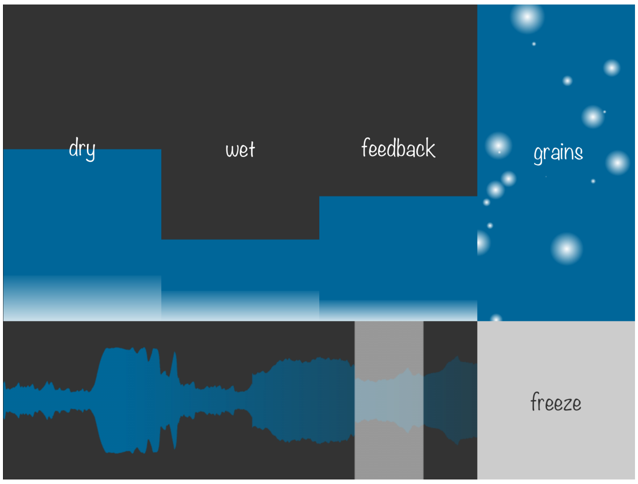

Figure 2: Screenshot on iPad with controls in blue color

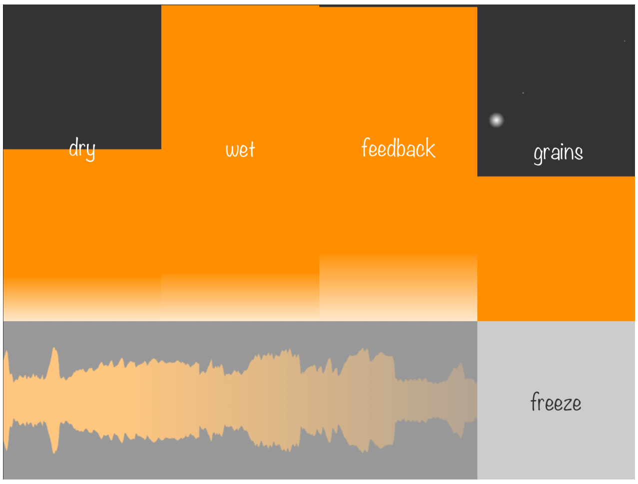

Figure 3: Second synthesizer with controls in orange color

were mapped to synthesis parameters to allow expressive and intuitive manipulation. The visual design of *GrainProc* leverages visual feedback to give the user useful information on its state.

4.1 Layout

In designing a control layout (shown in Figure 2), we had to consider the physical limitations imposed by the device as well as the ergonomics of toe control. 4 vertical sliders, mapped to wet and dry signal gains, feedback gain, and grain density, are controlled comfortably and accurately by toe. Wet and dry signal gain controls were chosen in place of a wet/dry blend control, since this style of granularization conceives of each instance of granularization having its own sonic identity, rather than merely as an effected version of the dry signal. A buffer display at the bottom of the screen ("freezable" by a button to its right) displays the content of the buffer and offers control of the source window. A swipe gesture allows navigation between the control of two parallel instances of granularization, which are differentiated by their color (as shown in Figure 2 and Figure 3).

4.2 Interaction

The level of sliders can be changed continuously, by sliding, or quickly set by tapping at a target level. This allows expressive gestures without requiring high accuracy. An ambiguity between taps and swipe gestures (used to navigate between the two parallel granularizers) is resolved by a slight latency between initial touch and a resulting slider change.

Intuitive two-dimensional control maps x and y position of touches in the buffer window to source window position and source window size, respectively. A non-linear value mapping was chosen to allow an appropriate compromise in control detail at both small and large parameter values.

4.3 Parameterization

Design challenges that were faced in creating *GrainProc* included selecting an expressive synthesis algorithm, selecting a useful subset of all possible parameters for this algorithm, and creating linked parametric controls to join these parameters in a perceptually motivated fashion.

Parameter coupling is an important technique which motivates the replacement of independent parameter controls with perceptually motivated analogs. For instance, an increase in grain density is coupled with a corresponding decrease in wet gain, decorrelating perceived density and loudness. So that loudness is mainly invariant of grain density, a perceptually-motivated compromise between a completely un-coupled parameterization and a parameterization that keeps energy constant is employed.

4.4 Ergonomics

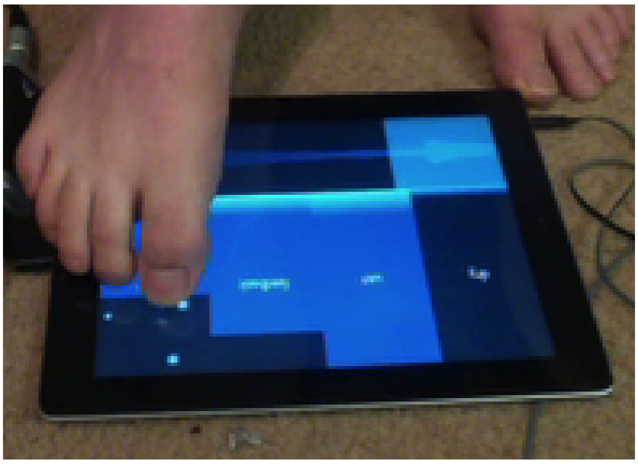

Figure 4: *GrainProc* in action

One of the main considerations for the design of *GrainProc* was ergonomics. Since the device is designed for toe control, many normal paradigms for touch control have to be modified or avoided. For instance, complicated gestural control (or multi-touch) is nigh impossible with toes. For single-touch operation, the toes can harness much less dexterity than fingers, and their dexterity is directionally-dependent (toes have more dexterity vertically than horizontally). Hence, multi-touch and complicated gestures have to be avoided. Large, easily-controlled sliders are forgiving to the relative inaccuracy of toes (as compared to fingers). Parameter control is restricted in single-touch operations, vertical and horizontal touch motions in a single window, and no pop-up windows. Present day touch screens use capacitive sensing and are designed for bare skin. Certain commercial gloves allow the use of touch screens but nothing exists for feet yet. This being the case, this tool requires performers to be barefoot at present.

4.5 Visual Feedback

Another design feature of *GrainProc* is the use of visual feedback. Each visual element in the interface serves a dual purpose. It allows the user to see and control the parameter values as well as get pertinent information at a glance. The gain sliders additionally display a translucent level meter. The grain density slider gives a visual indication of grain lifecycles. Visual feedback about the buffer's content is given by display of a continuously updating waveform. The waveform also fades away as it moves to the end of the buffer to indicate the flow of time. The Freeze button acts as a simple switch, slightly changing its shading for either case.

5. DISCUSSION

Design choices made in the creation of expressive musical tools help define the character of the sounds produced by the tool. Granular synthesis is a family of techniques with various architectures, each with many possible parameters. There are endless ways to control granularization. Controls such as grain length, grain transposition, and window type are common, as well as secondary frameworks around these controls, such as parameter trajectories and stochastically motivated parameter selection. Having a subset of all possible controls necessarily constrains certain uses of the tool, while foregrounding others. A reduction from all possible parameters to a few causes the tool to span a subspace of all possible sonic manipulations. This reduction was done on aesthetic and expressive grounds. For instance, although controls of grain length offer a powerful way to affect granular textures, this control was discarded to minimize windowing effects and give *GrainProc* a "smooth" sound. The omission of grain transposition control from *GrainProc* may seem curious. Although controls on grain transposition allow for a wide variety of effects, from flanging to harmonization, these controls were removed as a design choice, to foreground certain forms of musical expression. *GrainProc* was envisioned as a live performance tool for utilizing granular versions of common delay-line based effects, such as delay, reverb, and chorus. Grain transposition is difficult to harness in a live performance situation, and requires dexterity that may be beyond the typical human toe, so control of this parameter was foregone in favor of time- and texture-based controls. The controls included in *GrainProc* are well-suited to the level of dexterity that human toes retain.

Granular synthesis possesses an inherent randomness that has to be considered while using it in a real-time performance tool. Allowing control of the source window in size and position over a graphical representation of the waveform, in tandem with controllable grain density, translates to a very close control of this randomness. At the shortest allowed timescale, and at high grain density, *GrainProc* effectively recreates the sound from the source window. However, at long window sizes and low grain densities, the affected sound is much less predictable.

6. CONCLUSIONS

GrainProc leverages the ubiquity of the iPad to create an expressive implementation of granular synthesis. Specifically, the type of granular processing that *GrainProc* accomplishes falls under the category of real-time "granularization," [4] wherein grains are drawn from an input stream of real-time audio. Touch control on the iPad screen allows a player to manipulate processing parameters, while the screen gives feedback on the state of the synthesis parameters and signal at various points in the algorithm. This specific implementation of granularization was designed be very expressive, allowing for many possibilities and modes of operation with minimal controllable parameters. In this sense, being able to control every possible combination of granular operations on a sound has been sacrificed, in order to make a tool that is expressive. Additionally, the ergonomics of the touch controls have been designed so that all parameters and controls are accessible by toes, allowing players the use of *GrainProc*'s expressive capabilities without the use of their hands (which are often necessary for playing an instrument). *GrainProc* is designed to fit easily into a performer's workflow, since it runs on a very common platform (iPad), and is designed with performance in mind.

GrainProc can be downloaded from `http://grainproc.e7mac.com`

7. REFERENCES

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