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An Input Device to Control Granular Sound Processes

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ABSTRACT
In this paper we present the next state of the art of our previous work on the control of granular synthesis through evolutive processes occurring in Extended Gabor´s Space. We describe the GranularStreamer, a new version of EVOGrain's granular sounds synthesizer, and a suitable coupling to T-Stick, an input device which can control synthesis parameters in real time. This work is technologically oriented to achieve a Digital Musical Instrument which can be easily explored by a musician to trigger granular sound transformation processes according to Smalley´s Spectromorphology through a gestural interface.

0 INTRODUCTION

Granular Synthesis (GS) is a sound synthesis method firstly based on the concept of Gabor's Acoustical Quanta [1], the least energetic particle of sound that can be detected by an auditory device, such as, for example, the human ear. With this method, sounds, timbres, textures and music are obtained by temporal sequencing of tiny particles of sound by the order of one to a hundred milliseconds, which is nowadays named grains of sound [2,3,4]. A commonplace challenge to design sound synthesis systems operating at the microtime level is to find appropriated algorithms and devices in order to control streams with hundreds of grains per second and to get high-level structures generated by sometimes a huge amount of data. Recently we presented a prototype system [4], named EVOGrain which generates and controls streams of granular sounds in real time through a graphical interface, consisting of three windows, each one of them interpreted as a 2-dimensional real parameter space (R2). The three windows together encompass a 6-dimensional parameter space we named Extended Gabor Space. Using the mouse, the user draws a rectangle in each R2 window that defines a target in its respective two-dimensional space which will drive the evolution of a time-ordered set of generations. The winner individual of each generation, that is, the one closest to the target rectangle according to the metric (norm of the maximum) [5] defined in the extended

Gabor Space, is interpreted as control parameters of a stream of granular sounds.

This paper describe some recent efforts to find an alternative interface to EVOGrain focusing on gestural controllers. Although Granular Synthesis is a well know electronic music technique, it's use in live performance is not widely spread, specially when controlled by digital instruments. The particularity of this sound material, that is, grains of sound, place it's own difficulties on the development of an input device like the Poseidon [6,7], a digital controller that makes use of sliders and pressure pads to control granular synthesis.

This research is a collaboration of the Interdisciplinary Nucleus of Sound Communication (NICS), UNICAMP, Brazil, and the Input Devices and Music Interaction Laboratory (IDMIL) from McGill University, Canada. The following sections describes, shortly, the core of the granular synthesis system, some early experiments with commercial and academic input devices, and finally, propose the development of a new input device suitable to control granular sound transformation processes .

1 GRANULAR STREAMS AND PROCESSES

In this section we present the sound synthesis algorithm used in this paper, the GranularStreamer (a new version of EVOGrain, our Real Time Granular Synthesis Machine). It also features a new network layer that receives parameters updates in real time through Open Sound Control (OSC) messages. Next we discuss the expected spectromorphological behavior of the granular sounds that we intend to control in real time with an input device or gestural controller.

1.1 GranularStreamer

As its antecessor EVOGrain, the GranularStreamer is a granular synthesizer that generates multiple streams of grains in real time, currently working with sample rate of 44.100Hz, 16 bits depth and 2 channels. It uses the RtAudio library, a set of realime audio i/o classes, to access the system's audio devices [8].

To achieve better performance the source code of the GranularStreamer was converted from JAVA to C++, and some fine tuning was made in the algorithm (e.g. better use of system memory, optimization of the real time loop, use of 1024-points wavetables with two-point linear interpolation for all wave and envelope types). Now it's possible to synthesize many simultaneous streams of grains limited only by the system's resources. The Real Time Granular Synthesis Machine architecture is built under the producer/consumer paradigm. The producer thread is responsible for calculating samples and storing them in a buffer. The consumer thread waits until the buffer is completed and then sends its samples to the computer soundboard.

To run GranularStreamer the user should type a command line that specifies the number of streams of grains, the maximum number of overlapping grains (shared for all streams) and the wave and envelope types for each stream. The currently available wave types are Sine, Square, Sawtooth and Granulation [2]. The latter allows the user to granulate a selected wave mono file, this opens possibilities to a wide range of waveforms. The available envelope types are Gaussian, Expodec, Recpodec and None [2].

Each stream is controlled by six pairs of dynamic parameters (initial value and final value for each parameter) that may be updated at any time. Every new synthesized grain will be created with six parameter values sorted, with the uniform statistical distribution, within the intervals defined by each pair of parameter. To control the synthesis parameters in realtime we developed an OSC message listener using the oscpack library [9]. OSC is a communication protocol for messaging among computers, sound synthesizers and multimedia connected by computer networks or USB ports. In this way, GranularStreamer can be easily integrated to any input device or sound system capable of sending OSC messages as, for instance, PureData patches or the Mapping Tools described next section. A complete documentation of the OSC messages supporte by the GranularStreamer can be found at http://www.nics.unicamp.br/~fernando/granularstreamer.html. The real time parameters that GranularStreamer currently accepts for each stream are listed below:

-Initial and Final Frequency: the frequency of the grain waveform in Hertz;

-Initial and Final Grainsize: the grain size in milliseconds;

-Initial and Final Density: the flux density of the stream in grains per second. If Initial and Final Density are equal, a synchronous stream is obtained, otherwise the density of the flux will be changed after the creation of every grain.

-Initial and Final Offset: if a wavefile is being used as waveform, the offset parameter is used to define the reading position within the wavefile.

-Initial and Final Amplitude: the amplitude of each grain.

-Initial and Final Pan: the panoramic position (left/right) for each grain;

In addition to the parameters above the system can be controlled by a secondary set of messages called “width parameters” where, instead of specifying an initial value and a final value for each, it specifies one center value and the width of the interval. For instance, to specify the frequency of a cloud of grains the system can be controlled by the parameters Center Frequency and Bandwidth or, in the case of Amplitude, Center Amplitude and Amplitude Variation.

1.2 Granular processes and spectromorphology

Microsound opened new horizons not only to sound synthesis but also to music composition. Composing with grains should give emphasis on the sound transformation process in time rather than on the establishment of rigid sound objects [10]. As mentioned above, the prototype system EVOGrain is presented as a graphical interface that allows the user to conduct the texture in the Extended Gabor Space in an intuitive manner and it doesn't require absolute control of the process. Here we are looking for a Digital Musical Instrument (DMI) with the same characteristics of EVOGrain that could be useful to trigger a wide variety of granular sound transformation processes like those present, for example, in the famous composition Riverrun of Barry Truax [11], where each stream leaves its own spectral blurring. Motion and growth processes are very suitable to describe that variety of granular sounds transformations as stressed in the quote below by Smalley.

“The metaphors of motion and growth are appropriate ways of considering a time-based art like electroacoustic music. Traditional concepts of rhythm are inadequate to describe the often dramatic contours of electroacoustic gesture and the internal motion of texture which are expressed through a great variety of spectromorphologies. Quite often listeners are reminded of motion and growth processes outside music and the terms selected are intended to evoke these kinds of connections. Since motion and growth have spectral contours, they are set in spectral space. Therefore their occupancy of spectral space and their spectral density will be important additional qualifiers” [12].

For those ends we describe a list of motion and growth processes according to Smalley's Spectromorphology [12] that will serve as reference to the evaluation of the proposed DMI:

-Linear: a linear ascendent or descendent progression;

-Parabolic: an ascendent function followed by an descendent function and vice-versa;

-Cyclic/Spiral: an oscillatory movement described by a circular or spiral trajectory.

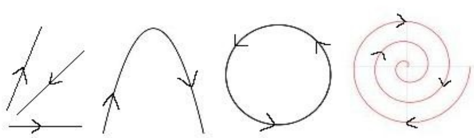

Figure 1 Spectromorphological Processes

These processes describe the position occupied by a particle in a 2-dimensional trajectory in certain moment of time. Projecting the position of the particle to Cartesian coordinates X and Y, we can obtain a parameter variation in time that can be scaled to any parameter of the 6-dimensional Extend Gabor's Space (grain frequency, grain size, stream density, wave offset, amplitude and panoramic position). If we predefine the trajectories, the overall time of the process will be determined by the simulated speed of the particle. For instance, the X coordinate of the above parabolic trajectory (Fig.1) can be scaled to stream density resulting in a increasing density of grains per second, while the Y coordinate can be scaled to grain frequency resulting in a process of rising and then lowering the frequency of the grains. The X and Y coordinates can also be scaled to any other parameter like those in the set called “width parameters” resulting in processes of agglomeration, dissipation, dilation and contraction. For example, projecting the X coordinate of a cyclic trajectory to the parameter that controls the bandwidth of a cloud we obtain an oscillatory process of dissipation (while the grains are being scattered within an increasing bandwidth) and contraction (while the bandwidth decreases and the grains concentrates around the center frequency). So the class of curves above, can be mapped in any of the control parameters leading to complex sound streams mediated by suitable Input devices. Audio examples of these processes synthesized by the GranularStreamer can be found at http://www.nics.unicamp.br/~fernando/aes2010.html.

1.3 Mapping Tools

In this section we present Mapping Tools, a Max MSP patch that makes easy to connect source DMIs to sound parameters, followed by the T-Stick, a gestural music controller used in this paper to do preliminary experiments controlling granular processes with gestures.

Mapping Tools is a collaborative development system that allows mapping between controllers and sound parameters in a simple and fast way being especially useful when connecting a large group of controllers to sounds parameters or accelerating the exploration of a suitable controller to a new sound synthesis algorithm [13].

The Mapping Tools interface is divided into three sections. The left section shows the Sources, that is, all controllers connected to the system, e.g., SpaceNavigator, T-Stick, Keyboards, Joysticks, MIDI PADs and others. The right section shows the Destinations, that is, all sound generators connected to the system, e.g., any MAX MSP or PD patch, or our GranularStreamer. In the center of the interface, between the Sources and the *Destinations* are located the Connections. A connection is established between a source and a destination by click on the controller and on the sound system. After doing a connection, the mapper shows the details of the controller, that is, the list of all available sensors, and the list of all sound parameters. Then it is possible to connect each sensor to each sound parameter using an appropriate user-defined expression.

The Mapping Tools is in charge of receiving the controller OSC messages with sensor values, evaluating the conversion expression, and sending OSC messages with the sound parameter values to the sound system. Details on functioning of Mapping Tools and its documentation can be founded in the page http://www.idmil.org/software/mappingtools.

1.4 The T-Stick

The T-Stick is a gestural controller developed by J. Malloch at the IDMIL (Input Devices and Music Interaction), Music Technology Area in McGill University [11]. It is a DMI equipped with accelerometers, pressure sensors, touch sensors and other sensors. Its outputs determine how much or how strong the instrument is being touched, shaken, twisted, tilted, etc.

Figure 2 The T-Stick

The T-Stick offers a wide range of possibilities to control the GranularStreamer. It can be used like a performer instrument. For example, mapping the ′shake′ parameter simultaneously into stream density (grains per second) and amplitude we obtain a granular shaker, and it can also be used as a conductor instrument triggering sound transformation processes like those described in section 1.2. To achieve this we defined a gesture to be performed with the T-Stick that is, holding the T-Stick with both hands at one extremity, simulate a hit in direction of the ground. The hit can be done in a straight line downwards, with slight semi-circular bounce at the end or with a full circular movement at the end.

The stick is equipped with a 3-axis accelerometer at the free extremity of the stick, that is, the extremity opposed to the one being held. After extracting and processing the data received from the accelerometer we obtained two normalized parameters that are used to trigger the granular processes. The first, “Hit Power”, is controlled by the intensity of the hit, and the second “Hit Spin” is determined by the amount of circular movement preformed at the end of the hit.

These parameters are then sent to a middle layer named “trajectory layer” where we codified two fixed trajectories (linear and circular) with same length of 1000 units. The “Hit Spin” parameters is used to determine the trajectory; if “Hit Spin” < 0.5 the trajectory will be linear; if “Hit Spin” ≥ 0.5 the trajectory will be circular. The “Hit Power” parameter is used to control the speed of the process, so we scale “Hit Power” in such a way that; if “Hit Power” = 0 the complete linear or circular process will be 10 seconds long and if “Hit Power” = 1 the complete process will be one second long. The trajectory layer is then responsible to calculate the X and Y axis projections and sending this values as parameters updates to the GranularStreamer.

2 CONCLUSIONS AND PERSPECTIVES

In the experiments that we did in this paper we reduced the possibilities of the spectromorphological trajectories (linear and circular) and used only two gesture inputs (hit power and hit spin). Although we realized that the gesture proposed to be performed with the T-Stick is not very suitable because is hard to have a satisfactory control of power and spin, the sound processes obtained using the model proposed above strongly suggests that rich granular synthesis transformations can be triggered by a gesture performed with a DMI.

In order to extend the results obtained in this paper we begin the construction of a new DMI suitable for triggering processes of granular sounds transformation but with a simple and intuitive interface [15]. This device is an individual alternate controller metaphorically inspired in the shape of a baseball ball with greater dimensions (about 15 cm of diameter). The user is going to trigger the sound transformation processes by performing the gesture of throwing the ball forward, downward or upward; with different angles and spin effects. The DMI will be equipped with a 3-axis accelerometer, a gyroscope to sense spin effect and a pressure sensor. The user should also be provided with selectors to choose the active stream and the combination of synthesis parameters that are going to be updated by the “trajectory layer”.

The “trajectory layer” itself can then be upgraded to compute multiple trajectories with variable shapes, lengths and speeds according to the parameters of the throw performed with the DMI like throw power, elevation, spin effect and pressure increasing the variety and richness of the granular sound transformation processes.

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BIBLIOGRAPHY

[1] Gabor, D.; Acoustical quanta and the theory of hearing, Nature 159(4040), pp. 591-594 (1947).

[2] Roads, C.; Microsound, MIT Press, Combridge, MA (2001).

[3] Thomson, P.; Atoms and Errors: towards a history and aesthetics of microsound, Organized Sound 9(2), pp. 207-218, Cambridge Press (2004).

[4] Souza, F.F.; Maia Jr., A.; Evolutive Processes for Granular Synthesis in Extended Gabor Spaces. 7o Congresso de Engenharia de Áudio. AES Brasil, São Paulo, SP (2009).

[5] Bryant, V.; Metric Spaces: Iteration and Application, Comabridge University Press (1985).

[6] Opie, T.; Creation of a Real-Time Granular Synthesis Instrument for Live Performance, Mater Thesis, Brisbane, Australia (2003).

[7] Opie, T.; Granular Synthesis: Experiments in Live Performance, Proc. ACMA, Fitzroy, Australia (2002).

[8] Copyright (c) 2001-2010 Gary P. Scavone. http://www.music.mcgill.ca/~gary/rtaudio/index.html

[9] Copyright © 2004-2006 Ross Bencina. http://www.audiomulch.com/~rossb/code/oscpack/

[10] Clark, M.; Composing at the intersection of time and frequency, Organized Sound 1(2), pp. 107-117. Combridge University Press (1996).

[11] Truax, B.; Real-time Granular Synthesis with Digital Signal Processing Computer, Computer Music Journal 12(2), pp. 14-16 (1988).

[12] Smalley, D.; Spectromorphology: explaining sound-shapes, Organized Sound 2(2), pp. 107-126. Cambridge University Press (1997).

[13] Malloch, J.; Sinclair, S.; Wanderley, M.M.; A Network-based Framework for Collaborative Development and Performance of Digital Musical Instruments. Proc. Of Computer Music Modeling and Retrieval 2007 Conference, Berlin (2008).

[14] Malloch, J.; A consort of Gestural Musical Controllers: Design, Construction and Performance. M.A. Thesis, McGill University (2007).

[15] Wanderley, M.M.; Depalle, P.; Gestural Control of Sound Synthesis. Proceedings of the IEEE, Vol.92, No.4 (2004).